UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

**Refer to NMFS No: WCR-2018-9330**

May 24, 2018

Alicia Forsythe
Program Manager
U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825-1898

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Fish and Wildlife Coordination Act Recommendations for the Current Operations of Arroyo Canal and Sack Dam in Fresno and Madera counties

Dear Ms. Forsythe:

Thank you for your letter of December 6, 2017, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act (ESA) of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Current Operations of Arroyo Canal and Sack Dam.

Enclosed is NMFS's biological opinion (BO) based on our review of the proposed Current Operations of Arroyo Canal and Sack Dam (proposed action) associated with the San Joaquin River Restoration Program (SJRRP) in Fresno and Madera counties, California, and its effects on the federally listed as threatened California Central Valley (CCV) steelhead (*Oncorhynchus mykiss*) and the Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*) population being reintroduced by the SJRRP in accordance with section 7 of the ESA of 1973, as amended (16 U.S.C. 1531 et seq.). This population of CV spring-run Chinook salmon has been designated by NMFS as a Non-essential Experimental Population in accordance with section 10(j) of the ESA.

This BO is based on information provided in the final biological assessment (BA), along with information highlighted in NMFS' BO on the effects of the Arroyo Canal Fish Screen and Sack Dam Fish Passage Improvement Project (NMFS 2013), and numerous scientific articles and reports from both the peer reviewed literature and agency "gray literature."

Based on the best available scientific and commercial information, this BO concludes that the proposed action, as presented by Reclamation, is not likely to jeopardize the continued existence of the listed species. An incidental take statement that includes reasonable and prudent measures and non-discretionary terms and conditions that are expected to minimize the impact of the anticipated incidental take of CCV steelhead is included with this BO. These measures would also minimize impacts to CV spring-run Chinook salmon.

This BO contains conferencing for CV spring-run Chinook salmon because it was requested by Reclamation. A conferencing opinion is only required if the analysis of the proposed action results in a jeopardy determination, and we concluded the proposed action will not jeopardize the continued existence of the CV spring-run Chinook salmon Evolutionarily Significant Unit, therefore a formal conferencing opinion is not included in this BO.

Because the action area for the proposed action is within the SJRRP Restoration Area, NMFS also concluded that the proposed action would not further adversely affect EFH beyond what was analyzed as part of the EFH consultation included in the NMFS SJRRP BO (NMFS 2012). Therefore, no further EFH consultation is required as part of this BO.

Please contact T.J. Yockachonis at (916) 930-3710 or Thomas.Yockachonis@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

for Maria Rea

Barry A. Thom
Regional Administrator

Enclosure

cc: To the file: 151422-WCR2017-SA00396

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# Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Fish and Wildlife Coordination Act Recommendations

Current Operations of Arroyo Canal and Sack Dam

National Marine Fisheries Service (NMFS) Consultation Number: WCR-2018-9330

Action Agency: U.S. Bureau of Reclamation

Affected Species and NMFS' Determinations:

| ESA-Listed Species | Status | Is Action Likely to Adversely Affect Species or Critical Habitat?* | Is Action Likely To Jeopardize the Species? | Is Action Likely To Destroy or Adversely Modify Critical Habitat? |
|---|---|---|---|---|
| California Central Valley Steelhead DPS (*O. mykiss*) | Threatened | Yes: species<br>NA: critical habitat | No | NA |
| Central Valley Spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*) | Threatened (Non-essential Experimental Population) | Yes: species<br>NA: critical habitat | No | NA |

**Consultation Conducted By:** National Marine Fisheries Service, West Coast Region

**Issued By**:

Barry A. Thom
Regional Administrator

**Date**: May 24, 2018

LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| BMPs | Best Management Practices |
| BA | Biological Assessment |
| BO | Biological Opinion |
| CCV | California Central Valley |
| CDFG | California Department of Fish and Game |
| CDFW | California Department of Fish and Wildlife |
| CCID | Central California Irrigation District |
| DWR | California Department of Water Resources |
| CV | Central Valley |
| CVI | Central Valley Index |
| TRT | Central Valley Technical Review Team |
| CWT | Coded-wire tag |
| CRR | Cohort Replacement Rates |
| Coleman | Coleman National Fish Hatchery |
| DO | Dissolved Oxygen |
| DPS | Distinct Population Segment |
| EBMUD | East Bay Municipal Utilities District |
| ESA | Endangered Species Act |
| EFH | Essential Fish Habitat |
| ESU | Evolutionarily Significant Unit |
| FRFH | Feather River Fish Hatchery |
| FRRP | Fish Rescue and Relocation Plan |
| GIS | Geographic Information System |
| HMRD | Henry Miller Reclamation District #2131 |
| LWM | Large Woody Material |
| MSA | Magnuson-Stevens Fishery Conservation and Management Act |
| MMP | Monitoring and Maintenance Plan |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NEP | Non-essential Experimental Population |
| PBFs | Physical or Biological Features |
| PVA | Population Viability Analysis |
| RBDD | Red Bluff Diversion Dam |
| RM | River Mile |
| RST | Rotary Screw Trap |
| SJR | San Joaquin River |
| SLCC | San Luis Canal Company |
| SJRRP | San Joaquin River Restoration Program |
| T&C | Terms and Conditions |
| DQA | The Data Quality Act |
| Corps | U.S. Army Corps of Engineers |
| Reclamation | U.S. Bureau of Reclamation |
| USFWS | U.S. Fish and Wildlife Service |
| VSP | Viable Salmonid Population |

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# 1 INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

## 1.1 Background

National Marine Fisheries Service (NMFS) prepared the biological opinion (BO) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

An essential fish habitat (EFH) consultation on the proposed action was not completed as part of this opinion because the effects to EFH were considered as part of the San Joaquin River Restoration Program (SJRRP) BO (NMFS 2012). The current operations of Arroyo Canal and Sack Dam (proposed action) do not exceed or change the effects originally analyzed, and are within the boundary of the SJRRP. NMFS 2012 concluded that implementation of the SJRRP, through 2025, would adversely affect EFH of Pacific Coast salmon, and conservation measures were recommended, which have been and are currently being taken to avoid, minimize, or otherwise offset the adverse effects to EFH from SJRRP actions.

Because the proposed action would modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources, and enabling the Federal agency to give equal consideration with other project purposes, as required under the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.).

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). A complete record of this consultation is on file at the NMFS California Central Valley Office.

Reclamation does not have discretion over the water deliveries requested by the Exchange Contractors. Therefore, incidental take exemptions under section 7 of the ESA, for listed anadromous fish affected by the proposed action, will only apply for aspects that Reclamation has discretion over.

The analysis of effects (conferencing) of the proposed action on CV spring-run Chinook salmon is for informational purposes only. This BO contains conferencing for CV spring-run Chinook salmon because it was requested by Reclamation. A conferencing opinion is only required if the analysis of the proposed action results in a jeopardy determination, and we concluded the proposed action will not jeopardize the continued existence of the CV spring-run Chinook salmon ESU, therefore a formal Conferencing Opinion is not included in this BO. There will be no take issued for CV spring-run Chinook salmon as part of this BO, and the experimental population of CV spring-run Chinook salmon will not be addressed in the Incidental Take Statement.

### 1.1.1 Arroyo Canal and Sack Dam

Friant Dam, owned and operated by Reclamation, releases water in reach 1 of the RA where a portion arrives at Sack Dam and can be diverted into Arroyo Canal. The Arroyo Canal begins on the west side of the river, and continues approximately 20 miles to the northwest, where it becomes part of the Santa Fe Canal, near the town of Los Banos. Henry Miller Reclamation District #2131 (HMRD) owns and operates Sack Dam in order to supply irrigation water to approximately 47,000 acres within the San Luis Canal Company (SLCC) service area. HMRD also delivers water to the San Luis Wildlife Refuge Complex and the California State Wildlife Refuge lands within Grasslands Water District. The original Sack Dam was built around 1870; the existing Sack Dam was constructed in the 1940s and is a 5.75-foot high concrete and wood diversion structure delivering water to the Arroyo Canal.

SLCC receives daily diversion requests to meet irrigation demands that are called in each day to the SJR Exchange Contactors Water Authority Watermaster (Watermaster). The Watermaster coordinates daily water diversions from the Mendota Pool and the Delta Mendota Canal for all four Exchange Contractor entities. The Watermaster also coordinates SJRRP Restoration Flows (Restoration Flows) into the Mendota Pool, as directed by Reclamation. Central California Irrigation District (CCID), the owner of Mendota Dam, coordinates with the Watermaster to release the required daily amount of Restoration Flows through Mendota Dam for downstream delivery into Reaches 3 and 4A of the SJR. Daily requested flow changes for SLCC and the SJRRP are sent to the Watermaster and then released from Mendota Pool into Reach 3 of the SJR and arrive at the Arroyo Canal Headworks and Sack Dam each day.

### 1.1.2 Restoration Flow Releases

Restoration Flows are specific volumes of water released from Friant Dam in accordance with Exhibit B of the Settlement (Stipulation of Settlement in NRDC et al. v. Kirk Rodgers et al.). Interim Flows were experimental flows that began in 2009 with the purpose of collecting data concerning flows, temperatures, fish needs, seepage losses, recirculation, recapture, and reuse. Interim Flows continued until Restoration Flows were initiated in 2014. Currently, Restoration Flows are limited by a combination of restricted channel capacity and by seepage limitations. As structural improvements to the system are implemented over time, and as seepage issues are addressed, Restoration Flows will increase accordingly.

In order to release Restoration Flows into Reach 4A, the four Lo-Pac Gates installed in the western bays of Sack Dam were put into service. The gates operate off an upstream water level sensor in the SJR and SLCC daily diversions are measured in real-time just downstream of the Arroyo Canal Headworks. At the same time, the balance of the water in the SJR is pushed through the Lo-Pac Gates as Restoration Flows to meet the Restoration Administrator’s daily hydrograph.

### 1.2 Consultation History

On September 19, 2017, Reclamation provided NMFS with a draft BA regarding the current operation of Arroyo Canal and Sack Dam for review.

On September 21, 2017, Reclamation conducted a meeting with NMFS to discuss consultation strategy and to provide an overview of the draft BA.

On October 16, 2017, NMFS provided Reclamation with comments on the draft BA.

On November 1, 2017, Reclamation conducted a meeting with NMFS to address their comments on the draft BA.

On December 6, 2017, NMFS received a November 29, 2017 letter from Reclamation transmitting a final draft BA regarding the current operation of Arroyo Canal and Sack Dam BA and a letter requesting formal Section 7 consultation with NMFS.

On December 6, 2017, NMFS initiated formal consultation.

On December 19, 2017, NMFS transmitted a sufficiency letter to Reclamation, after review of the final draft BA.

### 1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02).

Under the FWCA, an action occurs whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatever, including navigation and drainage, by any department or agency of the United States, or by any public or private agency under Federal permit or license" (16 USC 662(a)).]

This BO addresses the current operations and associated maintenance activities of Arroyo Canal and Sack Dam. Reclamation is the Federal Action Agency associated with this proposed action.

#### 1.3.1 Operations

The proposed action includes the following operational components (A-D below):

A. Release of water from Mendota Dam into Reach 3
    - Based upon daily SLCC diversion requests Central California Irrigation District (CCID), the owner and operator of Mendota Dam, adds or cuts water released through Mendota Dam and into Reach 3 of the SJR for downstream delivery to SLCC.

B. Diversion of water from the San Joaquin River (SJR) into Arroyo Canal
    - The Arroyo Canal Headworks operate to deliver water into the Arroyo Canal based on SJR water levels.

C. Release of water from Sack Dam into Reach 4A
    - In order to release Restoration Flows into Reach 4A, the four Lo-Pac Gates installed in the western bays of Sack Dam are put into service. The Lo-Pac Gates of Sack Dam and the Arroyo Canal Headwork gates work collectively based on SJR water levels to direct water through Sack Dam downstream into Reach 4A.Currently, the limiting channel capacity for Restoration Flows is 300 cfs, which occurs in Reach 4A.

D. Maintenance of Arroyo Canal and Sack Dam

### 1.3.2 Maintenance

The proposed action includes the following key maintenance components:

- General Maintenance
    - Debris removal upstream and downstream of Sack Dam as necessary
    - Adjusting (adding or removing) weir boards as necessary
    - Sediment removal as necessary to ensure the solar gate structure can operate properly

- Solar Gates Maintenance
    - Weekly
        - Cleaning upstream and downstream sensors
        - Clean solar panels
    - Monthly
        - Test batteries
        - Test gates to ensure proper movement

- Flood Operation Activities
    - Remove Gates before flood event
    - Repair the banks that Sack Dam tie into (east and west sides of Sack Dam)
        - Once the floodwater starts flowing over the top of the dam, it starts to erode the cobble and dirt wing walls on both the east and west sides of Sack Dam. After flood flows recede, HMRD staff bring in imported fill dirt and cobble to backfill material that has been washed downstream by the floodwater; this material is brought to the site by dump trucks and off-loaded on the outer banks of the SJR. An excavator or backhoe (and sometimes both) are used to place the material in the void between the concrete dam wing walls and the berm on the east side, and the river levee on the west. There is no excavation of the river bottom material or sediment during this process.
    - Reinstall Gates after flood event (including repair of electrical for sensors upstream and downstream of Sack Dam)

### 1.3.3 Interrelated/Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The proposed action, regarding the current operations of Arroyo Canal and Sack Dam, has no interrelated or interdependent actions.

# 2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the ecosystem upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

## 2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and/or an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214).

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.

- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA to the proposed action.

## 2.2 Rangewide Status of the Species

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02.

The descriptions of the status of species in this BO are a synopsis of the detailed information available on NMFS' West Coast Regional website (http://www.westcoast.fisheries.noaa.gov/). Table 1 below identifies the federally listed species with the potential to occur in the action area and the species' associated Evolutionary Significant Units (ESUs) or Distinct Population Segments (DPSs). The website links listed below Table 1 lead to websites that provide more detailed information regarding species life history and geographical distribution, as well as the Federal Register Notices for species listing and critical habitat designation.

**Table 1.** ESA Listing History.

| Species | ESU or DPS | Original Final FR Listing | Current Final Listing Status |
|---|---|---|---|
| Spring-run Chinook salmon (*Oncorhynchus tshawytscha*) | Central Valley ESU (Non-essential Experimental Population 12/31/2013 78 FR 79622) | 9/16/1999<br>64 FR 50394<br>Threatened | 6/28/2005<br>70 FR 37160<br>Threatened |
| Steelhead (*O. mykiss*) | California Central Valley DPS | 3/19/1998<br>63 FR 13347<br>Threatened | 1/5/2006<br>71 FR 834<br>Threatened |

Detailed CV spring-run Chinook salmon ESU and critical habitat information:
http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/central_valley_spring_run/central_valley_spring_run_chinook.html

Detailed CCV steelhead DPS and critical habitat information:
http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/california_central_valley/california_central_valley_steelhead.html

### 2.2.1 California Central Valley steelhead Distinct Population Segment (DPS)

**A. Species Listing History**

CCV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good *et al.* 2005a) and after application of the agency's hatchery listing policy, NMFS reaffirmed its status as threatened and also listed the Feather River Hatchery and Coleman National Fish Hatchery stocks as part of the DPS in 2006 (71 FR 834). In June 2004, after a complete status review of 27 west coast salmonid ESUs and DPSs, NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological, and behavioral factors, and therefore warranted delineation as a separate DPS (71 FR 834). On May 5, 2016, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2016a).

**B. Life History**

1. Egg to Parr

The length of time it takes for eggs to hatch depends mostly on water temperature. Steelhead eggs hatch in three to four weeks at 10°C (50°F) to 15°C (59°F) (Moyle 2002). After hatching, alevins remain in the gravel for an additional two to five weeks while absorbing their yolk sacs, and emerge in spring or early summer (Barnhart 1986). Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Upon emergence, fry inhale air at the stream surface to fill their air bladders, absorb the remains of their yolks in the course of a few days, and start to feed actively, often in schools (Barnhart 1986, NMFS 1996).

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas (Hartman 1965; Everest and Chapman 1972; Fontaine 1988).

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or bolders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Optimal water temperatures for growth range from 15°C (59°F) to 20°C (68°F) (McCullough et al. 2001, Spina 2006). Cherry et al. (1975)

found preferred temperatures for rainbow trout ranged from 11°C (51.8°F) to 21°C (69.8°F) depending on acclimation temperatures (cited in Myrick and Cech 2001).

2. Smolt Migration

Juvenile steelhead often migrate downstream as parr in the summer or fall of their first year of life, but this is not a true smolt migration (Loch et al. 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean, and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating steelhead smolts use the lower reaches of the Sacramento River, the SJR, and the Delta primarily as a migration corridor to the ocean. There is little evidence that they rear in the Delta or on floodplains, though there are few behavioral studies of this life-stage in the California Central Valley (Table 2).

3. Ocean Behavior

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986). It is possible that California steelhead may not migrate to the Gulf of Alaska region of the north Pacific as commonly as more northern populations such as those in Washington and British Colombia. Burgner (1993) reported that no coded-wire tagged steelhead from California hatcheries were recovered from the open ocean surveys or fisheries that were sampled for steelhead between 1980 and 1988. Only a small number of disk-tagged fish from California were captured. This behavior might explain the small average size of CCV steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

Pearcy (1990) found that the diets of juvenile steelhead caught in coastal waters of Oregon and Washington were highly diverse and included many species of insects, copepods, amphipods, but by biomass the dominant prey items were small fishes (including rockfish and greenling) and euphausids.

There are no commercial fisheries for steelhead in California, Oregon, or Washington, with the exception of some tribal fisheries in Washington waters.

4. Spawning

CCV steelhead generally enter freshwater from August to November (with a peak in September [Hallock et al. 1961]), and spawn from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Table 2; Williams 2006; Hallock et al. 1961; McEwan and Jackson 1996). The timing of upstream migration is correlated with high flow events, such as freshets, and the associated change in water temperatures (Workman et al. 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. The threshold of a 56°F maximum water temperature that is commonly used for Chinook salmon is often extended to steelhead, but temperatures for spawning steelhead are not usually a concern as this activity occurs in the late fall and winter months when water temperatures are low. Female steelhead construct redds in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

Few direct counts of fecundity are available for CCV steelhead populations, but since the number of eggs laid per female is highly correlated with adult size, adult size can be used to estimate fecundity with reasonable precision. Adult steelhead size depends on the duration of and growth rate during their ocean residency (Meehan and Bjornn 1991). CCV steelhead generally return to freshwater after one or two years at sea (Hallock et al. 1961), and adults typically range in size from two to twelve pounds (Reynolds et al. 1993). Steelhead about 55 cm fork length (FL) long may have fewer than 2,000 eggs, whereas steelhead 85 cm (FL) long can have 5,000 to 10,000 eggs, depending on the stock (Meehan and Bjornn 1991). The average for Coleman National Fish Hatchery since 1999 is about 3,900 eggs per female (USFWS 2011).

Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning multiple times before death (Busby et al. 1996). However, it is rare for steelhead to spawn more than twice before dying; and repeat spawners tend to be biased towards females (Busby et al. 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners were relatively numerous (17.2 percent) in Waddell Creek. Null et al. (2013) found between 36 percent and 48 percent of kelts released from Coleman NFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for Coleman NFH in the 1971 season, where only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider et al. 1986).

5. Kelts

Post-spawning steelhead (kelts) may migrate downstream to the ocean immediately after spawning, or they may spend several weeks holding in pools before outmigrating (Shapovalov and Taft 1954). Recent studies have shown that kelts may remain in freshwater for an entire year after spawning (Teo et al. 2011), but that most return to the ocean (Null et al. 2013).

**Table 2.** The temporal occurrence of (a) adult and (b) juvenile California CV steelhead at locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

| (a) Adult migration | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | |
| [1]Sacramento R. at Fremont Weir | Low | Low | Low | Low | Low | | | | | | | Low | Low | Low | Low | Medium | High | High | High | Medium | Low | Low | Low | Low |
| [2]Sacramento R. at RBDD | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Medium | Medium | High | Medium | Low | Low | Low | Low |
| [3]Mill & Deer Creeks | Medium | Medium | High | Medium | Medium | Low | Low | Low | Low | Low | Low | Low | | | | | | | Medium | High | High | Low | Low | Low |
| [4]Mill Creek at Clough Dam | Low | Low | Medium | High | Medium | Medium | Low | Low | | | | | | | | | | Low | Medium | High | High | High | Medium | Medium |
| [5]San Joaquin River | High | High | Medium | Medium | Low | Low | | | | | | | Low | Low | Low | Low | Medium | Medium | Medium | Medium | Medium | Medium | High | High |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| (b) Juvenile migration | | | | | | | | | | | | | | | | | | | | | | | | |
| Location | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | |
| [1,2]Sacramento R. near Fremont Weir | Low | Low | Low | Low | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Low | Low | Low | Low | Low | Low | Medium | Medium | Medium | Medium | Low | Low |
| [6]Sacramento R. at Knights Landing | High | High | High | High | Medium | Medium | Medium | Medium | Low | Low | Low | Low | | | | | | | | | Low | Low | Low | Low |
| [7]Mill & Deer Creeks (silvery parr/smolts) | Low | Low | Low | Low | Medium | High | High | High | High | High | Low | Low | | | | | | | Low | Low | Low | Low | Low | Low |
| [7]Mill & Deer Creeks (fry/parr) | Low | Low | Low | Low | Low | Low | Medium | Medium | High | High | High | High | | | | | | | Medium | Medium | Medium | Medium | Medium | Medium |
| [8]Chipps Island (clipped) | Medium | Medium | High | High | Medium | Medium | Low | Low | Low | Low | | | | | | | | | | | | | Low | Low |
| [8]ChippsIsland (unclipped) | Medium | Medium | Medium | Medium | High | High | High | High | High | High | Medium | Medium | Low | Low | | | | | | | | | Low | Low |
| [9]San Joaquin R. at Mossdale | | | Low | Low | Medium | Medium | High | High | High | High | Low | Low | | | | | | | Low | Low | | | | |
| [10]Mokelumne R. (silvery parr/smolts) | Low | Low | Medium | Medium | Medium | Medium | High | High | High | High | Medium | Medium | Medium | Medium | | | | | | | | | | |
| [10]Mokelumne R. (fry/parr) | | | Low | Low | Low | Low | Low | Low | Medium | Medium | High | High | Medium | Medium | | | | | | | | | | |
| [11]Stanislaus R. at Caswell | Low | Low | Medium | Medium | High | High | Medium | Medium | Medium | Medium | Low | Low | | | | | | | | | | | | |
| [12]Sacramento R. at Hood | Low | Low | High | High | High | High | High | High | High | High | High | | | | | | | | | | Low | Low | Low | Low |

Relative Abundance: = High = Medium = Low

*Sources: [1](Hallock 1957); [2](McEwan 2001); [3](Harvey 1995); [4]CDFW unpublished data; [5]CDFG Steelhead Report Card Data 2007; [6]NMFS analysis of 1998-2011 CDFW data; [7](Johnson and Merrick 2012); [8]NMFS analysis of 1998-2011 USFWS data; [9]NMFS analysis of 2003-2011 USFWS data; [10]unpublished EBMUD RST data for 2008-2013; [11]Oakdale RST data (collected by FishBio) summarized by John Hannon (Reclamation) ; [12](Schaffter 1980).*

## C. Description of Viable Salmonid Population (VSP) Parameters

As an approach to determining the conservation status of salmonids, NMFS has developed a framework for identifying attributes of a viable salmonid population (VSP). The intent of this framework is to provide parties with the ability to assess the effects of management and conservation actions and ensure their actions promote the listed species' survival and recovery. This framework is known as the VSP concept (McElhany *et al.* 2000). The VSP concept measures population performance in term of four key parameters:  abundance, population growth rate, spatial structure, and diversity.

1. Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the Red Bluff Diversion Dam (RBDD) declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being planned (Eilers et al. 2010).

Current abundance data is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable, as redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

Coleman National Fish Hatchery (Coleman) operates a weir on Battle Creek, where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the Central Valley DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, Coleman stopped transferring all adipose-fin clipped steelhead above the weir, resulting in a large decrease in the overall numbers of steelhead above the weir in recent years. In addition, in 2003, Coleman transferred about 1,000 clipped adult steelhead to Keswick Reservoir, and these fish are not included in the data. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

Prior to 2002, hatchery and natural-origin steelhead in Battle Creek were not differentiable, and all steelhead were managed as a single, homogeneous stock, although USFWS believes the majority of returning fish in years prior to 2002 were hatchery-origin. Abundance estimates of natural-origin steelhead in Battle Creek began in 2001. These estimates of steelhead abundance include all *O. mykiss*, including resident and anadromous fish (Figure 1).

Steelhead returns to Coleman NFH have increased over the last four years. After hitting a low of only 790 fish in 2010, the last two years have averaged 2,895 fish (Figure 2). Since 2003, adults returning to the hatchery have been classified as wild (intact adipose) or hatchery produced (adipose fin clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relative steady, typically 200-300 fish each year. Numbers of wild adults returning each year have ranged from 252 to 610 from 2010 to 2014 (Figure 2).

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 143 redds have been counted on the American River from 2002-2015 [(Figure 3; data from (Hannon *et al.* 2003, Hannon and Deason 2008, Chase 2010)]. Surveys were not conducted in some years on the American River due to high flows and low visibility. An average of 178 redds have been counted in Clear Creek from 2001 to 2015 (Figure 4; data from USFWS). The Clear Creek steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USFWS has steadily increased since 2001 (Figure 4). The average redd index from 2001 to 2011 is 178, representing a range of approximately 100-1023 spawning adult steelhead on average each year, based on an approximate observed adult-to-redd ratio in Clear Creek (U.S. Fish and Wildlife Service 2015). The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek.

The East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season, and the overall trend is a slight increase. However, it is generally believed that most of the *O. mykiss* spawning in the Mokelumne River are resident fish (Satterthwaite *et al.* 2010b), which are not part of the CCV steelhead DPS. In the most recent 5-year status review, NMFS upheld its decision not to include this population in the DPS (National Marine Fisheries Service 2016c).

The returns of steelhead to the Feather River Hatchery experienced a sharp decrease from 2003 to 2010, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure 5). In recent years, however, returns have experienced an increase with 830, 1797, and 1505 fish returning in 2012, 2013 and 2014 respectively. Almost all these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for age classes that showed poor returns in the late 2000s.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the proportion of wild steelhead relative to hatchery steelhead (CDFG; ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead at these facilities has been highly variable since 1993 (Figure 5). Variability in catch is likely due to differences in water year types as Delta exports fluctuate. The percentage of wild origin steelhead in salvage has also fluctuated, but has generally declined since 100 percent clipping started in 1998. The number of hatchery origin steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

The years 2009 and 2010 showed poor returns of steelhead to the Feather River Hatchery and Coleman Hatchery, probably due to three consecutive drought years in 2007-2009, which would have impacted parr and smolt growth and survival in the rivers, and possibly due to poor coastal upwelling conditions in 2005 and 2006, which strongly impacted fall-run Chinook salmon post-smolt survival (Lindley *et al.* 2009b). Wild origin (intact adipose) adult counts appear not to have decreased as greatly in those same years, based on returns to the hatcheries and redd counts conducted on Clear Creek, and the American and Mokelumne rivers. This may reflect greater fitness of naturally produced steelhead relative to hatchery fish, and certainly merits further study.

Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2015 that no clear trend is present, other than the facts that the numbers are still far below those seen in the 1960s and 1970s, and only a tiny fraction of the historical estimate. Returns of natural origin fish are very poorly monitored, but the little data available suggest that the numbers are very small, though perhaps not as variable from year to year as the hatchery returns.

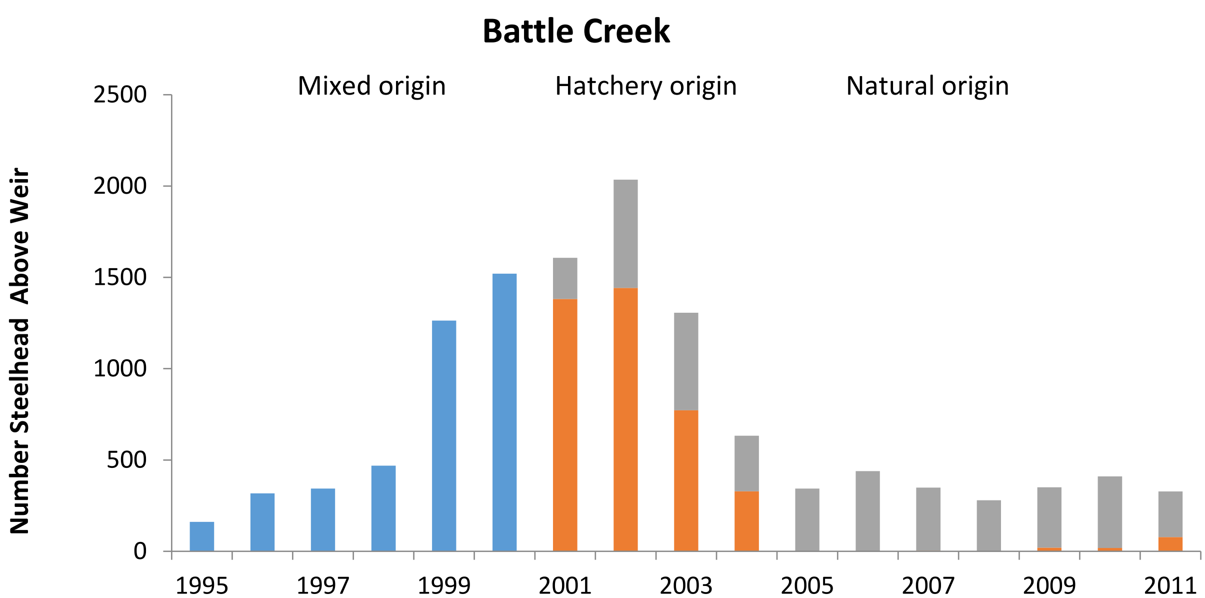



**Figure 1.** Steelhead returns to Battle Creek from 1995-2009
Starting in 2001, O. mykiss were classified as either wild (intact adipose) or hatchery produced (adipose clipped). Includes fish passed above the weir during broodstock collection and fish passing through the fish ladder March 1 to August 31. Data are from USFWS.

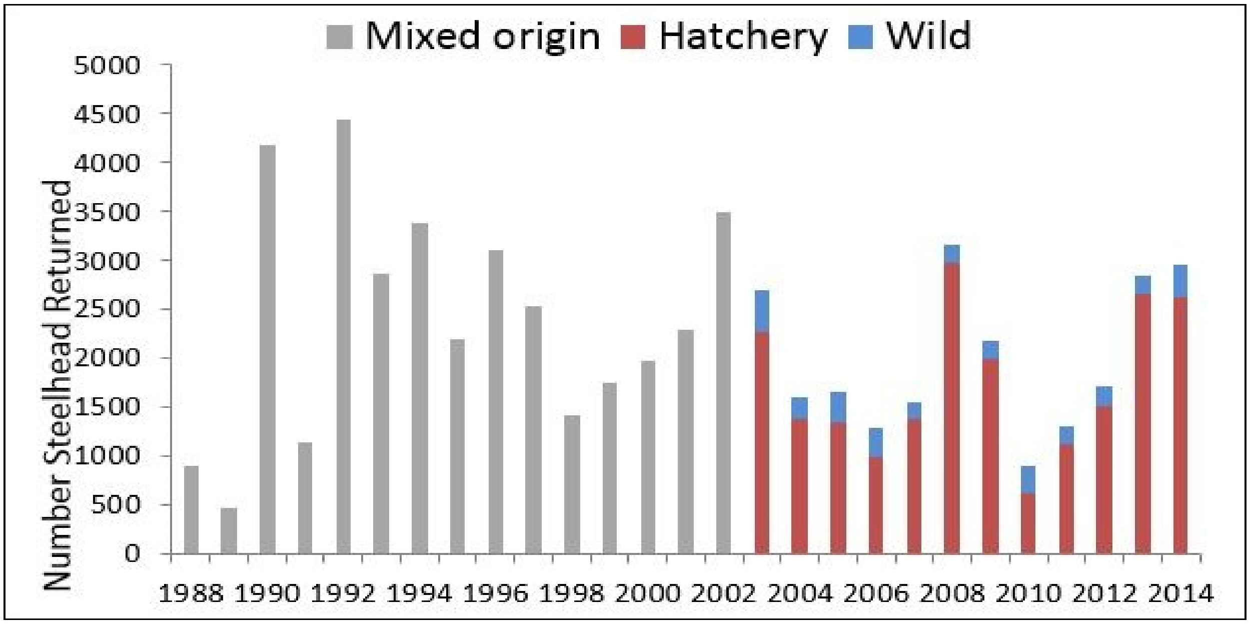



**Figure 2.** Steelhead returns to Coleman NFH from 1988-2014.
*Starting in 2001, fish were classified as either wild (unclipped) or hatchery produced (clipped).*

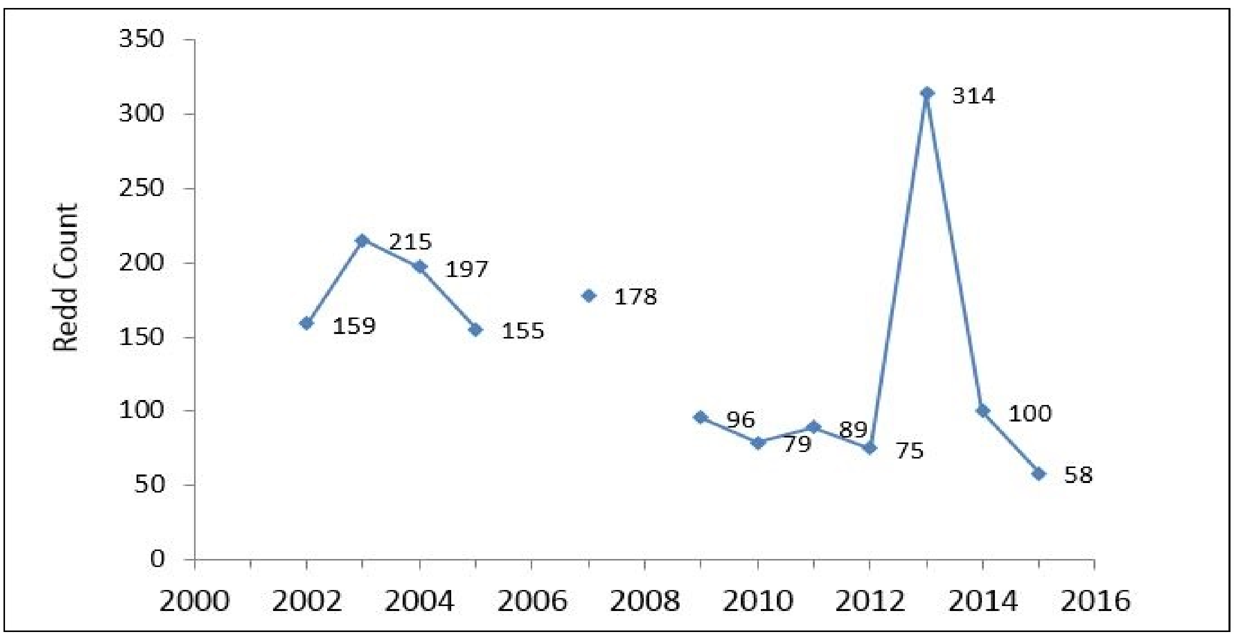



**Figure 3**. Steelhead redd counts from surveys on the American River from 2002-2015.
*Surveys could not be conducted in some years due to high flows and low visibility.*

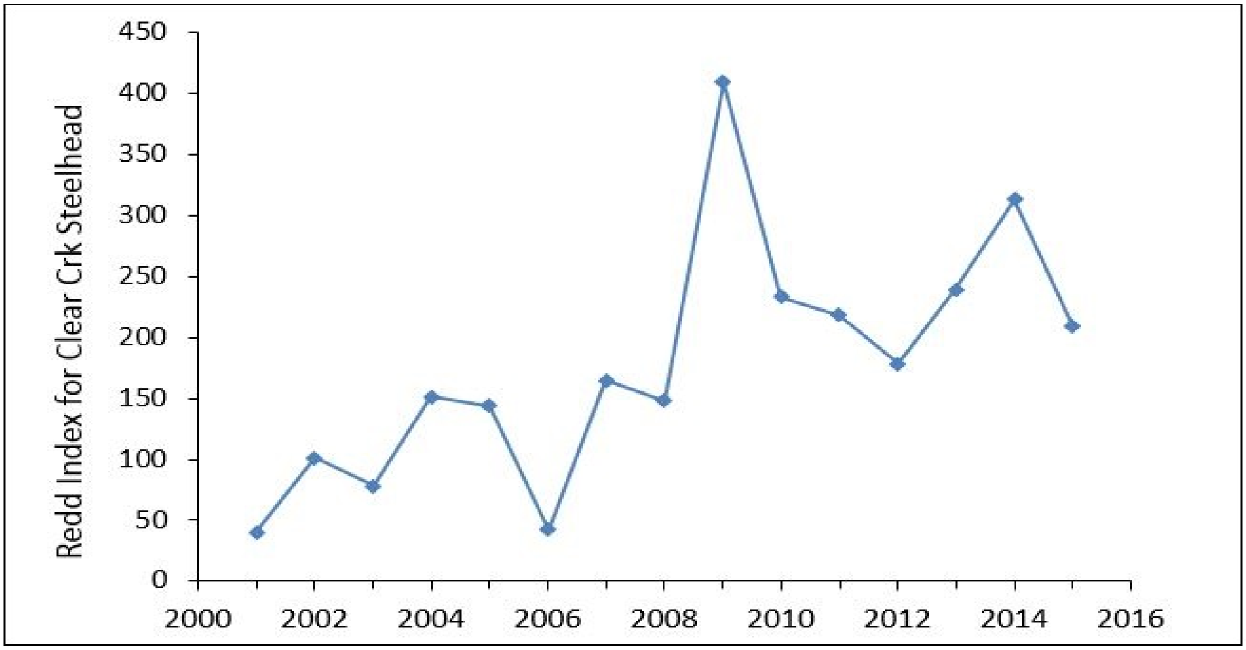



**Figure 4.** Redd counts from USFWS surveys on Clear Creek from 2001-2015.

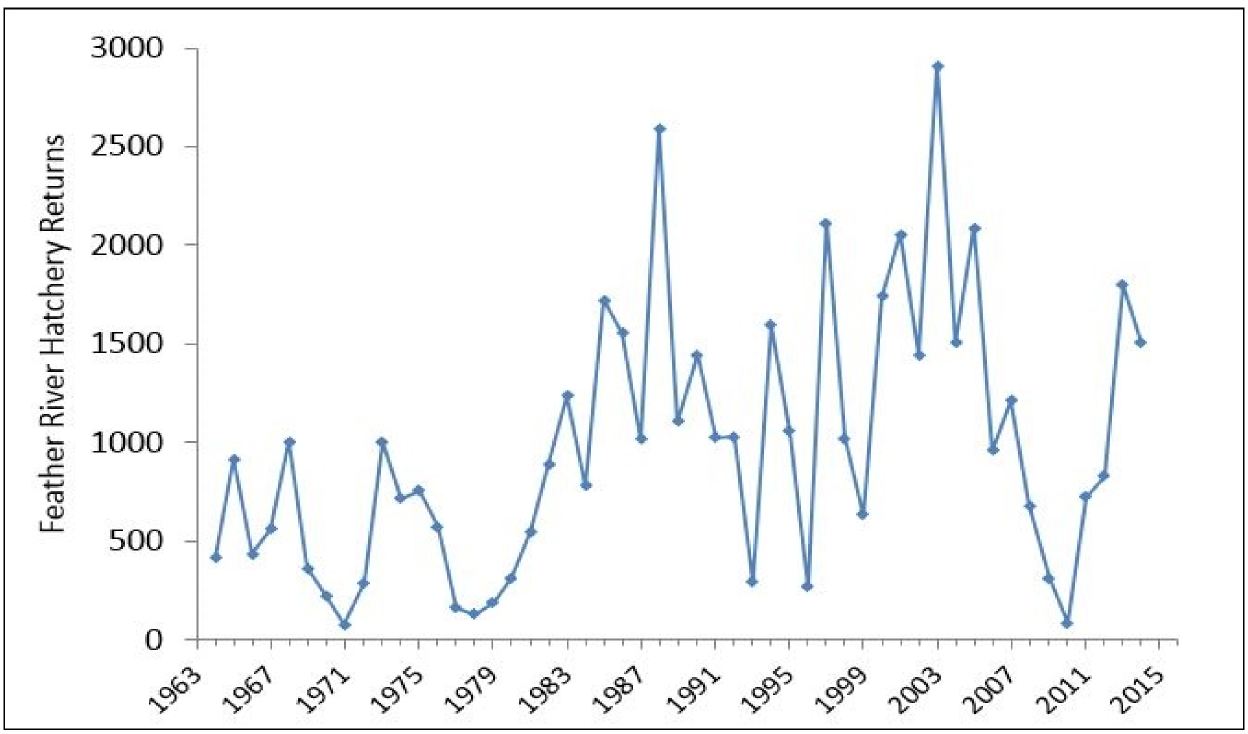



**Figure 5**. Steelhead returns to the Feather River Hatchery from 1964-2015.

2. Productivity

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are expected to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). The Mossdale trawls on the SJR conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams et al. 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Good et al. (2005) made the following conclusion based on the Chipps Island data:

> *"If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".*

The Chipps Island midwater trawl dataset maintained by the USFWS provides information on the trend in abundance for the CCV steelhead DPS as a whole. Updated through 2014, the trawl data indicate that the level of natural production of steelhead has remained very low since the 2011 status review (Figure 6). Catch per unit effort (CPUE) has fluctuated but remained level over the past decade, but the proportion of the catch that is adipose-clipped (100% of hatchery steelhead production have been adipose fin-clipped starting in 1998) has risen, exceeding 90 percent in some years and reaching a high of 95 percent in 2010 (Williams *et al.* 2011a). Because hatchery releases have been fairly constant, this implies that natural production of juvenile steelhead has been declining in the Central Valley.

The top of Figure 6 shows the catch of steelhead at Chipps Island by the USFWS midwater trawl survey. The middle section shows the fraction of the catch bearing an adipose fin clip. 100 percent of steelhead production has been marked starting in 1998, denoted with the vertical gray line. The bottom section shows CPUE in fish per million m-3 swept volume. CPUE is not easily comparable across the entire period of record, as over time, sampling has occurred over more of the year and catches of juvenile steelhead are expected to be low outside of the primary migratory season.

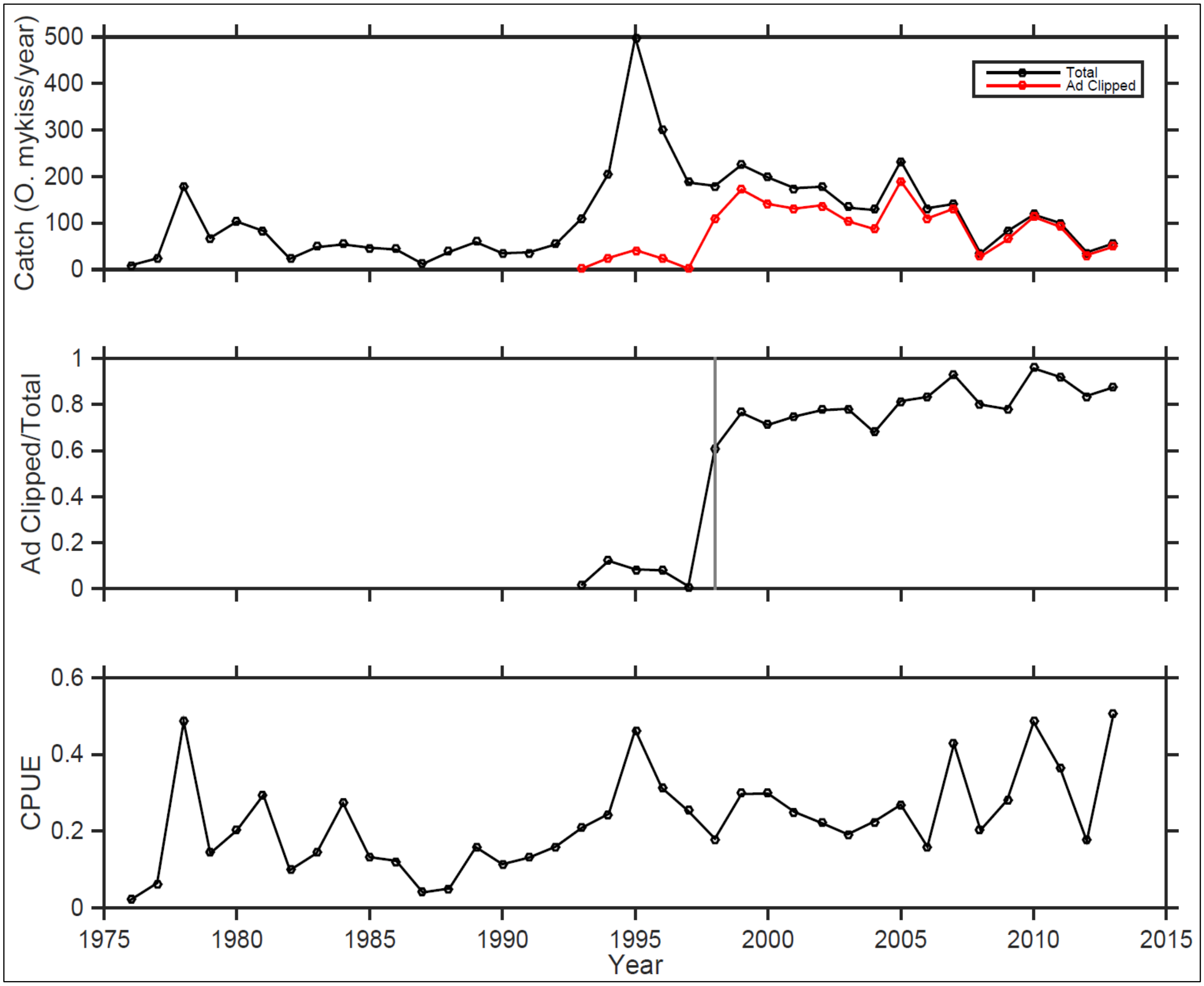



**Figure 6**. Steelhead Catch at Chipps Island midwater trawl.

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to Satterthwaite et al. (2010), it is likely that most of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production. In the past, this hatchery received fish imported from the Feather River and Nimbus hatcheries (Merz 2002). However, this practice was discontinued for Nimbus stock after 1991, and discontinued for Feather River stock after 2008. Recent genetic studies show that the Mokelumne River Hatchery steelhead are closely related to Feather River fish, suggesting that there has been little carry-over of genes from the Nimbus stock.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the production of wild steelhead relative to hatchery steelhead (ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead has declined dramatically since the early 2000s, with an overall average of 2,705 in the last 10 years, as measured by expanded salvage (Figure 7). The percentage of wild fish in salvage has fluctuated, but has leveled off to an average of 36 percent since a high of 93 percent in 1999. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated. This relatively constant hatchery production, coupled with the dramatic decline in hatchery-origin steelhead catch at the south Delta fish collection facilities suggests that either stocked hatchery fish from the Sacramento basin are using a more natural outmigration path and not being pulled into the south Delta fish facilities or the immediate survival of those stocked fish has decreased. With respect to wild steelhead, the data shown in figure 7 indicate that over the last few years, fewer adults are spawning (fewer eggs deposited), survival of early life stages has decreased, and/or wild steelhead are experiencing reduced exposure to the south Delta fish facilities.

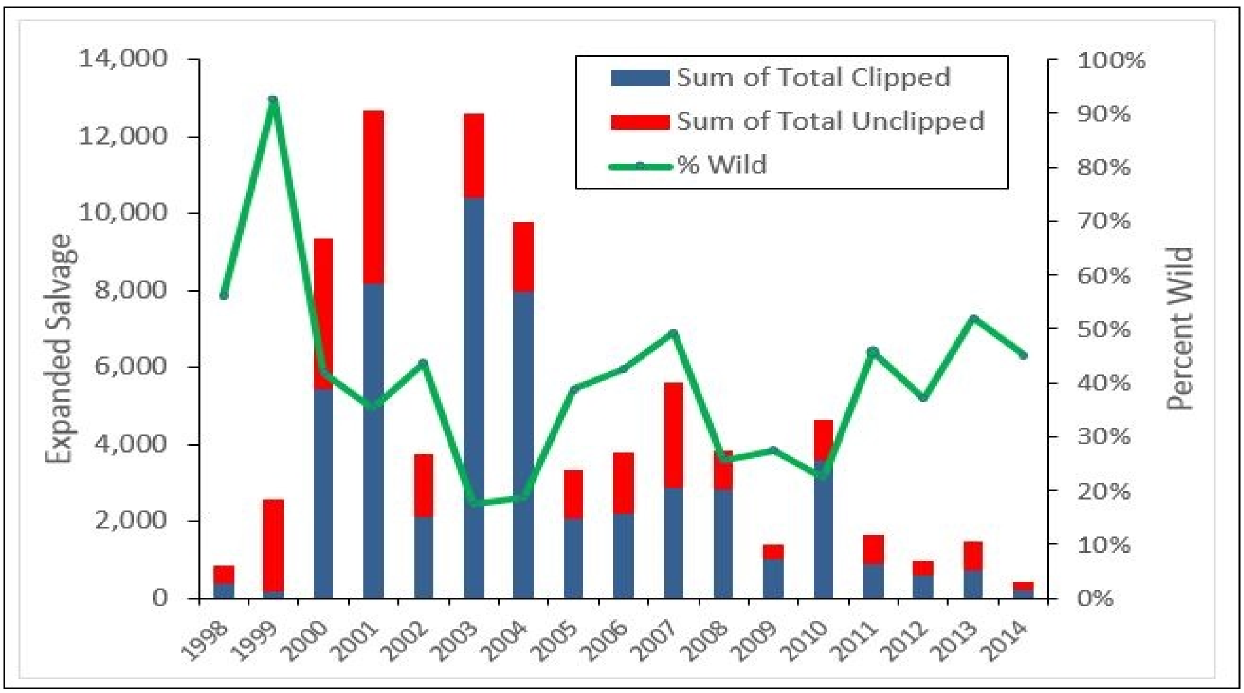



**Figure 7**. Steelhead salvaged in the Delta fish collection facilities from 1993 to 2014. *All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFW, at: ftp.delta.dfg.ca.gov/salvage.*

Since 2003, fish returning to the Coleman National Fish Hatchery have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely; ranging from 624 to 2,968 fish per year.

3. Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). The extent of habitat loss for CCV steelhead most likely was much higher than that for salmon because CCV steelhead were more extensively distributed (Lindley *et al.* 2006). Due to their superior jumping ability, the timing of their upstream migration which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, CCV steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama et al. 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. CCV steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of CCV steelhead in the Tulare Basin (Latta 1977).

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005a, National Marine Fisheries Service 2016c). Zimmerman *et al.* (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major SJR tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer & Associates 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon; these weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FISHBIO LLC 2012, FISHBIO 2013a). Also, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO 2013b). Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012, when a total of 381 were caught (FISHBIO LLC 2013). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24-hour period. Annual Kodiak trawl surveys are conducted on the SJR at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (California Department of Fish and Wildlife 2013).

Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adult intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River. This is confounded, of course, by the fact that most of the dedicated monitoring programs in the Central Valley occur on rivers that are annually stocked. Clear Creek and Mill Creek are the exceptions.

Implementation of CDFW's Steelhead Monitoring Program began in the Sacramento River Basin during the fall of 2015. Important components of the program include a mainstem Sacramento River Steelhead Mark-Recapture Program and an Upper Sacramento River Basin Adult Steelhead Video/DIDSON Monitoring Program. The monitoring program would use a temporally stratified mark-recapture survey design in the lower Sacramento River, employing wire fyke traps to capture, mark, and recapture upstream migrating adult steelhead to estimate adult steelhead escapement from the Sacramento-SJR Delta. Data collected from recaptured adult steelhead would provide additional information on tributary escapement, survival, population structure, population distribution, and spatial and temporal behavior of both hatchery- and natural-origin steelhead.

The low adult returns to the SJR tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of CCV steelhead populations if the passage programs are implemented for steelhead. In addition, the SJRRP calls for a combination of channel and structural modifications along the SJR below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2016a).

4. Diversity

*a. Genetic Diversity:* CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen et al. 2003). Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extinction (Lindley et al. 2007). There are four hatcheries (Coleman National Fish Hatchery, Feather River Fish Hatchery, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling CCV steelhead smolts each year. These programs are intended to mitigate for the loss of CCV steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS.

*b. Life-History Diversity*: CCV steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning.

Between 1944 and 1947, annual counts of summer-run CCV steelhead passing through the Old Folsom Dam fish ladder during May, June, and July ranged from 400 to 1,246 fish. After 1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run CCV steelhead were no longer able to access their historic spawning areas, and perished in the warm water downstream of Old Folsom Dam (Gerstung 1971).

Only winter-run (ocean maturing) CCV steelhead currently are found in California Central Valley rivers and streams (Moyle 2002; McEwan and Jackson 1996). Summer-run CCV steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CV streams, presently located above impassible dams (Lindley et al. 2006).

Juvenile CCV steelhead (parr) rear in freshwater for one to three years before migrating to the ocean as smolts (Moyle 2002). The time that parr spend in freshwater is inversely related to their growth rate, with faster-growing members of a cohort smolting at an earlier age but a smaller size (Peven et al. 1994, Seelbach 1993). Hallock et al. (1961) aged 100 adult CCV steelhead caught in the Sacramento River upstream of the Feather River confluence in 1954, and found that 70 had smolted at age-2, 29 at age-1, and one at age-3. Seventeen of the adults were repeat spawners, with three fish on their third spawning migration, and one on its fifth. Age at first maturity varies among populations. In the Central Valley, most CCV steelhead return to their natal streams as adults at a total age of two to four years (Hallock et al. 1961, McEwan and Jackson 1996).

Deer and Mill creeks were monitored from 1994 to 2010 by the CDFW using rotary screw traps to capture emigrating juvenile CCV steelhead (Johnson and Merrick 2012). Fish in the fry stage averaged 34 and 41 mm FL in Deer and Mill, respectively, while those in the parr stage averaged 115 mm FL in both streams. Silvery parr averaged 180 and 181 mm in Deer and Mill creeks, while smolts averaged 210 mm and 204 mm. Most silvery parr and smolts were caught in the spring months from March through May, while fry and parr peaked later in the spring (May and June) and were fairly common in the fall (October through December) as well.

In contrast to the upper Sacramento River tributaries, Lower American River juvenile CCV steelhead have been shown to smolt at a very large size (270 to 350 mm FL), and nearly all smolt at age-1 (Sogard *et al.* 2012).

5. Summary of ESU Viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005a, National Marine Fisheries Service 2016c); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock.

The ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance has remained at a relatively steady state since the 2011 status review and remains much lower than percentages observed in previous decades. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past decade.

Although there have been recent restoration efforts in the SJR tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance, and fluctuating return rates. Lindley *et al.* (2007a) developed viability criteria for Central Valley salmonids. Using data through 2005, Lindley *et al.* (2007a) found that data were insufficient to determine the status of any of the naturally-spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown because very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

The most recent status review of the CCV steelhead DPS (National Marine Fisheries Service 2016c) found that the status of the population appears to have remained unchanged since the 2011 status review (Good *et al.* 2005a), when it was considered to be in danger of extinction.

### 2.2.2 Central Valley spring-run Chinook Salmon Evolutionarily Significant Unit (ESU)

### A. Species Listing

CV spring-run Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of CV spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent CV spring-run Chinook salmon listing decision (70 FR 37160, June 28, 2005). Although FRFH spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibition if they are adipose fin clipped.

In April 2016, NMFS completed an updated status review of five Pacific Salmon ESUs, including CV spring-run Chinook salmon (National Marine Fisheries Service 2016b), and concluded that the species' status should remain as previously listed.

A final rule was published to designate a nonessential experimental population of CV spring-run Chinook salmon to allow reintroduction of the species between Friant Dam and the confluence with the Merced River on the SJR as part of the SJRRP (78 FR 251; December 31, 2013). Pursuant to ESA section 10(j), for the purpose of this conferencing opinion, the experimental population shall be treated as a candidate species. However, the rule includes proposed protective regulations under ESA section 4(d) that would provide specific exceptions to prohibitions under ESA section 9 for taking CV spring-run Chinook salmon within the experimental population area, and in specific instances elsewhere.

## B. Life History

### 1. Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (California Department of Fish and Game 1998b) and enter the Sacramento River beginning in March (Yoshiyama *et al.* 1998). CV spring-run Chinook salmon move into tributaries of the Sacramento River (*e.g*., Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley *et al.* 2004). Adult migration peaks around mid-April in Butte Creek, and mid- to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley et al. 2004, see Table 3 in text). Typically, CV spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 3ºC (38ºF) to 13ºC (56ºF) (Bell 1991, California Department of Fish and Game 1998c). Boles *et al.* (1988) recommends water temperatures below 18ºC (65ºF) for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 21ºC (70ºF), and that fish can become stressed as temperatures approach 21ºC (70ºF). Reclamation reports that CV spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 15.6 ºC (60ºF); although salmon can tolerate temperatures up to 18 ºC (65ºF) before they experience an increased susceptibility to disease (Williams 2006a).

2. Adult Spawning

CV spring-run Chinook salmon spawning occurs in September and October (Moyle 2002). Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998), but primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult CV spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994); CV spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

CV spring-run Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (U.S. Fish and Wildlife Service 1995, National Marine Fisheries Service 2007). Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Velocity typically ranging from1.2 feet/second to 3.5 feet/second, and water depths greater than 0.5 feet (Yuba County Water Agency *et al.* 2007). The upper preferred water temperature for spawning Chinook salmon is 13 ºC to 14 ºC (55ºF to 57ºF) (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, California Department of Fish and Game 2001). Chinook salmon are semelparous (die after spawning).

3. Eggs and Fry Incubation to Emergence

The CV spring-run Chinook salmon embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sac prior to emergence. A compilation of data from multiple surveys has shown that Chinook salmon prefer a range of substrate sizes between approximately 22mm and 48mm (Kondolf and Wolman 1993). The length of time for CV spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated intergravel environs where water temperatures range from about 5 to 13ºC (41 to 55.4ºF) embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (National Marine Fisheries Service 2014). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002). Incubating eggs require sufficient concentrations of dissolved oxygen. Coble (1961) noted that a positive correlation exists between dissolved oxygen (DO) levels and flow within redd gravel, and Geist *et al.* (2006) observed an emergence delay of 6-10 days at 4 mg/L DO relative to water with complete oxygen saturation.

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel permeability, and poor water quality. Studies of Chinook salmon egg survival to emergence conducted by Shelton (1955) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 5 ºC to 14 ºC (41ºF to 56ºF) (National Marine Fisheries Service 1997, Rich 1997, Moyle 2002). A significant reduction in egg viability occurs at water temperatures above 14 ºC (57.5ºF) and total embryo mortality can occur at temperatures above

17 ºC (62ºF) (National Marine Fisheries Service 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 16ºC and 3ºC (61ºF and 37ºF), respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in the redd. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The newly emerged fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 millimeters (mm) to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others migrate downstream to suitable habitat. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

4. Juvenile Rearing and Outmigration

Once juveniles emerge from the gravel, they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also would disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstem of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 feet to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of development (Kjelson *et al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. The daily migration of juveniles passing RBDD is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found that Chinook salmon fry travel as fast as 30 km per day in the Sacramento River. As Chinook salmon begin the smolt stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

CV spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year, or as juveniles, or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). Studies in Butte Creek (Ward *et al.* 2003, McReynolds *et al.* 2007) found the majority of CV spring-run Chinook salmon migrants to be fry, which emigrated primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of CV spring-run Chinook salmon were observed to remain in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). The California Department of Fish and Game (1998a) observed the emigration period for CV spring-run Chinook salmon extending from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000). More recently there have been reports of adult Chinook salmon returning in February through June to SJR tributaries, including the Mokelumne, Stanislaus, and Tuolumne rivers (Workman 2003; Franks 2012; Guignard 2015). These spring-running adults have been observed in several years and exhibit typical spring-run life-history characteristics, such as returning to tributaries during the springtime, over-summering in deep pools, and spawning in early fall (Workman 2003; Franks 2011; Guignard 2015). Likewise, juveniles expressing atypical fall-run outmigration behavior, more characteristic of spring-run (e.g., yearlings) have also been observed on the Mokelumne, Tuolomne, and Stanislaus rivers (Fuller 2008; Watry et al. 2012; Bilski et al. 2013). It is possible that the progeny of adult spring-run Chinook salmon stray from the Sacramento River basin into the SJR tributaries and represent the early stages of recolonization into the SJR basin (Fuller 2008; Watry et al. 2012; Bilski et al. 2013).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin et al. 1997, CDFG 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 12ºC to 14 ºC (54ºF to 57ºF) (Brett 1952).

5. Estuarine Rearing

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Levings et al. 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean.

6. Ocean Rearing

Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California Current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Moyle 2002, Lindley *et al.* 2009a). After entering the ocean, juveniles become voracious predators on small fish and crustaceans, and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic fishes are most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The Ocean stage of the Chinook life cycle lasts one to five years. Information on salmon abundance and distribution in the ocean is based upon CWT recoveries from ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One extremely important assumption of this approach is that hatchery and natural stock components are assumed to be similar in their life histories and ocean migration patterns.

Ocean harvest of CV Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of CV Chinook salmon are caught) to escapement (adult spawner populations that have “escaped” the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River Chinook salmon congregate off the California coast between Point Arena and Morro Bay.

**Table 3.** The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

| (a) Adult migration | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | |
| Sac. River basin[a,b] | | | | | M | M | M | M | H | H | H | H | M | M | M | M | M | M | L | | | | | |
| Sac. River Mainstem[b,c] | | L | L | L | M | M | M | M | M | M | M | M | M | M | L | L | | | | | | | | |
| Mill Creek[d] | | | | | L | L | M | H | H | H | H | M | M | L | L | | | | | | | | | |
| Deer Creek[d] | | | | | L | L | M | H | H | H | H | M | M | | | | | | | | | | | |
| Butte Creek[d,g] | | | L | M | M | M | M | H | H | H | H | M | L | | | | | | | | | | | |
| (b) Adult Holding[a,b] | | | | L | L | M | M | H | H | H | H | H | H | H | H | M | M | L | L | | | | | |
| (c) Adult Spawning[a,b,c] | | | | | | | | | | | | | | | L | M | H | H | M | L | | | | |
| (d) Juvenile migration | | | | | | | | | | | | | | | | | | | | | | | | |
| Location | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | |
| Sac. River Tribs[e] | M | M | M | M | M | M | | | | | | | | | | | | | M | M | H | H | H | H |
| Upper Butte Creek[f,g] | H | H | H | H | M | M | M | M | M | M | L | L | | | | | | | L | L | L | L | H | H |
| Mill, Deer, Butte Creeks[d,g] | H | H | H | H | M | M | M | M | M | M | L | L | | | | | | | L | L | L | L | L | L |
| Sac. River at RBDD[c] | H | H | L | L | L | L | L | L | L | | | | | | | | | | | | H | H | H | H |
| Sac. River at KL[h] | M | M | M | M | H | H | H | H | M | M | | | | | | | | | | | M | M | H | H |

Relative Abundance: H = High; M = Medium; L = Low

*Sources: [a]Yoshiyama et al. (1998); [b]Moyle (2002); [c]Myers et al. (1998); [d]Lindley et al. (2004); [e]CDFG (1998);[f]McReynolds et al. (2007); [g]Ward et al. (2003); [h]Snider and Titus (2000)*

*Note: Yearling CV spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year CV spring-run Chinook salmon emigrate during the first spring after they hatch.*

## C. Description of Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the CV spring-run Chinook salmon ESU, and determine the extinction risk of the ESU, NMFS uses the VSP concept. In this section, we evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany et al. 2000).

1. Abundance

Historically spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (California Department of Fish and Game 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929).

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (California Department of Fish and Game 1998a). The SJR historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000–500,000 adults returning annually (California Department of Fish and Game 1990). Construction of Friant Dam on the SJR began in 1939 and when completed in 1942 blocked access to all upstream habitat. This population persisted until the Madera and Friant-Kern Canals were brought on line, several years later.

The FRFH spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population and the potential development of a conservation strategy for the hatchery program. On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 (California Department of Water Resources 2001). However, after 1981, CDFG (now CDFW, California Department of Fish and Wildlife) ceased to estimate in-river spawning spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. Spring-run Chinook salmon estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages have declined each year to a low of 1,742 fish in 2011, and 2012 through 2015 were back up slightly to just over 2,000 fish [(California Department of Fish and Wildlife 2016); Table 4].

Genetic testing has indicated that substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (California Department of Water Resources 2001). Because Chinook salmon have not always been spatially separated in the FRFH, spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock (Good *et al.* 2005a, Cavallo *et al.* 2011).

In addition, coded-wire tag (CWT) information from these hatchery returns has indicated that fall-run and spring-run Chinook salmon have overlapped (California Department of Water Resources 2001). For the reasons discussed above, the FRFH spring-run Chinook salmon numbers are not included in the following discussion of ESU abundance trends.

Monitoring the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates that some spawning occurs in the river. The lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem very difficult, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run Chinook salmon abundance. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (The Energy Planning and Instream Flow Branch 2003).

Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; 2012 observed zero redds, and 2013, 57 redds in September (CDFG, unpublished data, 2014).

Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (California Department of Fish and Game 1998a). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance. All tributaries combined are shown in Table 4, which are dominated by returns in Mill, Deer and Butte creek. Combined tributary returns from 1988 to 2015 have ranged from 1,013 in 1993 to 23,787 in 1998 (Table 4). Escapement numbers are dominated by Butte Creek returns (Good *et al.* 2005a), which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000 fish. During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remained well below estimates of historic abundance.

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C for 10 or more days in July (Williams 2006a). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of *Columnaris* (*Flexibacter columnaris*) and *Ichthyophthiriasis* (*Ichthyophthirius multifiis*) diseases in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek due to the diseases. In 2015, Butte Creek again experienced severe temperature conditions, with nearly 2,000 fish entering the creek, only 1,081 observed during the snorkel survey, and only 413 carcasses observed, which indicates a large number of pre-spawn mortality.

Declines in abundance from 2005 to 2016 placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (National Marine Fisheries Service 2016b). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2017 was nearly sufficient to classify it as a high extinction risk based on this criterion. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include Butte, Deer, and Mill creeks (National Marine Fisheries Service 2016b). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek, have seen population gains in the years from 2001 to 2014, but the overall abundance numbers have remained low. 2012 was a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799) and Butte Creek with an escapement of 17,000. Additionally, 2013 escapement numbers increased, in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 appears to be lower, just over 5,000 fish for the tributaries combined, which indicates a highly fluctuating and unstable ESU abundance. Even more concerning were returns for 2015, which were record lows for some populations. Snorkel surveys of Butte Creek returning adults remain low currently, and are down from 4,450 (2016) to just 982 in 2017 (Azat 2018).

2. <u>Productivity</u>

The productivity of a population (*i.e.,* production over the entire life cycle) can reflect conditions (*e.g.,* environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000). In general, declining productivity equates to declining population abundance. McElhany *et al.* (2000) suggested criteria for a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). In the absence of numeric abundance targets, this guideline is used. Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation. CRR's for CV spring-run Chinook salmon from 1986 to 2015 are detailed below (Table 4).

From 1993 to 2007 the 5-year moving average of the tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011. The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown. However, the FRFH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive (1.85). However, 2015 returns were very low, with a CRR of 0.14, when using Butte Creek snorkel survey numbers, the lowest on record. Using the Butte Creek carcass surveys, the 2015 CRR for just Butte Creek was only 0.02. CRR's for 2016 and 2017 were 0.28 and 0.20, respectively, based on snorkel CDFW survey data (Azat 2018).

**Table 4.** Central Valley Spring-run Chinook salmon population estimates from CDFW Grand Tab (2015) with corresponding cohort replacement rates for years since 1986.

| Year | Sacramento River Basin Escapement Run Size[a] | FRFH Population | Tributary Populations | 5-Year Moving Average Tributary Population Estimate | Trib CRR[b] | 5-Year Moving Average of Trib CRR | 5-Year Moving Average of Basin Population Estimate | Basin CRR | 5-Year Moving Average of Basin CRR |
|---|---|---|---|---|---|---|---|---|---|
| **1986** | 3,638 | 1,433 | 2,205 | | | | | | |
| **1987** | 1,517 | 1,213 | 304 | | | | | | |
| **1988** | 9,066 | 6,833 | 2,233 | | | | | | |
| **1989** | 7,032 | 5,078 | 1,954 | | 0.89 | | | 1.93 | |
| **1990** | 3,485 | 1,893 | 1,592 | 1,658 | 5.24 | | 4,948 | 2.30 | |
| **1991** | 5,101 | 4,303 | 798 | 1,376 | 0.36 | | 5,240 | 0.56 | |
| **1992** | 2,673 | 1,497 | 1,176 | 1,551 | 0.60 | | 5,471 | 0.38 | |
| **1993** | 5,685 | 4,672 | 1,013 | 1,307 | 0.64 | 1.55 | 4,795 | 1.63 | 1.22 |
| **1994** | 5,325 | 3,641 | 1,684 | 1,253 | 2.11 | 1.79 | 4,454 | 1.04 | 1.18 |
| **1995** | 14,812 | 5,414 | 9,398 | 2,814 | 7.99 | 2.34 | 6,719 | 5.54 | 1.83 |
| **1996** | 8,705 | 6,381 | 2,324 | 3,119 | 2.29 | 2.73 | 7,440 | 1.53 | 2.03 |
| **1997** | 5,065 | 3,653 | 1,412 | 3,166 | 0.84 | 2.77 | 7,918 | 0.95 | 2.14 |
| **1998** | 30,533 | 6,746 | 23,787 | 7,721 | 2.53 | 3.15 | 12,888 | 2.06 | 2.23 |
| **1999** | 9,838 | 3,731 | 6,107 | 8,606 | 2.63 | 3.26 | 13,791 | 1.13 | 2.24 |
| **2000** | 9,201 | 3,657 | 5,544 | 7,835 | 3.93 | 2.44 | 12,669 | 1.82 | 1.50 |
| **2001** | 16,865 | 4,135 | 12,730 | 9,916 | 0.54 | 2.09 | 14,300 | 0.55 | 1.30 |
| **2002** | 17,212 | 4,189 | 13,023 | 12,238 | 2.13 | 2.35 | 16,730 | 1.75 | 1.46 |
| **2003** | 17,691 | 8,662 | 9,029 | 9,287 | 1.63 | 2.17 | 14,161 | 1.92 | 1.43 |
| **2004** | 13,612 | 4,212 | 9,400 | 9,945 | 0.74 | 1.79 | 14,916 | 0.81 | 1.37 |
| **2005** | 16,096 | 1,774 | 14,322 | 11,701 | 1.10 | 1.23 | 16,295 | 0.94 | 1.19 |
| **2006** | 10,828 | 2,061 | 8,767 | 10,908 | 0.97 | 1.31 | 15,088 | 0.61 | 1.21 |
| **2007** | 9,726 | 2,674 | 7,052 | 9,714 | 0.75 | 1.04 | 13,591 | 0.71 | 1.00 |
| **2008** | 6,162 | 1,418 | 4,744 | 8,857 | 0.33 | 0.78 | 11,285 | 0.38 | 0.69 |
| **2009** | 3,801 | 989 | 2,812 | 7,539 | 0.32 | 0.69 | 9,323 | 0.35 | 0.60 |
| **2010** | 3,792 | 1,661 | 2,131 | 5,101 | 0.30 | 0.53 | 6,862 | 0.39 | 0.49 |
| **2011** | 5,033 | 1,969 | 3,064 | 3,961 | 0.65 | 0.47 | 5,703 | 0.82 | 0.53 |
| **2012** | 14,724 | 3,738 | 10,986 | 4,747 | 3.91 | 1.10 | 6,702 | 3.87 | 1.16 |
| **2013** | 18,384 | 4,294 | 14,090 | 6,617 | 6.61 | 2.36 | 9,147 | 4.85 | 2.06 |
| **2014** | 8,434 | 2,776 | 5,658 | 7,186 | 1.85 | 2.66 | 10,073 | 1.68 | 2.32 |
| **2015** | 3,074 | 1,586 | 1,488 | 7,057 | 0.14 | 2.63 | 9,930 | 0.21 | 2.28 |
| **Median** | 9,775 | 3,616 | 6,159 | 6,541 | 1.97 | 1.89 | 10,220 | 1.00 | 1.46 |

[a] *NMFS is only including the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.*
[b] *Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary*

3. Spatial Structure

Spatial structure refers to the arrangement of populations across the landscape, the distribution of spawners within a population, and the processes that produce these patterns. Species with a restricted spatial distribution and few spawning areas are at a higher risk of extinction from catastrophic environmental events (*e.g.*, a single landslide) than are species with more widespread and complex spatial structure. Species or population diversity concerns the phenotypic (morphology, behavior, and life-history traits) and genotypic (DNA) characteristics of populations. Phenotypic diversity allows more populations to use a wider array of environments and protects populations against short-term temporal and spatial environmental changes. Genotypic diversity, on the other hand, provides populations with the ability to survive long-term changes in the environment. To meet the objective of representation and redundancy, diversity groups need to contain multiple populations to survive in a dynamic ecosystem subject to unpredictable stochastic events, such as pyroclastic events or wild fires.

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Figure 8) (Lindley *et al.* 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence. Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, is thought to have extirpated CV spring-run Chinook salmon from these watersheds of the SJR, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2014).

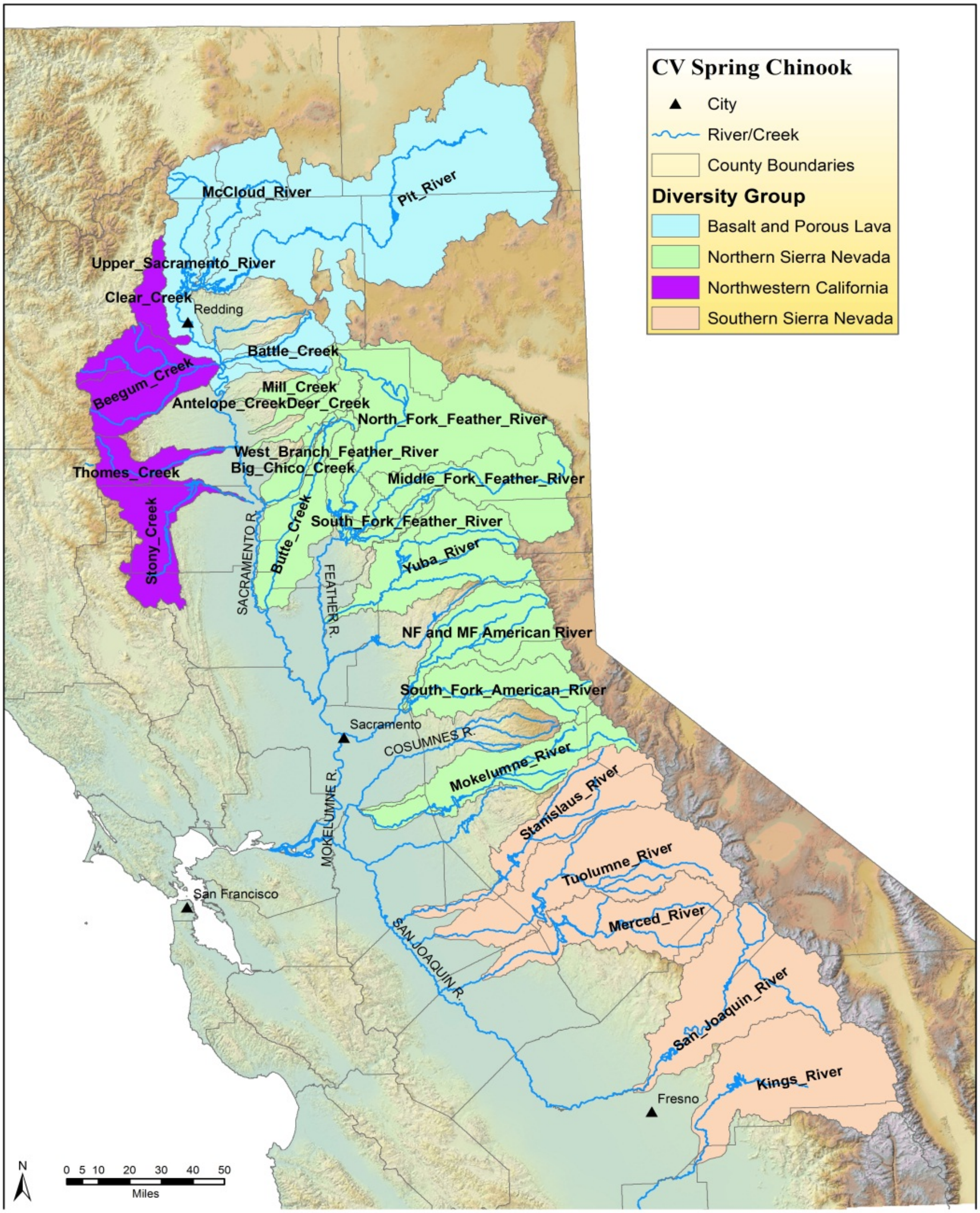



**Figure 8.** Diversity Groups for the Central Valley spring-run Chinook salmon ESU.

With only one of four diversity groups currently containing viable independent populations, the spatial structure of CV spring-run Chinook salmon is severely reduced. Butte Creek spring-run Chinook salmon adult returns are currently utilizing all available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and Battle Creek, with habitat restoration proposed actions completed and more underway, are anticipated to add to the spatial structure of the CV spring-run Chinook salmon ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the CV spring-run Chinook salmon ESU would still be lacking due to the extirpation of all SJR basin spring-run Chinook salmon populations. However, recent information suggests that perhaps a self-sustaining population of CV spring-run Chinook salmon is occurring in some of the SJR tributaries, most notably the Stanislaus and the Tuolumne rivers as described in the following section.

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December of 2003, which would indicate CV spring-run Chinook salmon spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult CV spring-run Chinook salmon (Anderson *et al.* 2007), and 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FishBio 2015). Finally, rotary screw trap (RST) data provided by Stockton U.S. Fish and Wildlife Service (USFWS) corroborates the CV spring-run Chinook salmon adult timing, by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with CV spring-run juvenile Chinook salmon emigration (Franks 2014). Although there have been observations of springtime running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams. Genetic assessment or natal stream analyses of hard tissues could inform our understanding of the relationship of these fish to the ESU.

The SJRRP has also been releasing juvenile CV spring-run Chinook into Reach 5 of the San Joaquin River Restoration area. The first release of CV spring-run Chinook salmon juveniles into the SJR occurred in April, 2014. A second release occurred in 2015, and 2016 releases included the first generation of CV spring-run Chinook salmon reared entirely in the SJR in over 60 years. Releases of juveniles have continued in 2017 and 2018, and future releases are planned to continue annually during the spring. The SJRRP's future long-term contribution to the CV spring-run Chinook salmon ESU has yet to be determined, but the 2014 NMFS Central Valley Salmon and Steelhead Recovery Plan (Recovery Plan) (NMFS 2014) specifically targets the SJR spring-run Chinook population as one of the key areas needed to recover the CV spring-run Chinook ESU.

Lindley *et al.* (2007b) described a general criteria for "representation and redundancy" of spatial structure, which was for each diversity group to have at least two viable populations. More specific recovery criteria for the spatial structure of each diversity group have been laid out in the NMFS Recovery Plan (NMFS 2014). According to the criteria, one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group, in addition to maintaining dependent populations are needed for recovery. It is clear that further efforts would need to involve more than restoration of currently accessible watersheds to make the ESU viable. The NMFS Recovery Plan also calls for reestablishing populations into other historical habitats currently blocked by large dams, such as the reintroduction of a population upstream of Shasta Dam, and to facilitate passage of fish upstream of Englebright Dam on the Yuba River (NMFS 2014).

4. Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics (including rate of gene-flow among populations). Criteria for the diversity parameter are that human-caused factors should not alter variation of traits. The more diverse these traits (or the more these traits are not restricted), the more adaptable a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany *et al.* 2000). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The CV spring-run Chinook salmon ESU is composed of two known genetic complexes. Analysis of natural and hatchery CV spring-run Chinook salmon stocks in the Central Valley indicates that the northern Sierra Nevada diversity group CV spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retains genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised. The Feather River spring-run Chinook salmon have introgressed with the Feather River fall-run Chinook salmon, and it appears that the Yuba River spring-run Chinook salmon population may have been impacted by FRFH fish straying into the Yuba River (and likely introgression with wild Yuba River fall-run has occurred). Additionally, the diversity of the CV spring-run Chinook salmon ESU has been further reduced with the loss of the majority if not all of the SJR basin spring-run Chinook salmon populations. Efforts underway like the SJRRP (to reintroduce a CV spring-run population below Friant Dam), are needed to improve the diversity of CV spring-run Chinook salmon.

5. Summary of ESU Viability

Because the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Lindley *et al.* (2007a) indicated that the spring-run Chinook salmon populations in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of spring-run Chinook salmon was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run Chinook salmon ESU failed to meet the “representation and redundancy rule” since there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them, or out of the four diversity groups as described in the NMFS Recovery Plan (NMFS 2014). Over the long term, these three remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Until 2012, the status of CV spring-run Chinook salmon ESU had deteriorated on balance since the 2005 status review and the Lindley *et al.* (2007a) assessment, with two of the three extant independent populations (Deer and Mill creeks) of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to rate of population decline. In contrast, spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams *et al.* 2011a). The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

The viability assessment of CV spring-run Chinook salmon conducted during NMFS' 2010 status review (National Marine Fisheries Service 2011), found that the biological status of the ESU had worsened since the last status review (2005) and recommend that its status be reassessed in two to three years as opposed to waiting another five years, if the decreasing trend continued and the ESU did not respond positively to improvements in environmental conditions and management actions. In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review was conducted in 2015 (National Marine Fisheries Service 2016b), which looked at promising increasing populations in 2012-2014. However, the 2015 returning fish were extremely low (1,488), with additional pre-spawn mortality reaching record lows. Because the effects of the 2012-2015 drought have not been fully realized, we anticipate at least several more years of very low returns, which may reach catastrophic rates of decline.

### 2.2.3 Climate Change

One major factor affecting the rangewide status of the threatened and endangered anadromous fish in the Central Valley, and aquatic habitat at large is climate change.

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen *et al.* 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger *et al.* 2004). Specifically, the Sacramento

River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph. The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (VanRheenen *et al.* 2004). Factors modeled by VanRheenen *et al*. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100% in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (VanRheenen *et al*. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the SJR watersheds to the south.

Projected warming is expected to affect Central Valley Chinook salmon. Because the runs are restricted to low elevations as a result of impassable rim dams, if climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon populations can persist (Williams 2006b). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951- 1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats used by naturally producing fall-run Chinook salmon are thermally acceptable. This would particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the SJR and its tributaries.

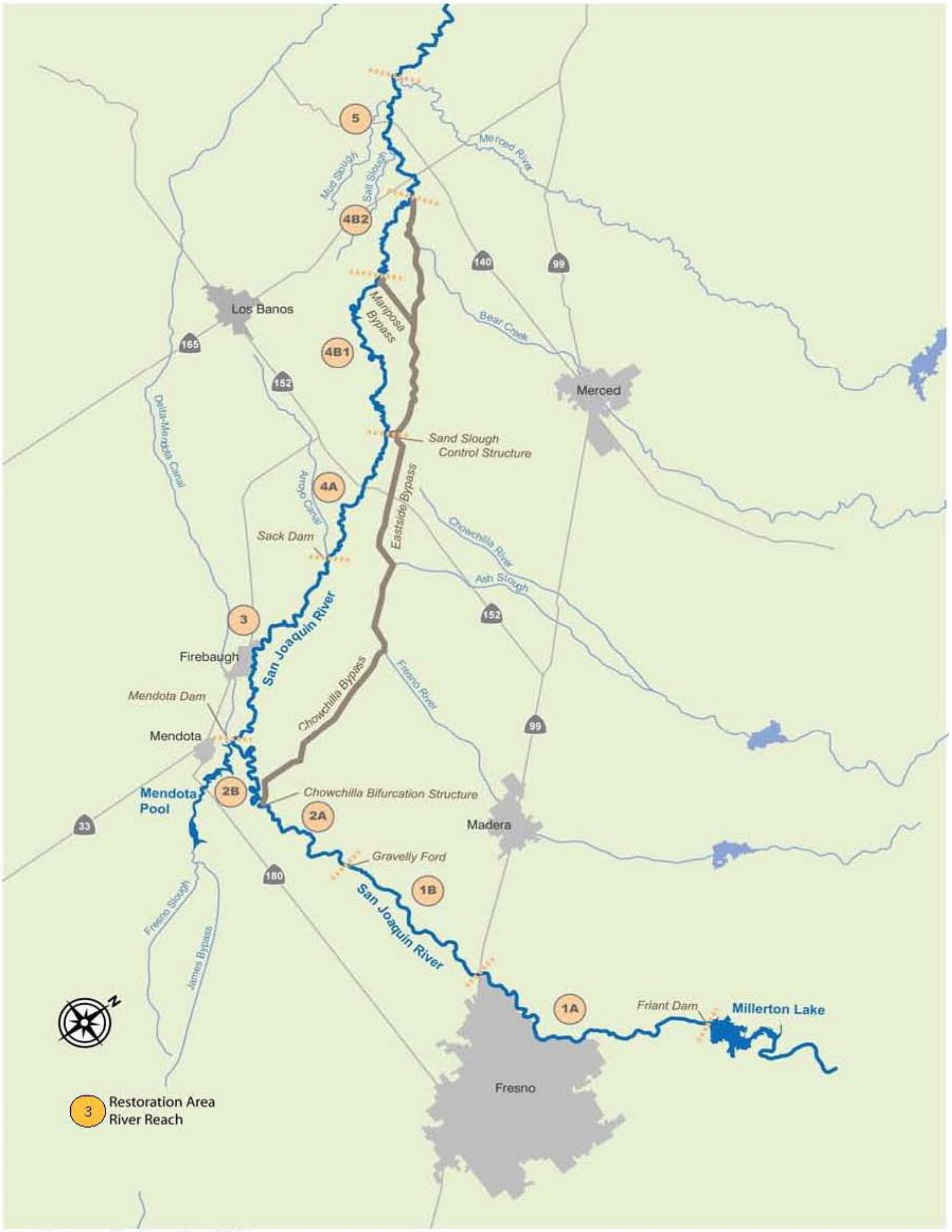
Spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson *et al.* 2011). Spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures. In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser *et al.* 2013).

Although steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 14°C to 19°C (57°F to 66°F). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001b). In fact, McCullough et al. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F). Successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support wild steelhead populations.

## 2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area for this BO includes areas that may be affected, directly or indirectly, by the proposed action. The proposed action is located in Fresno and Madera counties, approximately 7 miles southeast of Dos Palos, California. The action area includes all reaches downstream of Mendota Dam in the Restoration Area (see figures 9 and 10 below). Sack Dam is on the SJR in the western region of the San Joaquin Valley. The facilities are owned and operated by HMRD.




Source: Reclamation 2010

**Figure 9.** Overview of SJRRP Restoration Area and Arroyo Canal-Sack Dam Project Site.

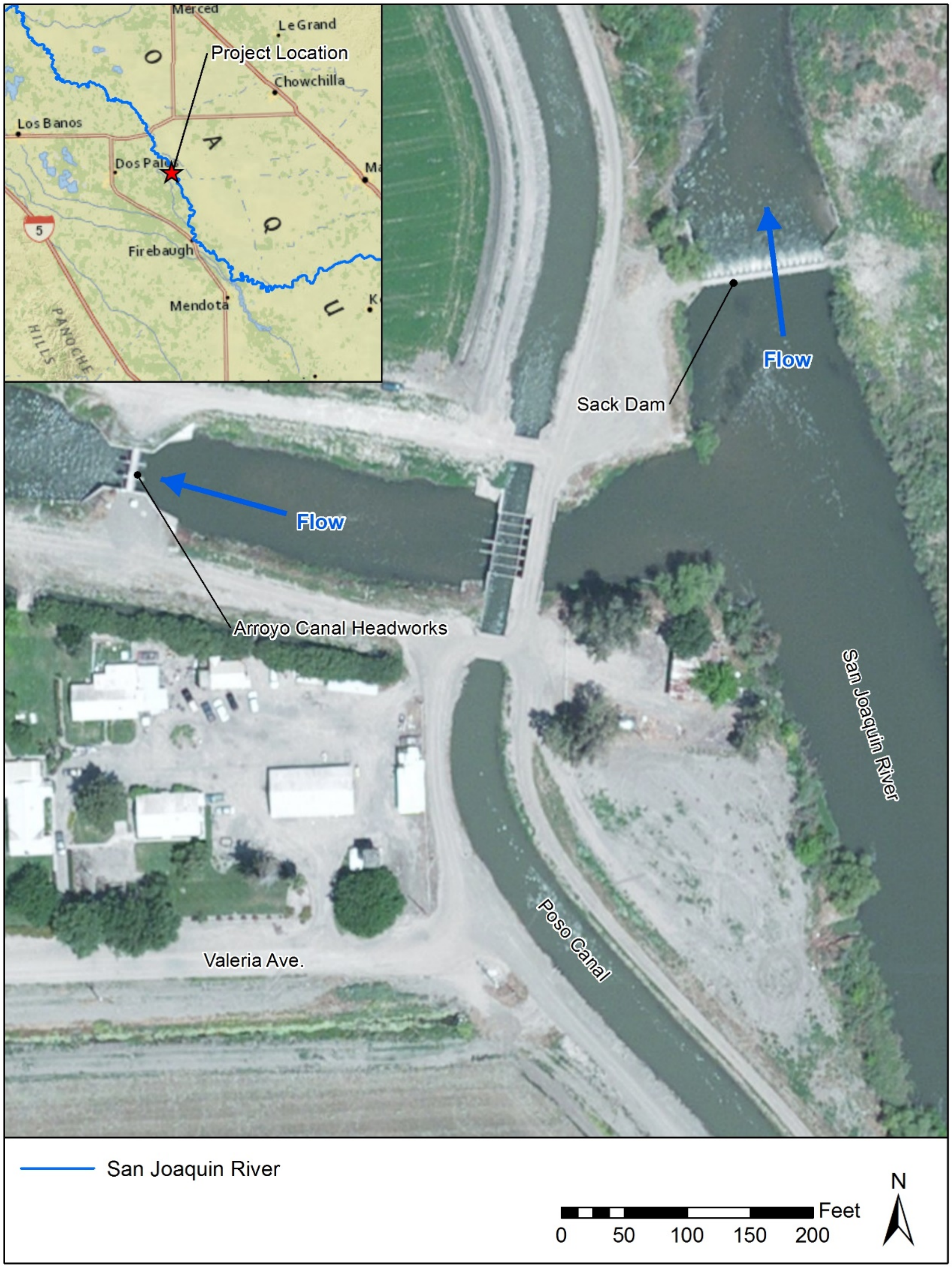



**Figure 10.** Project Location and Area Map

## 2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

### 2.4.1 Status of the Species in the Action Area

#### 2.4.1.1 Status of Central Valley spring-run Chinook salmon in the action area

Historically, CV spring-run Chinook salmon spawned in the SJR from about the present day location of Friant Dam to as far upstream as Mammoth Pool (RM 322) (McBain and Trush 2002). During the late 1930s and early 1940s, as Friant Dam was being constructed, large runs continued to return to the river. After the dam was completed and the reservoir was filling, runs of 30,000 to 50,000 fish continued to return and spawn in the river downstream of Friant Dam. These runs were completely gone by 1950, as diversions from Friant Dam resulted in the river being dry for extended sections starting at Gravelly Ford and below Sack Dam (McBain and Trush 2002). The occurrence data and available information suggest that CV spring-run Chinook salmon were not recently present within the proposed action area prior to SJRRP restoration activities. Temporal occurrence for CV spring-run Chinook salmon has been estimated for the SJRRP Restoration Area (Table 5). Although these environmental criteria and estimated temporal occurrences are based on published scientific literature from SJR and Sacramento River basin tributaries and other Pacific coast rivers, they are estimates and are subject to other variables such as fishery stock characteristics, hydrological conditions, local conditions, and water quality.

**Table 5.** Spring-run Chinook Salmon Temporal Occurrence by Life-stage, SJR Reach, and Month

| Life Stage | Jan | Feb | Mar | Apr | May | June | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adult Migration[1] | | | 5, 4, MB, EB, 3, 2, 1 | 5, 4, MB, EB, 3, 2, 1 | 5, 4, MB, EB, 3, 2, 1 | 5, 4, MB, EB, 3, 2, 1 | 5, 4, MB, EB, 3, 2, 1 | 5, 4, MB, EB, 3, 2, 1 | | | | |
| Adult Holding[2, 3] | | | | 1A | 1A | 1A | 1A | 1A | 1A | | | |
| Spawning[1, 4] | | | | | | | | 1A | 1A | 1A | | |
| Incubation and Emergence[5, 6] | 1A | 1A | 1A | | | | | 1A | 1A | 1A | 1A | 1A |
| In-River Fry/Juvenile Rearing[1, 7] | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 | 1, 2<br>3, 4, MB, EB, 5 |
| Fry Migration[6, 8, 9] | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | | | | | | | | | | 1, 2, 3, 4, MB, EB, 5 |
| Smolt Migration[6, 8, 9] | | | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | | | | | | |
| Yearling Migration[6, 8, 9] | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | | | | | | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 | 1, 2, 3, 4, MB, EB, 5 |

*Source: 2007 SJRRP Spring-run Technical Memorandum*
*Periods and/or locations of high relative abundance are shaded in grey*
*Reach # 1, 2, 3, 4, and 5*
*MB= Mariposa Bypass*
*EB= Eastside Bypass*

The SJRRP started releasing juvenile CV spring-run Chinook salmon into the SJR in 2014 (60,114 from Feather River Fish Hatchery (FRFH)), 2015 (54,924 FRFH), 2016 (57,320 FRFH and 47,550 from the Interim Salmon Conservation and Research Facility (SCARF)), 2017 (38,106 FRFH and 51,044 SCARF), and 2018 (167,758 SCARF). Some of the hatchery-reared juvenile CV spring-run Chinook salmon could have returned to the SJR as early as spring 2016, but none have been detected as of March 2018.

When adult CV spring-run Chinook salmon do return they will be trapped at the Hills Ferry Barrier and hauled to Reach 1 until there is unimpeded passage, which is anticipated to occur in 2021. With unimpeded passage, there will also be an increased possibility of CV spring-run Chinook salmon from outside the Restoration area naturally straying into the action area. These fish will be treated as part of the experimental population once they enter the Restoration area. Some migrating adult CV spring-run Chinook salmon may bypass the traps at the Hills Ferry Barrier location and continue migrating upstream. In order for these individuals to enter the action area, they would need to ascend past Sack Dam, which would likely be possible only during high flow events when the flashboards are removed at Mendota Dam. When adult CV spring-run Chinook successfully spawn in Reach 1, either after migrating naturally during a flood flow or being trapped and hauled from Reach 5, juveniles could emigrate through the proposed action area: approximately 2017 to 2019 (SJRRP 2015). Trapping of migrating adults would continue within Reach 5 and individuals would continue to be hauled to Reach 1 and released. If adult spring-run Chinook salmon successfully spawn in Reach 1, either after migrating naturally through the Restoration Area or being transported from Hills Ferry, juveniles could emigrate through the action area during operation of Arroyo Canal and Sack Dam. If emigrating spring-run juveniles reached Mendota Pool, the likelihood of survival would be low as current conditions do not reliably provide suitable rearing or migratory habitat and predation could be rampant. During flood operations, flows being directed down the Chowchilla Bypass at the Chowchilla Bifurcation Structure would result in the majority of juveniles outmigrating through the bypass system; thus, avoiding Arroyo Canal. Individuals that do make it to Reach 3 could encounter the Arroyo Canal Headworks and Sack Dam.

#### 2.4.1.2 Status of California Central Valley steelhead in the action area

Historic abundance of CCV steelhead in the action area is difficult to determine, but CCV steelhead were widely distributed, with abundance estimates of 1 to 2 million adults annually, throughout the Central Valley system as a whole (McEwan 2001). If adult steelhead successfully migrate and spawn in Reach 1, then juveniles could access Reach 3 under certain conditions by swimming downstream and passing through Mendota Dam. Kelts could also emigrate through Reach 3 from Reach 1 after spawning. If steelhead reached Mendota Pool, the likelihood of survival would be low as current conditions do not reliably provide suitable rearing or migratory habitat and predation would be likely based on the high occurrence of predatory fish. Individuals that do make it downstream of Mendota Pool could then swim downstream and encounter the Arroyo Canal headworks and Sack Dam at the end of Reach 3.

Steelhead have been captured in the three main tributaries of the SJR: the Stanislaus, Tuolumne, and Merced rivers. However, they likely do not currently occur in the SJR mainstem upstream of the lower terminus of Reach 5, which includes the action area (Eilers *et al.* 2010). The Steelhead Monitoring Plan (SMP) is conducted under the auspices of the SJRRP, which is a result of the Stipulation of Settlement in NRDC et al. v. Kirk Rodgers et al. (Settlement). One goal of the SJRRP is to include restoration flows for fish populations in the Restoration Area. Restoration flows could attract adult steelhead into the Restoration Area below Friant Dam prior to the completion of SJRRP habitat improvements and measures to obscure false migratory pathways. The purpose of the SMP is to monitor for the presence of CCV steelhead in the Restoration Area in advance of the complete restoration of the area. Due to the presence of numerous passage impediments, CCV steelhead in the Restoration Area would not have access to suitable spawning habitat upstream on the SJR. So, adult individuals would be captured, transported, and released into the SJR below the mouth of the Merced River where the CCV steelhead could then continue their migration to suitable spawning habitat downstream of the Restoration Area (NMFS 2017). The first two years of monitoring in 2012 and 2013 failed to capture CCV steelhead in Reaches 4B and 5, leading to the conclusion that CCV steelhead have been extirpated from all reaches of the SJRRP Restoration Area (SJRRP 2012b, SJRRP 2013). From the original implementation of the SMP in 2012 (SJRRP 2012b) to April 2018 (personal communication from Don Portz), monitoring activities did not result in the capture of any CCV steelhead in the monitoring area, which reinforces the consensus that there is an extremely low incidence of CCV steelhead in the project area. Monitoring will continue in the downstream reaches of the SJRRP Restoration Area as part of the SMP (NMFS 2017).

No spawning of steelhead has occurred in Reach 1 to date. Therefore, the likelihood of steelhead presence in the action area would continue to be very low throughout the current operation of Arroyo Canal and Sack Dam.

### 2.4.2 Factors Affecting the Species in the action area

CCV steelhead and CV spring-run Chinook salmon have the potential of entering the action area. Many of the factors affecting these species throughout their range are discussed in the *Status of the Species* section of this BO, and are considered the same in the action area. This section will focus on the specific factors in the action area that are most relevant to the proposed project.

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Flows released from Millerton Reservoir through Friant Dam have generally dried up or gone subsurface before or once reaching Gravelly Ford, and water that is pumped from the Delta via the Delta Mendota Canal forms Mendota Pool at the bottom of reach 2B. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices upstream require peak flood discharges to be held back and released over a period of weeks to avoid overwhelming the flood control structures downstream of the reservoirs (*i.e.* levees and bypasses). Consequently, managed flows in the mainstem of the river often truncate the peak of the flood hydrograph and extended the reservoir releases over a protracted period. These actions reduce or eliminate the scouring flows necessary to mobilize gravel and clean sediment from the spawning reaches of the river channel, and disrupt natural sediment transfer in general.

High water temperatures also limit habitat availability for listed salmonids in the lower SJR. High summer water temperatures in the lower SJR can exceed 72ºF, and create a thermal barrier to the migration of adult and juvenile salmonids (Myers *et al*. 1998). In addition, water diversions at the dams (*i.e.* Friant, Goodwin, La Grange, Folsom, Nimbus, and other dams) for agricultural and municipal purposes have reduced in-river flows below the dams. These reduced flows frequently result in increased temperatures during the critical summer months which potentially limit the survival of juvenile salmonids (Reynolds *et al*. 1993) in these tailwater sections.

Point and non-point sources of pollution resulting from agricultural discharge and urban and industrial development occur upstream of and within the action area. The effects of these impacts are discussed in detail in the *Status of the Species* section. Environmental stressors as a result of low water quality can lower reproductive success and may account for low productivity rates in fish (*e.g.* green sturgeon, Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (*i.e.* heavy metals) concentrations may deleteriously affect early life-stage survival of fish in the SJR (USFWS 1995b).

Degraded water quality in various segments of the SJR has been a long-term problem due to low river flows and discharges from agricultural areas, wildlife refuges, and municipal wastewater treatment plants. Adjacent to the action area is the Grasslands Watershed that encompasses both Mud and Salt sloughs; this watershed drains ~370,000 acres in the Western portion of the SJR basin in Merced County. Both sloughs discharge upstream of the Merced River within the Restoration Area. Historically, subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tail water) from the Grassland Watershed discharged to the SJR through Salt Slough and/or Mud Slough. With the start of the Grassland Bypass Project in 1996, all tile drainage from a 97,000 acre area known as the Grassland Drainage Area is consolidated and conveyed through San Luis Drain to Mud Slough, eliminating discharges of drainage water from the Grassland Drainage Area into Salt Slough and wetlands (Reclamation 2001).

### 2.4.3 NMFS Salmon and Steelhead Recovery Plan Action Recommendations

The NMFS Recovery Plan that includes both CCV steelhead and CV spring-run Chinook salmon (NMFS 2014) identifies recovery goals for the SJRRP area population that includes the proposed action area. Recovery efforts focus on addressing several key stressors that are vital to both CCV steelhead and CV spring-run Chinook salmon: (1) elevated water temperatures affecting adult migration and holding; (2) low flows and poor fish passage facilities, affecting attraction and migratory cues of migrating adults; and (3) possible catastrophic events (e.g. fire or volcanic activity).

#### 2.4.3.1 CV Spring-run Chinook Salmon Specific Recovery Plan Key Stressors in SJR Basin

A. Low spatial structure distribution (criteria includes two viable populations within the SJR Basin)
B. Passage Impediments/barriers
C. Warm water temperatures for holding and rearing
D. Limited quantity and quality of rearing habitat
E. Predation on juveniles in river and in the Delta
F. Agricultural diversions and entrainment

#### 2.4.3.2 CCV Steelhead Specific Recovery Plan Key Stressors

A. Low spatial structure distribution (criteria includes two viable populations within the SJR Basin)
B. Passage Impediments/barriers
C. Warm water temperatures for rearing
D. Hatchery effects
E. Predation
F. Loss of historical habitat/degradation of remaining habitat

Recovery actions identified in the recovery plan that are relevant to this consultation include: implementing restoration flows outlined in the SJRRP settlement agreement, reintroducing CV spring-run Chinook salmon, implementing channel modifications as outlined in the SJRRP settlement agreement, minimizing entrainment to non-viable migration pathways, and construction of a Mendota Pool Bypass.

### 2.4.4 Climate Change

Rangewide climate change information for CCV steelhead and CV spring-run is presented in Section 2.2 of this opinion and potential operational impacts due to changes in river runoff patterns and increases in water temperature from climate change are described in Section 2.2.3.

In the future, the proposed action area will likely experience additional changes in environmental conditions due to climate change. These changes may overlap with the direct and indirect effects of long term proposed actions. Thus, for long-term actions, we can no longer assume current environmental variability adequately describes environmental baseline conditions. Instead, we need to project baseline conditions into the future, synchronizing our projections with the duration of the effects of the proposed action we are analyzing.

The near-term effects of global climate change are unlikely to result in any perceptible declines to the overall health or distribution of the listed populations of anadromous fish within the action area that are the subject of this consultation when considering the relatively brief period of time over which the proposed action is scheduled to be constructed and operated.

## 2.5 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those caused by the proposed action and are later in time, but still are reasonably certain to occur.

Effects from the proposed action are described for each of the following operational components (A-D below):

A. Release of water from Mendota Dam into Reach 3
B. Diversion of water from the San Joaquin River (SJR) into Arroyo Canal
C. Release of water from Sack Dam into Reach 4A
D. Maintenance of Arroyo Canal and Sack Dam

### 2.5.1 Central Valley spring-run Chinook salmon

#### 2.5.1.1 Direct Effects

Juvenile salmonids may become entrained in Arroyo Canal with diversion of water from the SJR into Arroyo Canal (operational component B above). As water is diverted from the SJR, juveniles entrained into Arroyo Canal would be expected to die due to the extremely low chance of reorienting to the river channel. In order to analyze the potential effects from the proposed action, SJR flows have been predicted for water years 2018 through 2022 using the SJRRP Daily Flow Model. This timeframe was chosen because the construction of the Arroyo Canal fish screen is anticipated to start in 2020, as part of The Arroyo Canal Fish Screen and Sack Dam Fish Passage Project (Project). Table 6 shows predicted average monthly flows above Sack Dam for water years 2018-2022. Under typical operations, Restoration Flows within the SJR reaching Sack Dam are released into Reach 4A (operational component C above). The remaining water is diverted to the Arroyo Canal for irrigation or delivery to refuges. Diversions to Arroyo Canal range from zero to 800 cfs, however diversions typically do not exceed 600 cfs. Flood flows and flows greater than those required for diversion or Restoration Flows spill over Sack Dam and continue downstream.

**Table 6.** All Predicted Flows above Sack Dam for Water Years 2018-2022

| Year Type [a] | Average Monthly Flow (cfs)[b] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| All Years | 371 | 357 | 253 | 390 | 566 | 756 | 1079 | 954 | 851 | 654 | 420 | 365 |
| Wet | 381 | 426 | 577 | 1121 | 1475 | 2120 | 3704 | 3645 | 2851 | 1408 | 453 | 386 |
| Normal-wet | 404 | 432 | 361 | 430 | 368 | 663 | 1397 | 644 | 491 | 522 | 431 | 386 |
| Normal-dry | 384 | 366 | 178 | 270 | 432 | 576 | 636 | 407 | 481 | 521 | 431 | 386 |
| Dry | 388 | 385 | 184 | 228 | 533 | 551 | 338 | 389 | 475 | 517 | 428 | 385 |
| Critical-high | 388 | 374 | 184 | 228 | 378 | 456 | 233 | 319 | 403 | 477 | 388 | 325 |
| Critical-low | 280 | 161 | 37 | 62 | 208 | 171 | 166 | 319 | 403 | 477 | 388 | 325 |

Source: SJRRP Daily Flow Model

[a] Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

[b] All flow types were averaged over the entire model run

cfs = cubic feet per second

The fractional volume of flow into Arroyo Canal during each month was compared with juvenile salmonid emigration patterns to estimate the average annual percentage of entrainment for each water year type. Spring-run Chinook salmon are being reintroduced by the SJRRP, as required by the Settlement. Spring-run juveniles have been released into the river for the past five years (2014-2018); held in Reach 1, and transported down to Reach 5 for release. In 2016 and 2017, several adult spring-run Chinook salmon were released to spawn in Reach 1 naturally.

Some of the hatchery-reared juvenile CV spring-run Chinook salmon (Interim Facility and regional hatcheries) may return as adults to the SJR during the next several years when Arroyo Canal and Sack Dam are operating under current conditions. Adult spring-run Chinook salmon migrating through the SJR would be identified at Hills Ferry, then trapped in fyke nets in Reach

5 and hauled to Reach 1 until there is unimpeded passage in the Restoration Area, which is anticipated to occur in 2023. Some migrating adult spring-run Chinook salmon may bypass the traps in Reach 5 just upstream of the Hills Ferry and continue migrating upstream. In order for these individuals to enter Reach 1, they would need to either: (1) Ascend Sack Dam and Mendota Dam, which would be possible only during high flow events when the flash boards are removed at Mendota Dam; or (2) Migrate upstream through the Eastside and Chowchilla Bypass system to the Chowchilla Bifurcation Structure.

If adult spring-run Chinook salmon successfully spawn in Reach 1, either after migrating naturally through the Restoration Area or being transported from Hills Ferry, juveniles could emigrate through the action area during operation of Arroyo Canal and Sack Dam. If spring-run Chinook salmon reached Mendota Pool, the likelihood of survival would be low as current conditions do not reliably provide suitable rearing or migratory habitat and predation could be rampant. During flood operations, flows being directed down the Chowchilla Bypass at the Chowchilla Bifurcation Structure would result in the majority of juveniles out migrating through the bypass system; thus, avoiding Arroyo Canal. Individuals that do make it to Reach 3 could encounter the Arroyo Canal headworks and Sack Dam.

Calculating Migrating Juvenile Spring-Run Chinook Salmon at Arroyo Canal

Since implementation of the SJRRP, there is no data available on juvenile spring-run Chinook salmon survival or temporal emigration patterns, or estimates of age-specific adult escapement, in the SJRRP Restoration Area. Therefore, assumptions were made to estimate abundance and survival of emigrating juveniles, and escapement of adults to estimate abundance of juvenile salmon encountering the Arroyo Canal/Sack Dam site on the SJR; these assumptions are based largely on documents available on the SJRRP website (www.restoresjr.net), including the Draft Fisheries Framework (2017), Revised Framework for Implementation (2015), Near and Mid-Term Reintroduction Plan (2014), and the Fisheries Management Plan (2010). A number of assumptions were made in calculating the potential presence of juvenile spring-run Chinook salmon at Arroyo Canal, including equations and values to estimate losses and escapement. These equations and values, and their sources (literature), are detailed below in Table 7.

**Table 7.** Assumptions for Calculating Estimated Abundance of Juvenile Spring-Run Chinook Salmon Emigrating to Arroyo Canal/Sack Dam

| Criteria: | Value: | Source: |
|---|---|---|
| Juvenile survival through Restoration Area | 5.0% | Draft Fisheries Framework 2017 |
| Smolt-to-Adult Returns | 1.9% | Draft Fisheries Framework 2017 |
| 3-Year Adult Returns | 56.0% | Garman and McReynolds 2009; McReynolds et al. 2007; Ward et al. 2003 |
| 4-Year Adult Returns | 44.0% | Garman and McReynolds 2009; McReynolds et al. 2007; Ward et al. 2003 |
| Adult Passage Survival | 90.0% | Draft Fisheries Framework 2017 |
| Adult Survival to Spawning | 85.0% | Draft Fisheries Framework 2017 |
| Male/Female Adult Ratio | 50/50 | Draft Fisheries Framework 2017 |
| Fecundity | 4,200 | Draft Fisheries Framework 2017 |
| Egg-to-Fry Survival | 50% | Draft Fisheries Framework 2017 |
| Survival/River Mile (SRM) for Juveniles($SRM^{RM}$=5%; $0.05^{1/150}$=SRM) | 98.02% | Assuming constant loss rate by River Mile to equal 5% survival at Merced River |
| Spawning grounds to Arroyo Canal (RM) | 68 | Measured from Scout Island to Arroyo Canal |
| Estimated Survival to Arroyo Canal (Survival=$SRM^{RM}$) | 25.72% | Based on survival by RM and distance to Arroyo Canal |

Differentiating between “Wet”, “Normal-Wet”, and “other” categories of water year types was necessary because during “Wet” and “Normal-Wet” water year types, it is assumed hatchery reared spring-run Chinook salmon will be released in Reach 1 of the Restoration Area (upstream of Arroyo Canal); therefore, these fish will likely encounter the Arroyo Canal. During “other” water year types, it is assumed juvenile spring-run Chinook salmon will be released at the most downstream sections of Reach 5, and, therefore, will not encounter the Arroyo Canal and their survival rates will not be impacted by stressors in the Restoration Area. In addition, the estimates by water year type assume consistent cycles of the same water year category across the period of calculations (2018-2022) and doesn’t allow for unpredictable dynamic changes across years. Therefore, it is most appropriate to treat these values as the predicted minimum and maximum levels within each individual year.

## 1. Abundance of emigrating juvenile Spring-Run Chinook Salmon

Three components were used to derive the abundance estimate of emigrating juvenile spring-run Chinook salmon:

a. *Direct Releases of Hatchery Juveniles* – Totals of released (2016-17), and predicted releases (2018-22), of translocated fish, from regional hatcheries and fish reared at the SJRRP Interim Facility, were provided by California Department of Fish and Wildlife.

b. *Naturally Produced Juveniles from Released Hatchery Adults* - The combined total of released and predicted releases of adult fish reared at the SJRRP Interim Facility, were provided by California Department of Fish and Wildlife.

c. *Naturally Produced Juveniles from Returning Adults (Escapement)* – Calculations for abundance of juvenile spring-run Chinook salmon surviving and emigrating outside of the Restoration Area is described below.

## 2. Survival of Emigrating Juveniles to Arroyo Canal

a. *Wet and Normal-Wet Water Year Types* – During "Wet" and "Normal-Wet" water years, it was assumed releases of hatchery reared fish will occur in Reach 1 of the Restoration Area, and these fish, as well as those naturally produced in Reach 1 spawning grounds, must transition past Arroyo Canal to emigrate out of the Restoration Area. Based on historic (2014-16) fall-run Chinook salmon spawning in the Restoration Area, it was assumed river mile (RM) 250 (Scout Island) is the mid-point for salmon spawning grounds (Castle et al. 2016a; Castle et al. 2016b). Using a 5% outmigration survival rate (fry-to-smolt survival, Draft Fisheries Framework 2017) and a constant rate of emigration and a constant rate of loss through the Restoration Area, survival by river mile was calculated. Percent survival (25.72%) was multiplied by the estimated abundance of surviving naturally produced and hatchery released juvenile spring-run Chinook salmon emigrating downstream of their holding grounds (assumed Reach 1A, RM 250) to estimate the annual abundance of juvenile salmon encountering the Arroyo Canal/Sack Dam site (Table 8).

b. *"Other" Water Year Types* – During all water years not defined as "Wet" or "Normal-Wet" water years, it is assumed hatchery releases of fish will occur downstream and outside of the influence of Arroyo Canal. As a result, hatchery reared juveniles were not included in the calculations of loss at Arroyo Canal, were assumed to incur no loss (100% survival) through the Restoration Area, which, ultimately, resulted in an assumed higher escapement (return of adults) during these water year types. As a result, only naturally produced fish emigrating from Reach 1A were used in the above calculations to estimate annual abundance of juvenile salmon encountering the Arroyo Canal/Sack Dam during these water year types (Table 8).

**Table 8.** Estimated Abundance of Juvenile Spring-Run Chinook Salmon Emigrating to Arroyo Canal/Sack Dam

| Year Type [a] | Total Abundance of Juvenile Spring-Run Chinook Salmon | | | | |
|---|---|---|---|---|---|
| | **2018** | **2019** | **2020** | **2021** | **2022** |
| Wet | 72,891 | 306,578 | 507,288 | 620,909 | 466,614 |
| Normal-wet | 72,891 | 306,578 | 507,288 | 620,909 | 466,614 |
| Normal-dry | 21,459 | 131,710 | 306,705 | 353,464 | 543,832 |
| Dry | 21,459 | 131,710 | 306,705 | 353,464 | 543,832 |
| Critical-high | 21,459 | 131,710 | 306,705 | 353,464 | 543,832 |
| Critical-low | 21,459 | 131,710 | 306,705 | 353,464 | 543,832 |

Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

Calculating Entrainment of Migrating Juvenile Spring-Run Chinook Salmon at Arroyo Canal

Entrainment would occur when migrating juveniles are diverted into Arroyo Canal. An analysis was conducted in order to assess the level of entrainment associated with the current operations of Arroyo Canal and Sack Dam.

The analysis used a daily flow model combining historical hydrology with future river conditions and future SJRRP Flows for the next 5 years (through 2022). Table 9 shows the historical average monthly diversions at the Arroyo Canal Headworks from 1999 to 2016. The fractional volume of flows into Arroyo Canal during each month (Table 9) was used to create and average monthly percentage of entrainment for each water year type (Table 10). Based on the Sacramento River Basin juvenile spring-run Chinook salmon migration timing, we assume timing in the SJR Basin to be the same, from December through May based on Sacramento Basin timing.

**Table 9**. Historical Average Monthly Diversions at the Arroyo Canal Headworks

| Water Year Type[b] | Average Monthly Diversions (cfs)[a] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| All Years | 206 | 150 | 66 | 86 | 248 | 173 | 166 | 263 | 449 | 508 | 399 | 241 |
| Wet | 229 | 192 | 73 | 72 | 213 | 146 | 113 | 239 | 462 | 541 | 474 | 302 |
| Normal-Wet | 211 | 153 | 23 | 89 | 220 | 180 | 213 | 304 | 463 | 537 | 448 | 276 |
| Normal-Dry | 180 | 115 | 94 | 100 | 273 | 218 | 203 | 270 | 485 | 518 | 392 | 225 |
| Dry | 243 | 153 | 48 | 102 | 328 | 166 | 174 | 321 | 435 | 491 | 372 | 242 |
| Critical-High | 220 | 215 | 63 | 55 | 131 | 95 | 69 | 137 | 326 | 411 | 299 | 143 |
| Critical-Low | 142 | 113 | 64 | 18 | 220 | 82 | 37 | 104 | 292 | 336 | 198 | 102 |

*Source: San Luis Canal Company 2017*

[a] Period of Record Water Years 1999-2016

[b] Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

Key: cfs = cubic feet per second

**Table 10.** Average Monthly Percentage of Entrainment for Juvenile Spring-Run Chinook Salmon

| Year Type [a] | Percent Entrainment [b] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | |
| All Years | - | - | 12% | 7% | 15% | 7% | 3% | 7% | - | - | - | - | |
| Wet | - | - | 6% | 21% | 50% | 28% | 17% | 52% | - | - | - | - | |
| Normal-wet | - | - | 46% | 33% | 59% | 38% | 35% | 74% | - | - | - | - | |
| Normal-dry | - | - | 23% | 37% | 59% | 30% | 48% | 92% | - | - | - | - | |
| Dry | - | - | 30% | 20% | 29% | 20% | 26% | 49% | - | - | - | - | |
| Critical-high | - | - | 100% | 17% | 79% | 43% | 19% | 37% | - | - | - | - | |
| Critical-low | - | - | 12% | 7% | 15% | 7% | 3% | 7% | - | - | - | - | |

Source: Reclamation 2017

[a] Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

[b] Hatchery juveniles excluded from all years except "wet" and "normal-wet", it is assumed that all hatchery juveniles will be released downstream from Arroyo in all other water-year types.

The monthly percentage of entrainment was then compared to juvenile Chinook salmon emigration patterns and abundance to estimate the predicted amount of entrainment for each month of each year (2018-2022). For the purpose of estimating annual CV spring-run Chinook salmon entrainment in Arroyo Canal it was assumed that: (1) only juveniles would be entrained; (2) the percentage of flow diverted into Arroyo Canal is proportional to the fraction of fish diverted to the canal; and (3) the temporal distribution of migration is constant. It was also assumed that the emigrating life history distribution would be consistent with Table 7 in the Draft Fisheries Framework (2017) with a minimum composition of 20% fry, 20% parr, 10% smolt, and 10% yearling. Based on these assumptions, the average annual entrainment of juvenile CV spring-run Chinook salmon is presented in Table 11, and these effects directly result from operational component B of the proposed action. The lowest level of entrainment would occur during wet water years and the highest level of entrainment would occur during critical-low water years. The values presented are extremely conservative (high entrainment) and optimistic regarding the success of adult and juvenile migration through the Restoration Area. In reality, we expect that passage barriers, limited habitat, predation, and other factors to result in a much smaller amount of entrainment of juvenile spring-run Chinook salmon. However, we did want to quantify the potential for entrainment into Arroyo Canal during this interim phase because diversion of SJR water into Arroyo Canal is the only operational component of the proposed action anticipated to result in adverse effects to CV spring-run Chinook salmon.

**Table 11.** Estimated Average Annual Entrainment of Juvenile Spring-Run Chinook Salmon

| **Year Type [a]** | **Total Juvenile Spring-Run Chinook Salmon Entrained** | | | | |
|---|---|---|---|---|---|
| | **2018** | **2019** | **2020** | **2021** | **2022** |
| Wet | 6296 | 26483 | 43820 | 53635 | 40307 |
| Normal-wet | 21036 | 88476 | 146399 | 179189 | 134661 |
| Normal-dry | 10127 | 62158 | 144744 | 166811 | 256651 |
| Dry | 10338 | 63452 | 147756 | 170283 | 261993 |
| Critical-high | 6238 | 38286 | 89154 | 102746 | 158082 |
| Critical-low | 10544 | 64719 | 150706 | 173682 | 267224 |

[a] Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

NMFS does not anticipate routine maintenance activities (component D) outlined in section 1.3.2 to result in adverse effects to CV spring-run Chinook salmon. In addition, NMFS does not anticipate the release of water from Mendota Dam into Reach 3 (component A) and release of water from Sack Dam into Reach 4A (component D) to result in adverse effects to CV spring-run Chinook salmon, because during lower flows adult spring-run will be captured downstream from these structures and transported to the spawning reaches prior to completion of the fish passage improvements; during higher flows adult spring-run may be able to pass Sack Dam and Mendota Dam.

#### 2.5.1.2 Indirect Effects:

##### 2.5.1.2.1 Straying

Salmon typically home to their natal streams when returning to spawn in fresh water. Straying, however, is a natural behavior for a small fraction of individuals in a population (Lasko et. Al. 2014). Straying of fall-run Chinook salmon has been observed in both Mud and Salt sloughs, tributaries to the SJR in Reach 5. It can be assumed from this observation that spring-run Chinook salmon would likely also stray into these sloughs during upstream migration. The term "straying" refers to anadromous salmonids that either intentionally or unintentionally return to a non-natal stream. It is not known why some anadromous salmonids stray and the explanation is likely complex (Lasko et. al. 2014).

Mud and Salt sloughs act as drainage systems for a variety of stakeholders, including drainage generated from the deliveries of water from Arroyo Canal. This drainage can create attraction flows which can cause upstream migrating salmon to stray into these sloughs. Straying of fish into drainage areas, such as Mud and Salt sloughs, represent a "Passage Impediment" to migrating salmonids. According to NMFS (2008), a passage impediment is defined as any artificial structural feature or project operation that causes adult or juvenile fish to be injured, killed, blocked, or delayed in migration, to a greater degree than in a natural river setting. Passage impediments, such as straying into Mud and Salt sloughs, have several impacts that can reduce or prevent successful spawning of migrating adult salmonids, such as CV spring-run:

a. Migration Delay - Opportunities to veer off course delaying migration, adding stress, reducing energy stores, and potentially experiencing high temperatures

b. Fatigue – Cannot complete immediate passage or reduces ability to complete migration

c. Vulnerability – Predation and disease

d. Disorientation – Fish cannot find pathway or access to passage, impeding or reducing migration success

e. Water quality – Reduced water quality from agricultural drainage can cause physiological stress, respiratory impairments, and reduced predatory avoidance

f. Prespawn mortality – not finding a mate, straying into unsuitable temperature conditions for holding/egg incubation or habitat conditions

To account for the potential of straying, the number of straying returning adult spring-run Chinook salmon was estimated. In order to estimate straying, returning adult migration patterns and abundance were compared to the fractional volume of flow discharging from Mud and Salt sloughs during each month to estimate the average annual percentage of straying for each water year type.

The number of returning adults was calculated as part of the methodology for calculating the abundance of migrating juvenile spring-run Chinook salmon at Arroyo Canal (Table 12). For “Wet” and “Normal-Wet” water year types it was assumed that because juveniles would be released in Reach 1 and their survival rates would be impacted by stressors in the Restoration Area; therefore, the abundance of returning adults would be affected in-kind. For “other” water year types it was assumed that juveniles would be released in Reach 5 and the abundance of returning adults would not be affected by juvenile survival rates through the Restoration Area.

**Table 12.** Predicted Returns of Adult Spring-Run Chinook Salmon from Natural Production and Releases

| **Year Type**[a] | **Year** | | | | |
|---|---|---|---|---|---|
| | **2018** | **2019** | **2020** | **2021** | **2022** |
| Wet and Normal-Wet | 583 | 1580 | 1846 | 909 | 753 |
| “Other” | 583 | 1580 | 1846 | 2931 | 9215 |

[a] Period of Record Water Years 2004-2017; some years may be missing data

Flows for Mud and Salt sloughs were generated using historical average streamflow as recorded at USGS gaging stations located in an upstream portion of Mud Slough (MSG) and Salt Slough (SSH). Flows were averaged by month and split out by water year type. Flows in Mud and Salt sloughs were then compared to flows in the SJR at each confluence. A daily flow model was used to estimate flows in Reach 5 combining historical hydrology with future river conditions and future SJRRP Flows for the next 5 years (through 2022). Once flows were calculated for each month and water year type, the average monthly flow contribution at the confluence with the SJR was calculated for both Mud Slough and Salt Slough (Tables 13 and 14).

**Table 13.** Mud Slough Average Monthly Flow Contribution at the Confluence of the San Joaquin River

| Year Type [a] | Average Monthly Flow Contribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Wet | - | - | - | - | - | 13% | 8% | 5% | 6% | - | - | - |
| Normal-wet | - | - | - | - | - | 30% | 6% | 9% | 19% | - | - | - |
| Normal-dry | - | - | - | - | - | 26% | 16% | 18% | 12% | - | - | - |
| Dry | - | - | - | - | - | 21% | 16% | 17% | 15% | - | - | - |
| Critical-high | - | - | - | - | - | 23% | 17% | 9% | 8% | - | - | - |
| Critical-low | - | - | - | - | - | 43% | 26% | 15% | 28% | - | - | - |

Source: USGS 2017, Gage Stations MSG and FFB
[a] Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

**Table 14**. Salt Slough Average Monthly Flow Contribution at the Confluence of the San Joaquin River

| Year Type [a] | Average Monthly Flow Contribution | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Wet | - | - | - | - | - | 28% | 18% | 11% | 13% | - | - | - |
| Normal-wet | - | - | - | - | - | 45% | 17% | 34% | 68% | - | - | - |
| Normal-dry | - | - | - | - | - | 53% | 40% | 70% | 69% | - | - | - |
| Dry | - | - | - | - | - | 44% | 54% | 71% | 70% | - | - | - |
| Critical-high | - | - | - | - | - | 30% | 68% | 100% | 100% | - | - | - |
| Critical-low | - | - | - | - | - | 100% | 100% | 100% | 100% | - | - | - |

Source: USGS 2017, Gage Stations SSH and SJS
a. Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."

The average monthly flow contribution at the confluence with the SJR is used to calculate the percentage of returning adult spring-run Chinook salmon that would stray into Mud Slough and Salt Slough, and be potentially affected through migration delay, poor water quality, increased predation, and other straying stressors previously discussed above in Section 2.5.1. For the purpose of estimating annual adult spring-run Chinook salmon straying into Mud and Salt sloughs it was assumed that adults migrate from March until June each year (based on Sacramento Basin timing), the rate of migration is constant over time, and the percentage of flow contributed by Mud Slough and Salt Slough is proportional to the fraction of fish straying to those systems. Straying is calculated first at Mud Slough, as the salmon would first encounter that confluence, and is then calculated at Salt Slough with the remaining fish that did not stray. Based on these assumptions, the average annual straying of returning adult CV spring-run Chinook salmon is presented in Table 15. The lowest level of straying is expected to occur during Wet water years and the highest level of straying would occur during Critical-high and Critical-low water years. However, negative effects of straying into Mud and Salt sloughs may be reduced or eliminated through the trapping (fyke nets and/or weirs) of spring-run Chinook salmon and hauling them to Reach 1 of the Restoration Area, that occurs as part of the SJRRP (NMFS 2012). As part of the SJRRP, trapping would be triggered once adult spring-run Chinook salmon are visually detected via a Vaki Riverwatch Fish Counter. Spring-run Chinook salmon would not be trapped if flows were to become high enough to be considered dangerous for monitoring personnel. This action would be carried out in accordance with the *Near-Term Spring-Run Chinook Salmon Management and Monitoring Study* as part of the *Monitoring and Analysis Plan* (SJRRP 2018). Therefore, straying of adult spring-run Chinook salmon would be dramatically reduced or eliminated during most water year types and flow scenarios. Additionally, the degraded water quality of these areas during certain periods could further act as a deterrent against straying of adults into these sloughs. The poor water quality of these areas are discussed in further detail above in section 2.4.2. However, adverse effects are expected to occur as a result of straying.

**Table 15.** Average Annual Straying of Returning Adult Central Valley Spring-Run Chinook Salmon

| **Year Type** [a] | **Total Adult Straying (Mud and Salt Sloughs)** | | | | |
|---|---|---|---|---|---|
| | **2018** | **2019** | **2020** | **2021** | **2022** |
| Wet | 142 | 385 | 450 | 221 | 183 |
| Normal-wet | 293 | 794 | 927 | 457 | 378 |
| Normal-dry | 383 | 1037 | 1212 | 1924 | 6048 |
| Dry | 390 | 1056 | 1234 | 1959 | 6161 |
| Critical-high | 455 | 1232 | 1439 | 2285 | 7183 |
| Critical-low | 583 | 1580 | 1846 | 2931 | 9215 |

*a Restoration year types are defined in Appendix J of the PEIS/R, "Surface Water Supplies and Facilities Operations."*

### 2.5.2 Central Valley steelhead

#### 2.5.2.1 Direct Effects:

Currently, CCV steelhead are extirpated from all waters upstream of the Merced-SJR confluence. However, irrigation return, flood flows, and Restoration Flows could attract adult steelhead into the Restoration Area. Attracted steelhead would not have access to appropriate spawning habitat due to a number of barriers, primarily Hills Ferry Barrier, Sack Dam, and Mendota Dam.

During the programmatic consultation with NMFS for the SJRRP, Reclamation proposed to implement a steelhead monitoring plan in order to evaluate whether steelhead were using the lower Restoration Area, which they are currently implementing. If steelhead detections occur, Reclamation will immediately contact NMFS. Monitoring for steelhead takes place from January through March of each year when Restoration Flows reach the confluence of the Merced River and may potentially provide connectivity for upstream migrating steelhead. The steelhead monitoring plan includes the following activities:

- Monitor for adult CCV steelhead on the SJR from Sack Dam to the Merced River confluence.
- Relocate CCV steelhead, in the event of a capture, to more suitable habitat below the confluence with the Merced River.
- Establish a long-term Steelhead Monitoring Plan that provides additional data to steelhead monitoring occurring at locations on the Sacramento and northern SJR tributaries.

While no spawning population of CCV steelhead currently exists in the SJR, individuals could potentially reach spawning grounds in Reach 1 during high flow events. In order for these individuals to migrate through the system they would need to either: (1) Ascend Sack Dam and Mendota Dam, which would likely be possible only during high flow events when the flash boards are removed at Mendota Dam; or (2) Migrate upstream through the Eastside and Chowchilla Bypass system to the Chowchilla Bifurcation Structure.

If adult steelhead successfully migrate and spawn in Reach 1, then juveniles could access Reach 3 under certain conditions by swimming downstream and passing through Mendota Dam. Kelts could also emigrate through Reach 3 from Reach 1 after spawning. If steelhead reached Mendota Pool, the likelihood of survival would be low as current conditions do not reliably provide suitable rearing or migratory habitat and predation is rampant. Individuals that do make it downstream of Mendota Pool could then swim downstream and encounter the Arroyo Canal headworks and Sack Dam at the end of Reach 3. Reclamation will monitor for CCV steelhead below Mendota and Sack Dams and at entrainment areas such as Mud and Salt sloughs, and notify NMFS of CCV steelhead presence in accordance with the Terms and Conditions outlined in section 2.9.4 of this BO. In addition, if passage becomes possible due to high flows, Reclamation will perform monitoring in spawning reaches of the SJR to detect the occurrence of adult passage and subsequent spawning, in accordance with Terms and Conditions outlined in section 2.9.4 of this BO. These efforts will help to inform SJRRP management and would further minimize the likelihood of early life stage CCV steelhead of becoming entrained into Arroyo Canal during emigration.

No spawning of steelhead has been detected in Reach 1 to date. Therefore, the likelihood of steelhead presence in the action area would continue to be very low throughout the current operation of Arroyo Canal and Sack Dam. However, due to the slight possibility that CCV steelhead could be present in some lifestage, the proposed action might result in direct effects to the species. NMFS expects adverse effects to occur to early-life stage steelhead from the proposed action from entrainment of kelts and/or juveniles into Arroyo Canal when migrating downstream, where it is expected these individuals would die as a result from operational component B. Other potential, but extremely unlikely to occur effects involve fish migrating through the action area during the routine maintenance activities described in Section 1.3.2. In addition, release of water from Mendota Dam into Reach 3 (component A) and release of water from Sack Dam into Reach 4A (component D) are not anticipated to result in adverse effects to CCV steelhead. Reclamation will monitor for CCV steelhead below Mendota and Sack Dams and at entrainment areas such as Mud and Salt sloughs, and notify NMFS of CCV steelhead presence.

The action area does not overlap with designated critical habitat for CCV steelhead, and is therefore not included in this consultation.

#### 2.5.2.2 Indirect Effects:

Similar to salmon, steelhead typically return to their natal streams when returning to spawn in fresh water. Straying, however, is a natural behavior for a small fraction of individuals in a population (Lasko et. al. 2014). Straying of fall-run Chinook salmon has been observed in both Mud and Salt sloughs, tributaries to the SJR in Reach 5. It is assumed from this observation that steelhead would also stray into these sloughs during upstream migration.

CCV steelhead are currently extirpated from all waters upstream of the Merced-SJR confluence. However, irrigation return, flood flows, and Restoration Flows would likely attract adult steelhead into the Restoration Area. Therefore, a small number of adult steelhead are expected to enter the Restoration Area and stray into Mud or Salt slough, which would result in reduced fitness and survival, consistent with those described for CV spring-run Chinook salmon in Section 2.5.1.

### 2.6 Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

**A.** Agricultural Practices

Agricultural practices in the SJR and Delta may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the SJR and Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the SJR and Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998a, Dubrovsky *et al.* 1998b, Daughton 2003).

**B.** Increased Urbanization

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. For example, the General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. From 2010 to 2015 the population of the City of Manteca increased by 12% reaching over 75,000 people (U.S. Census Bureau 2015). The population of the City of Lathrop grew by approximately 15% from 2010 to 2015 (U.S. Census Bureau 2015). Increased growth would place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, would not require Federal permits, and thus would not undergo review through the ESA section 7 consultation processes with NMFS.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially would degrade riparian and wetland habitat by eroding channel banks and mid-Channel Islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially re-suspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation in the SJR and Delta is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the water bodies of the SJR and Delta.

## 2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution.

The Analytical Approach section above described the analyses and tools we have used to complete this analysis. This section is based on analyses provided in the Status of the Species, the Environmental Baseline, and the Effects of the proposed action sections.

### 2.7.1 Status of the Species and Effects of the Action on Listed Species

The Status of the Species ESU/DPS are described in section 2.2 above. Currently CCV steelhead are believed to be extirpated from the action area, and the only use of the action area by CV spring-run Chinook salmon would be the result of activities related to the 10(j) non-essential experimental population reintroduction. However, once SJRRP restoration and reintroduction activities have progressed, the action area is likely to become an important migratory pathway for both species, and may also provide juvenile rearing.

Populations of CV spring-run Chinook salmon and CCV steelhead in California have declined drastically over the last century, and some subpopulations have been extirpated. The current status of listed salmonids within the action area, based upon their risk of extinction, has not significantly improved since the species were listed (NMFS 2016). This severe decline in populations over many years, and in consideration of the degraded environmental baseline, demonstrates the need for actions which would assist in the recovery of both of the ESA-listed species in the action area, and that if measures are not taken to reverse these trends, the continued existence of CV spring-run Chinook salmon, and CCV steelhead could be at risk.

<u>Central Valley Spring-run Chinook Salmon</u>

The adverse effects expected to occur as a result of the proposed action are entrainment of juveniles into Arroyo Canal and straying of adults into Mud and Salt sloughs.

<u>California Central Valley steelhead</u>

While the likelihood of CCV steelhead presence in the action area currently is very low, the likelihood of presence increases in future years during operation of Arroyo Canal and Sack Dam, and as the SJRRP is implemented. CCV steelhead that do enter the Action Area would be subjected to similar effects to those discussed above for CV spring-run Chinook salmon. Adverse effects to adults are associated with straying by either being delayed or entrained into Mud or Salt Slough. The proposed action's effects on early-life stage CCV steelhead are not expected to exceed the entrainment of one individual kelt per year and/or one individual juvenile per year into Arroyo Canal.

### 2.8 Conclusion

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CCV steelhead.

This BO determined the proposed activities are not likely to jeopardize the continued existence of CV spring-run Chinook salmon, and a conferencing opinion is only required if the analysis of the proposed action results in a jeopardy determination. Therefore, a conferencing opinion is not required.

### 2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

The effects analysis of the proposed action for CV spring-run Chinook salmon is only included in this BO because it was requested by Reclamation for conferencing. There will be no take issued for CV spring-run Chinook salmon as part of this BO, and the experimental population of CV spring-run Chinook salmon is not addressed in the Incidental Take Statement. The analysis on CV spring-run Chinook salmon is for informational purposes only.

#### 2.9.1 Amount or Extent of Take

While spawning of CCV steelhead is not thought to currently exist in the SJR, individuals are expected to only reach spawning grounds in Reach 1 during high flow events (described above in section 2.5.2).

Juveniles produced from adult steelhead that successfully migrate and spawn in Reach 1, may access Reach 3 under certain conditions by swimming downstream and passing through Mendota Dam. Kelts could also emigrate through Reach 3 from Reach 1 after spawning. A high proportion of steelhead that reach Mendota Pool, are expected to have low survival. Individuals that make it downstream of Mendota Pool could then swim downstream and encounter the Arroyo Canal headworks and Sack Dam at the end of Reach 3.

No spawning of steelhead has occurred in Reach 1 to date. Therefore, the likelihood of steelhead presence in the action area would continue to be very low throughout the operation of Arroyo Canal and Sack Dam. However, it is reasonable to expect a few CCV steelhead individuals reaching Arroyo Canal/Sack Dam under current operations, resulting in incidental take of the species. Incidental take for operation of Arroyo Canal is not expected to exceed one juvenile, one spawning adult, and one kelt CCV steelhead per year. Incidental take will be exceeded if more than one individual of each life-stage is taken.

### 2.9.2 Effect of the Take

In the BO, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species.

### 2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1. Reclamation shall monitor the action area for CCV steelhead presence.

2. Reclamation shall minimize straying of CCV steelhead into Mud and Salt sloughs.

### 2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). Reclamation or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1: *"Reclamation shall immediately contact NMFS if CCV steelhead are observed within an area affected by the operations associated with the proposed action."*

    a. NMFS shall be notified within 24 hours if CCV steelhead adults are observed below Mendota and/or Sack dams, and/or entrainment areas within the action area, including Arroyo Canal and Mud and Salt sloughs.
    b. In the event that high flows occur to the degree that could allow for passage of migrating adult CCV steelhead at Mendota and Sack Dams, Reclamation shall notify NMFS of this flow condition immediately, and shall perform monitoring within spawning reaches of the SJR in an effort to detect any CCV steelhead passage and

subsequent spawning that occurs. Monitoring shall be carried out as soon as reasonably feasible.

2. The following terms and conditions implement reasonable and prudent measure 2: *"Reclamation shall minimize straying into Mud and Salt sloughs."*
    a. Reclamation shall study potential options for permanent and/or temporary passage barriers at Mud and Salt sloughs
    b. Reclamation shall provide NMFS with recommend option by 2020, for approval.

### 2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Reclamation should monitor and evaluate agricultural drain operations and water quality associated with the proposed action, and any potential effects on listed species.

2. HMRD and Reclamation should work to develop a monitoring system to inform the need for temporary screening of Arroyo Canal during the interim period between issuance of this BO and the completed installation of the permanent Arroyo Canal fish screen.

### 2.11 Reinitiation of Consultation

This concludes formal consultation for Current Operations of Arroyo Canal and Sack Dam, the proposed action.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

### 2.12 Supplemental Consultation

Reclamation must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

# 3 FISH AND WILDLIFE COORDINATION ACT

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). The FWCA establishes a consultation requirement for Federal agencies that undertake any action to modify any stream or other body of water for any purpose, including navigation and drainage (16 USC 662(a)), regarding the impacts of their actions on fish and wildlife, and measures to mitigate those impacts. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources, and providing equal consideration for these resources. NMFS' recommendations are provided to conserve wildlife resources by preventing loss of and damage to such resources. The FWCA allows the opportunity to provide recommendations for the conservation of all species and habitats within NMFS' authority, not just those currently managed under the ESA and MSA.

The following recommendations apply to the proposed action:

1. Reclamation should continue to implement high priority actions in the NMFS Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014) to the maximum extent feasible.

The action agency must give these recommendations equal consideration with the other aspects of the proposed action to meet the purpose of the FWCA.

This concludes the FWCA portion of this consultation.

# 4 DATA QUALITY ACT DOCUMENTATION AND PREDESSIMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

## 4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are Reclamation. Other interested users could include HMRD, SLCC, USFWS, CDFW, and DWR. Individual copies of this opinion were provided to Reclamation. This opinion will be posted on the Public Consultation Tracking System website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

## 4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

### 4.3 Objectivity

Information Product Category: Natural Resource Plan

***Standards:*** This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq..

***Best Available Information:*** This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion contain more background on information sources and quality.

***Referencing:*** All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

***Review Process:*** This consultation was drafted by NMFS staff with training in ESA and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

## 5 FEDERAL REGISTER NOTICES CITED

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