UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
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Endangered Species Act (ESA) Section 7(a)(2) Biological and Conferencing Opinion, Section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Issuance of an ESA Section 10(a)(1)(A) Enhancement Permit to the United States Fish and Wildlife Service for Implementation of the San Joaquin River Restoration Program and an accompanying Hatchery and Genetic Management Plan

National Marine Fisheries Service (NMFS) PCTS Consultation Number: WCR-2018-10368
Action Agencies: United States Fish and Wildlife Service, National Marine Fisheries Service

Affected Species and NMFS's Determinations:

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern Resident Killer Whale DPS (*Orcinus orca*)	Endangered	No*	NA	NA	NA

*Please refer to Section 2.11 for the analysis of this species that is not likely to be adversely affected.

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No

Consultation Conducted By: National Marine Fisheries Service, West Coast Region, California Central Valley Office

Issued By:

Barry A. Thom
Regional Administrator

Date: AUG 22 2018

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LIST OF ABBREVIATIONS AND ACRONYMS

ATU	Accumulated Thermal Unit
BKD	bacterial kidney disease
CABA	Center for Aquatic Biology and Aquaculture, Davis, California
CCV	California Central Valley
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CNFH	Coleman National Fish Hatchery
CRR	cohort replacement rates
CPUE	catch per unit effort
CV	Central Valley
CVI	Central Valley Index
CWT	coded-wire tag
DSCP	Donor Stock Collection Plan
DO	dissolved oxygen
DPS	distinct population segment
DSCHP	De Sabla-Centerville Hydroelectric Project
DQA	Data Quality Act
EBMUD	East Bay Municipal Utilities District
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FL	fork length
FRFH	Feather River Fish Hatchery
FWCA	Fish and Wildlife Coordination Act
HGMP	Hatchery and Genetic Management Plan
HSRG	Hatchery Scientific Review Group
IHNV	infectious hematopoietic necrosis virus
JSATS	Juvenile Salmon Acoustic Telemetry System
MS-222	Tricaine Methane Sulfonate
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEP	nonessential experimental population
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRDC	Natural Resources Defense Council
NWFSC	Northwest Fisheries Science Center
PBFs	physical or biological features
PCE	primary constituent elements
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric
pHOS	proportion natural origin spawners
PIT	passive integrated transponder
PNI	Proportionate Natural Influence
pNOB	proportion natural origin in broodstock

PVA	population viability analysis
Restoration Area	San Joaquin River Restoration Program Restoration Area
RBDD	Red Bluff Diversion Dam
RST	rotary screw trap
SCARF	Salmon Conservation and Research Facility
Settlement	Settlement in NRDC *et al.* v. Kirk Rodgers *et al.*
Silverado	Silverado Fisheries Base, Yountville, California
SIRF	Satellite Incubation and Rearing Facility
SJH	San Joaquin Fish Hatchery
SJR	San Joaquin River
SJRRP	San Joaquin River Restoration Program
SWE	Snow Water Equivalent
TRT	Central Valley Technical Review Team
Reclamation	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
VSP	viable salmonid population
WD	Whirling Disease
YCWA	Yuba County Water Agency
YOY	young-of-year

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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.

The Proposed Action is funded by the United States Bureau of Reclamation (BOR) and is implemented by the United States Fish and Wildlife Service (USFWS) and the California Department of Fish and Wildlife (CDFW). The USFWS proposes to continue hatchery activities associated with the San Joaquin River Restoration Program (SJRRP) which includes the release of Central Valley spring-run Chinook salmon into the San Joaquin River Basin (Table 1). The Conservation Hatchery Program is intended to help meet fisheries management objectives while working, "to restore and maintain fish populations in 'good condition' in the mainstem of the San Joaquin River below Friant Dam downstream to the confluence of the Merced River, including naturally-reproducing and self-sustaining populations of salmon and other fish."

The conservation hatchery program, as described in Section 1.6 of the Hatchery Genetic Management Plan (HGMP), "is an Integrated-Recovery[1] program" producing Central Valley (CV) spring-run for reintroduction purposes in order to restore a self-sustaining population in the San Joaquin River. Fish from the program are intended to spawn naturally in order to establish, supplement, and support the reintroduction of new CV spring-run Chinook salmon population in the San Joaquin River.

Table 1. The Proposed Action, including Program Operator and Funding Agency.

Hatchery and Genetics Management Plan	Program Operator(s)	Funding Agency
San Joaquin River Nonessential Experimental Population of spring-run Chinook Salmon	CDFW and USFWS	BOR

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the ESA of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. The opinion documents consultation on the action proposed by the USFWS and the BOR.

The NMFS also completed an Essential Fish Habitat (EFH) consultation. It was prepared in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801, *et seq*.) and implementing regulations at 50 CFR 600.

The opinion, incidental take statement, and EFH conservation recommendations are in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review. The document will be available through NMFS's Public Consultation Tracking System

[1] These terms are defined in Section 2.4.1.

(https://pcts.nmfs.noaa.gov/pcts-web/homepage.pct, [PCTS #: WCR-2017-SA00345]). A complete record of this consultation is on file at the California Central Valley Office, in Sacramento, California (Administrative File Number: 151422-WCR2017-SA00345).

1.1.1. San Joaquin River Restoration Program and Settlement Act

In 1988, a coalition of environmental and fishing groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit known as NRDC, *et al.*, v. Kirk Rodgers, *et al.*, to challenge the renewal of long-term water service contracts between the United States and Central Valley Project Friant Division contractors. On September 13, 2006, the Settling Parties, including NRDC, agreed on the terms and conditions of a settlement to the lawsuit (Settlement). Implementation of the Settlement is accomplished through the SJRRP.

One of the two primary goals of the Settlement, the Restoration Goal, is to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish.

The Federal Implementing Agencies are authorized to carry out the Settlement by the San Joaquin River Restoration Settlement Act (Settlement Act) (Pub. L. 111-11, 123 Stat. 1349 (2009)). This legislation also mandates that CV spring-run Chinook reintroduced into the San Joaquin River under the SJRRP be designated as a nonessential experimental population (NEP) pursuant to section 10(j) of the ESA of 1973 (16 U.S.C. 1539(j)). The collection of CV spring-run Chinook for use in establishing the experimental population, release of those individuals for the purpose of establishing self-sustaining population, and monitoring of the population, requires action pursuant to section 10(a)(1)(A) of the ESA.

This document constitutes an ESA biological opinion for California Central Valley (CCV) steelhead and CV spring-run Chinook salmon and also a conferencing opinion for the NEP of CV spring-run Chinook salmon. Conferencing opinions, as opposed to biological opinions, are required when species encountered are treated as species proposed for listing. Pursuant to ESA section 10(j), for the purpose of this conferencing opinion, the CV spring-run encountered in the SJRRP Restoration Area (Restoration Area) constitute a NEP, and shall be treated as a species that is proposed for listing (78 FR 79622; December 31, 2013). 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 species. The analysis for CV spring-run Chinook salmon in the Restoration Area is included in this opinion because of the value of monitoring the capture of CV spring-run Chinook salmon within the NEP area. The take exemption issued for CV spring-run Chinook salmon as part of this opinion will be for CV spring-run Chinook salmon encountered outside of the NEP area, and the NEP of CV spring-run Chinook salmon will not be addressed in the ITS. The analysis of NEP CV spring-run Chinook salmon is for informational purposes only. CCV steelhead are not the target species but some may be captured incidentally during monitoring and research activities on the San Joaquin River. CCV steelhead will be handled according to the methods outlined in the steelhead monitoring permit (16608-2R) or a subsequent renewal of that permit. Steelhead captured during spring-run Chinook salmon trap-and-haul would receive identical treatment to those captured during steelhead monitoring surveys.

1.2. Consultation History

While not a renewal, this permit, if issued would supplant two active section 10(a)(1)(A) permits issued to the USFWS, as part of the SJRRP, by NMFS: Permit 14868 and Permit 17781. Permit 14868 was issued to the USFWS on October 11, 2012, and authorized the collection of broodstock from Feather River Fish Hatchery (FRFH) for the SJRRP Conservation Hatchery Program. Permit 17781 was issued to USFWS by NMFS on March 21, 2014, and authorized additional collections from FRFH, as well as the release of FRFH transfers and fish being produced by the SJRRP Conservation Facilities into the San Joaquin River. In the application for Permit 20571, USFWS is proposing to continue previously authorized work under those two permits, in addition to some new activities, described in detail below. Additional details of activities covered under Permits 14868 and 17781, and additional activities requested in application 20571 are included in the Section 1.3 (Proposed Action) below. The full consultation history for Permit 20571 is not directly relevant to this analysis and so is not detailed here. That history is documented in the record for the section 7 consultations associated with Permits 14868 and 17781 and the application for Permit 20571, which are maintained by the California Central Valley Office in Sacramento, California.

The NMFS's West Coast Region received a permit application request (Permit 20571) from USFWS to conduct research and enhancement activities for listed salmonid species in California's Central Valley on June 9, 2017.

A Notice of Receipt for the application for Permit 20571 (82 FR 34931) was published on July 27, 2017, in the *Federal Register* asking for public comment on the application. This took place after a period of pre-consultation between NMFS and USFWS.

The public was then given 30 days to comment on the application. The public comment period ended on August 28, 2017. Public comments were received from two commenters, and application 20571 was changed in coordination with USFWS and other SJRRP implementing entities to ensure that the comments were satisfactorily addressed.

NMFS then initiated internal section 7 consultation on November 1, 2017. The species affected by the potential issuance of Permit 20571 to USFWS include threatened CCV steelhead and CV spring-run Chinook salmon, which are listed as threatened outside of the 10(j) NEP area, and are considered proposed for listing within the NEP area. The action area, as described in Section 2.3 below, includes activities both within and outside of the NEP area.

As part of the application for Permit 20571, USFWS attached the associated HGMP (CDFW 2016a) for the San Joaquin River Salmon Conservation and Research Program (Conservation Program). The HGMP was submitted by CDFW to NMFS on September 29, 2016. NMFS reviewed the draft HGMP, and on August 8, 2017, NMFS notified USFWS and CDFW that the

HGMP was considered sufficient[2] for consideration under section 10(a)(1)(A) of the ESA, and that the HGMP would become part of the package for consideration of issuance of Permit 20571.

The USFWS requested that the consultation be effective for up to five years so that research, monitoring, and evaluation (RM&E) included in the HGMP can provide meaningful results and inform future management decisions. The temporal scope of NMFS's effects analysis must be long enough to make a meaningful determination of effects, and thus the analysis in this Opinion is not limited to a five-year period. However, given the USFWS request, in addition to the standard regulatory reinitiation triggers, reinitiation will be required if implementation of the Proposed Action is to continue beyond December 31, 2023.

1.3. Proposed Federal Action

"Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. 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.

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg *et al.* 2004). In this specific case, the Proposed Action is described in the September 29, 2016, HGMP determined sufficient for formal consultation

The proposed action is the operation of a hatchery program that produces CV spring-run Chinook salmon as part of a 10(j) NEP for the SJRRP. Duration of the proposed action is five years. The purpose or reason for the hatchery program is to produce CV spring-run for reintroduction in order to restore a self-sustaining population in the San Joaquin River. The Conservation Program anticipates limited collections from extant CV spring-run populations (*e.g.*, Feather River, Butte Creek) and will use artificial propagation (with captive broodstock) to attain sufficient fish numbers for reintroduction.

Fisheries are not part of this proposed action and there are no fisheries that exist because of the proposed hatchery program (*i.e.*, the "but for" test does not apply), and therefore there are no interrelated and interdependent fishery actions. To the extent that there are existing fisheries that may catch SJRRP spring-run Chinook salmon, they are mixed fisheries and would exist with or

[2] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials would be meaningful.

without the SJRRP Conservation Program (and have previously been evaluated in a separate biological opinion (NMFS 2008b).

We are thus proposing to issue Permit 20571 pursuant to section 10(a)(1)(A) of the ESA. The permit would authorize USFWS and CDFW to take threatened CV spring-run Chinook salmon and CCV steelhead. "Take" is defined in section 3 of the ESA; it means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect [a listed species] or to attempt to engage in any such conduct. The following analysis therefore examines the take that may affect the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this opinion.[3]

The research and enhancement activities proposed under Permit 20571 include adult broodstock collection, releases of juvenile hatchery-origin spring-run Chinook salmon, and in-stream RM&E activities as described in further detail below.

1.3.1. Describing the Proposed Action

1.3.1.1. Proposed hatchery broodstock collection

Broodstock collections, as with all hatchery activities, would occur pursuant to the associated HGMP (CDFW 2016a), and include potential collections from Butte Creek (juvenile life stage), FRFH (juvenile and/or egg life stage), and/or the San Joaquin River (adult, juvenile, and/or egg life stage).

The Conservation Program consists of the Salmon Conservation and Research Facility (SCARF) which is currently under construction and planned to be completed by late-2018, an interim SCARF (Interim Facility), and a small, Satellite Incubation and Rearing Facility (SIRF; collectively called the Conservation Facilities). The Conservation Facilities were/are being constructed by CDFW under the SJRRP for the purpose of propagating CV spring-run Chinook salmon for reintroduction into the San Joaquin River as part of completion of the Restoration Goal of the Settlement.

The Interim Facility and SIRF are currently in operation. The SCARF is currently being constructed adjacent to the Interim Facility. The Interim Facility is located in Friant, California along the San Joaquin River adjacent to the CDFW's San Joaquin State Fish Hatchery (SJH). The SIRF is located 0.75 miles upstream of the SCARF on BOR's Friant Dam Property. The Interim Facility is expected to meet SJRRP production goals during construction of the SCARF and will be repurposed after the SCARF is fully operational.

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[3]An ESU of Pacific salmon (Waples 1991) and a DPS of steelhead (71 FR 834) are considered to be "species" as the word is defined in section 3 of the ESA. In addition, we use the terms "artificially propagated" and "hatchery" interchangeably in the opinion (and the terms "naturally propagated" and "natural").

CDFW has prepared a Draft Environmental Impact Report (DEIR) to provide the public, responsible agencies, and trustee agencies with information about the potential environmental effects of the proposed SCARF and Related Fisheries Management Actions[4].

Juveniles and eggs collected from donor stocks will be transported to an approved quarantine facility and after clearing fish health assessment, will be transferred to the Conservation Facilities. Fish will be reared under controlled hatchery conditions to sufficient age for spawning. Depending on Interim Facility and SCARF capacity, a portion of the broodstock may be released to the San Joaquin River as ancillary broodstock. After fish reach maturity at the Interim Facility or SCARF, they will be spawned and their progeny reared at the facility from the egg stage to be released to the San Joaquin River at the juvenile stage. Some eggs or juveniles may be transferred to the SIRF for rearing and or research. These activities are described in further detail below.

Broodstock origin and number: The total number of broodstock collected from each source population over the course of the reintroduction will depend on the viability of those stocks and the effects of removal on the associated risk factors. While source population viability may limit the number of fish collected, collection goals are based on the number of fish necessary to capture the genetic diversity of the source stocks. Because all three potential source populations are distinct, they must be considered independently when setting collection goals. If large numbers of fish are available from all three source populations, broodstock collection could be undertaken at a higher rate to assist in meeting SJRRP escapement goals. All three populations should be used in roughly equal proportion as much as feasible; using one population at a much higher level than the others would overwhelm the genetic diversity in the other, smaller populations.

In an effort to increase broodstock effective population size, hatchery staff will attempt to double the number of males used in spawning events. Therefore, the SJRRP proposes to collect up to 5,400 individuals from all potential sources, although 2,700 is the minimum needed to meet production targets. Because the ratio of juveniles in a population is expected to be 50:50, and because the sex cannot be immediately determined, doubling the number of males in a broodstock population calls for a doubling of the total number of collected individuals. Additionally, 60 fish from each collection event will be sacrificed for pathology screening at the time of collection and another 10 from each collection event will be sacrificed for pathology screening near the end of the quarantine period. Therefore, a maximum of 5,470 spring-run Chinook salmon eggs or juveniles will be collected for broodstock across all collections, including 70 for pathology studies from each collection event. A subset of the collection will be intentional (directed) mortality taken for fish health analysis. The total number of eggs or juveniles collected annually and the collection source will be constrained by the Interim Facility or SCARF capacity and donor stream conditions. If conditions are suitable, the SJRRP would prefer to collect equally from all three donor sources, with collection ratios dependent on acceptable take from each donor source.

[4] The DEIR, Notice of Determination, and Final EIR can be accessed at: https://www.wildlife.ca.gov/Regions/4/San-Joaquin-River/EIR

Feather River Fish Hatchery: If the FRFH is the only available donor source, the SJRRP will collect a maximum of 5,470 individuals from the FRFH including collections for pathology. Actual collection numbers will depend on availability of fish from FRFH and other sources. Under the previous permits 14868 and 17781, FRFH was the only source for broodstock. The SJRRP staff will assist with the spawning activities at FRFH to track each cross made, ensuring that egg collections for the SJRRP are from crossed parents exhibiting the spring-run Chinook salmon phenotype.

Butte Creek: The SJRRP proposes to collect a maximum of 2,910 juveniles annually from Butte Creek including collections for pathology (2,700 for broodstock, and 70 for pathology for up to 3 collection periods). The actual number collected will depend on the number of adult returns to Butte Creek the previous spring and the number of individuals collected from other broodstock sources as detailed above. Escapement on Butte Creek will be monitored and determined by either direct adult counts at a counting weir or by snorkel survey estimates during the holding period. Escapement estimates by carcass surveys will be used for validation and to account for pre-spawn mortality. These surveys are currently conducted annually. CDFW Regional Staff will be consulted in September or October each year to discuss annual escapement and proposed juvenile collection numbers the following winter and spring. Validation of escapement and confirmation of collection numbers will occur after carcass surveys are complete. Environmental conditions affecting the Butte Creek population (*e.g.*, drought, flood) will also be considered in determining annual collection numbers.

No juveniles will be collected if the number of female spawners is less than 250. The maximum number collected will scale up from 250 on a two to one basis with the number of female spawners up to 1,455. When the number of female spawners exceeds 1,455 up to the maximum of 2,910 juveniles may be collected.

San Joaquin River: When spring-run Chinook salmon adults return to the Restoration Area, the SJRRP proposes to collect a maximum of 2,980 juveniles or eggs, including collections for pathology from the San Joaquin River. If adults are collected for broodstock spawning, the SJRRP proposes to collect a maximum of ten percent of returning adults, up to 250 individuals annually.

An annual Donor Stock Collection Plan (DSCP) reviewed and approved by the NMFS and CDFW will outline how many individuals will be collected every year from each donor source, the manner in which collections will occur, and at which life stage collections will take place. The DSCP will be provided to NMFS at least 60 days prior to any collections. The donor stock collection window is quite long because egg collections at FRFH can take place as early as September, but juvenile collections would take place throughout the spring. The final determination on collecting wild donor stock will be informed by spawner surveys. Since these data will not be available prior to planning egg collections, if the SJRRP modifies actions described in the DSCP, an addendum to the DSCP will be provided to NMFS.

Proportion of natural-origin fish in the broodstock (pNOB): The Conservation Program will prioritize the collection of natural (non-hatchery) fish, but FRFH fish may be utilized if non-hatchery fish are not available or collections are not permitted from wild populations. While the

SCARF is under construction, the Conservation Program will seek to annually collect enough juvenile fish and eggs to obtain a total 50-100 relatively unrelated females and 100-200 relatively unrelated males to breeding age. Between 2018 and 2022, the Conservation Program will include fish from at least two and up to three of the potential broodstock source populations.

Beginning in 2023, the Conservation Program would like to add a fourth source population, natural origin fish from the Deer and Mill Creek Complex. Once the full-scale SCARF is in use, the Conservation Program will collect enough juvenile fish and eggs each year from three source populations to produce a total of 150-450 adult broodstock pairs. Returning naturalized adults from the San Joaquin River may be incorporated into the broodstock, although returns are not expected until 2018 or later.

Broodstock selection: To allow the hatchery to identify close relatives and minimize mean kinship, all potential spawners will be genetically analyzed, generally prior to age-one. Thereafter, a relatedness estimate (*e.g.*, Queller and Goodnight 1989; Blouin *et al.* 1996) will be developed for all pairs of broodstock fish (Kozfkay *et al.* 2008; Sturm *et al.* 2009) including potential breeding pairs to evaluate potential mates and same-sex pairings to detect full-siblings. Based on the molecular relatedness estimate, a spawning matrix will be constructed following Sturm *et al.* (2009). The spawning matrix will be organized by female, with all potential male mates listed below her in order of preference, based on their coefficient of relatedness (most desirable male is the least genetically-related).

All fish will be spawned when ripe. Actual pairings will attempt to involve the males highest on the list when the female is ripe, but no matings will involve fish related at the level of halfsibling or higher. Eggs from each female will be divided into four groups of roughly equal size and each will be fertilized by a different male. If fecundity is particularly low (*i.e.*, less than 1,000 eggs per female), eggs may be divided into fewer groups. A target ratio of 2 males for every female will increase genetic diversity across all broodstock mated. No male should be used with more than three females, assuming egg lots are split four ways, and no male should be used to fertilize more than the equivalent of 3/4 of a total egg lot. Eggs and fry from each cross should be kept separately until shortly after emergence, when the major period of in-hatchery mortality is passed, to allow for evaluation of the success of the cross.

If undertaken, matings between two different source populations will probably follow a different protocol because inbreeding is not a concern for these crosses. Fish will be selected for outcrossing based on their mean pairwise relatedness estimate compared to all other fish in their source population. The fish that are most highly related to the other fish in their populations are at the highest risk for causing inbreeding depression and are the least likely to have alleles otherwise not present within their populations. In the outcrossed fish protocol, females will be paired with four outgroup males randomly selected from the males chosen for outcrossing, and fertilization and rearing will proceed as described above for within population crosses.

Any returning naturalized adults in the San Joaquin River that are included in the broodstock should be evaluated using the same relatedness estimate approach identified above. Returning adults can be identified based on genetic or coded wire tags inserted before their initial release. Fish identified as strays may or may not be used as broodstock, depending on their origin. The natal origin for these fish can be determined based on otolith analysis (Barnett-Johnson *et al.* 2008) or genetic analysis. Eggs and/or juveniles resulting from these fish will be held separately until origin is determined.

<u>Males</u>: Some hatcheries faced with low male fertility use an approach where eggs are fertilized with a second male's milt (referred to as backup males) to ensure fertilization. Initially, backup males will not be used at the SCARF to avoid overrepresentation of some males due to advantages in sperm competition (Miller and Kapuscinski 2003, Campton 2004). Backup males may be required if infertility levels significantly reduce production below expected levels.

At the Interim Facility, the Conservation Program experienced high levels of precocious male maturation in both yearlings (age-1) and jacks (age-2). In 2012, 84 percent of the experimental fall-run male Chinook salmon matured as jacks. In 2013, 33 percent of the spring-run males matured as yearlings. Fortunately, the SJRRP was able to reduce yearling maturation to 3 percent and jacking to 7 percent of the male broodstock population during 2015 by managing growth rates during sensitive maturation decision periods. Because increased precocity in this program and others (Larsen *et al.* 2013), has been shown to be the result of hatchery practices, fish will most likely not pass the trait on to future generations. Therefore, the Conservation Program will allow contribution from precocious males when necessary to meet production goals. In general, Jacks will be used in a maximum of 20 percent of crosses to ensure representation of alternative life history strategies.

Method and location for collecting broodstock: The location and life-history stage of broodstock collected will vary based on several factors, including the population status of each source population, potential impacts to the source population, the accessibility of each life-stage, disease status, stipulations of collection permits, and guidance from the adaptive management process.

Table 2. Collection Methods and Maximum Annual Collection Levels by Source Populations (CDFW 2016a)

Population	Targeted Life Stage	Max Annual Collection[1]	Collection Methods
Feather River Fish Hatchery[2]	Eggs or Juveniles	5,470	Hatchery Operations
San Joaquin River	Eggs, Juveniles, or Adults	2,980	Redd Extraction, Emergence Trap, Rotary Screw Trap, Fykes or Weirs, Seine, Dip nets
Butte Creek	Juveniles	2,910	Rotary Screw Trap

[1] Maximum numbers included in section 10(a)(1)(A) permit application. Maximum collections from all source populations combined would be 5,400 eggs or juveniles per year, plus those required for pathology clearance (*i.e.*, 70 per collection), based on SCARF capacity and Conservation Program needs.
[2] All broodstock collections prior to 2018 will occur from Feather River Fish Hatchery.

<u>Feather River Fish Hatchery</u>: Spring-run Chinook broodstock collection protocols will be conducted according to methods described in the FRFH HGMP (Cavallo *et al.* 2012, update in progress). Only fish entering the FRFH between April 1 and June 30, that reenter the hatchery in

September, as identified by the presence of Hallprint® tags, will be used for broodstock for the Conservation Facility. These may be crossed according to FRHH protocols. Ovarian fluid samples from adults will be collected for analysis to determine presence of viruses and bacteria. After Fish Health Lab clearance, the preferred crosses can be segregated for the SJRRP. Selected broodstock eggs or juveniles will be transferred from FRH to the quarantine facility. Up to seventy individuals will be sacrificed for pathology and then pending clearance, the remainder will be transferred to the Interim Facility/SCARF. Individuals will only be collected that are in excess of what FRFH needs to meet its production targets, so that SJRRP collections will not impact FRFH production obligations.

Butte Creek: The SJRRP will collect juveniles from existing sampling occurring on Butte Creek to minimize additional handling and incidental mortality, control additional cost, and simplify logistics. Collections on Butte Creek will use the seasonal rotary screw trap (RST) and side diversion trap that are both located at the Parrot-Phelan Diversion Dam (PPDD) near Chico, which are used for annual monitoring of spring-run Chinook salmon juvenile out-migrants. The site is directly downstream of spring-run Chinook salmon spawning habitat and upstream of fall-run Chinook salmon spawning habitat; although periodically fall-run do spawn above the site. Therefore genetic testing would be performed to avoid mixing fall-run into the spring-run broodstock. Passive integrated transponder (PIT) tagging and genetic testing would occur after fish have reached a minimum fork length of 65 millimeters (mm) and may not occur until after juveniles are transferred to the Conservation Facilities.

During fish processing activities at the RSTs, a subsample of randomly selected juveniles of different size groups would be selected for broodstock collection. If, after initial collections, it becomes evident that size selection would be useful to eliminate fall-run Chinook salmon individuals from the sample, then larger yearling spring-run Chinook salmon may be targeted, as they are most readily distinguished from fall-run Chinook salmon. Life stages collected (*e.g.*, fry, parr, smolt), fork length ranges for each size group, and numbers collected of each per collection event will vary throughout the collection period in order to represent the diversity seen within the sample catches.

Collected juveniles will be held in self-contained rearing units or cages near (*i.e.*, within one-hour drive) the collection site during the collection period and prior to transfer for quarantine and fish health assessment. The site will be equipped with electrical power, water, and will be secured to prevent unauthorized entry or vandalism. Staff will be present daily for fish husbandry, system maintenance, and water quality monitoring (*e.g.*, temperature and dissolved oxygen).

Self-contained rearing units would include a five horse power chiller, mechanical and biological filters, a UV sterilizer, an aeration system, pumps to recirculate treated water, and a circular tank(s) (minimum 500-gallon capacity) capable of rearing up to 7,500 juvenile spring-run Chinook salmon at 200-fish/lb. In the event of loss of incoming water, the system would be able to run for up to one week with no adverse effects to the fish. The system will also be equipped with either a back-up generator or solenoid actuated diffused oxygen in case of power failure. If necessary due to equipment failure or unforeseen events, fish may be transferred to holding tanks at the Silverado Fisheries Base, the FRFH Annex, or any of the various Conservation Facilities.

Juveniles will then be transferred to a quarantine facility for a minimum 30-day holding and fish health assessment before ultimately being transferred to the Conservation Facilities. Annual collections from Butte Creek will be segregated into two to three groups for quarantine and fish health assessment in order to reduce the potential for disease transfer between early and late collections of fish.

<u>San Joaquin River</u>: The SJRRP may collect individuals at three different life stages: eggs, juveniles, or adults. Each life stage has advantages and disadvantages for collection. The number collected in any given year will be determined by the number of adult returns to the Restoration Area and the number of individuals collected from other source stocks.

Eggs: The SJRRP will pursue two basic methods for redd extractions; either redd pumping or redd excavation. These methods are described in more detail in Section 7.2.1 of the Hatchery and Genetics Management Plan (HGMP; CDFW 2016a). Up to 20 eggs per redd may be collected to be incorporated into broodstock to limit the number of siblings in the broodstock. Broodstock collected as eggs will be transferred or held for quarantine and fish health assessment prior to being transported to the SCARF.

If redd pumping is conducted, eggs will be collected from redds using a small portable backpack mounted water pump as described by Murdoch and Hopely (2005). An aluminum probe is inserted into the redd. The probe is designed with an air intake, which creates a Venturi effect that combines water and air. The mixture of air and water is used to float eggs to the surface. A collection basket covered with wire mesh and a cloth net bag on the downstream side will be used to collect eggs. The basket will be placed over the portion of redd to be sampled. In an effort to minimize stress to the redd, hydraulic sampling will begin at the farthest most downstream point of the tail spill and progressed systematically upstream as necessary. This method ensures that disturbance to the redd is confined to the furthest downstream portion of the redd, decreasing the probability of impacts from personnel (*i.e.*, stepping on egg pockets) or the sampling process (*e.g.*, changing the hydraulics of the redd). Each redd will be sampled carefully until the first egg is collected and the developmental stage verified (*i.e.*, eyed-egg stage). Eyed-eggs will be removed from the collection net by hand or with a small dip net and placed in small buckets. Buckets will then be placed in coolers on ice for transport to quarantine. Excess eggs will be re-injected into the redd using the hydraulic egg planter or carefully returned to the redd by hand.

Redd excavation consists of carefully hand-digging into the tail spill of identified spring-run redds to obtain live fertilized eggs. The specific redds from which eggs are to be obtained, will be selected from areas of shallower water and gentle velocities to facilitate obtaining eggs without loss. Gravel will be carefully removed from the tail spill of the red, by hand until eggs are reached. The digging process will proceed slowly so that a clear view of the excavated area can be maintained throughout the process. Snorkel gear will be used to get a clear underwater view of the excavated area. A fine mesh dip net will be used to retrieve the eggs. Eggs will be placed into a bucket of river water, maintained at or below the temperature of the river, as they are removed from the gravel. They will be counted as they are placed into the bucket until the desired number of eggs is reached (greater than 20 eggs). Once the eggs are obtained from the redd, gravel will be carefully replaced into the area from which it was removed until the pre-disturbance substrate contour is recreated.

Juveniles: The SJRRP will collect juveniles on the San Joaquin River via emergence traps, RSTs, fykes, weirs, or seines. Emergence traps may be placed over up to 40 spring-run Chinook salmon redds to monitor emergence and capture emerging juveniles. Up to 400 juveniles may be collected for incorporation into broodstock. An additional 600 juveniles may be sacrificed for genetic analysis. Juvenile collections within the Restoration Area will occur throughout the outmigration period in order to capture the maximum genetic diversity for SCARF broodstock. Collections may begin as early as November of each year and could extend through May, which is expected to encompass at least 95 percent of the juvenile outmigration period.

During the collection period, broodstock collected as juveniles will be transferred or held for quarantine and fish health assessment prior to being transported to the SCARF. Genetic testing will be used to confirm spring-run Chinook salmon origin and manage the genetic diversity in the broodstock. After genetic testing, each fish will be individually PIT tagged for sorting and incorporation as broodstock.

Adults: The SJRRP may choose to collect adults from the Restoration Area to provide broodstock at the SJRRP Conservation Facilities or to provide adults passage assistance to the spawning grounds when adults are not able to migrate on their own. Depending on river conditions and facility needs, adults may be collected at two different time periods, either prior to over summering in the system, or in the late summer/early fall just prior to spawning.

All adults will be trapped following the existing protocol for the SJRRP's adult trap and haul program. Adults will be trapped utilizing a fyke net, weir, seine, or dip net as detailed in Section 7.2.4 of the HGMP (CDFW 2016a). All adults will be tagged and fin clipped for genetic analysis to confirm spring-run origin. All individuals will then be transported to the upper Reaches of the Restoration Area and released near suitable spawning habitat, held in in-river net pens, or transferred to a holding facility. Adults collected in the spring and held in a holding facility or in-river net pens will be checked for ripeness during the fall. Adults released into the San Joaquin River will over summer in holding pools until spawning is estimated to have begun, then will be re-captured and checked for ripeness.

If a male and female are both ripe and are a good match genetically, they will be artificially spawned. Eggs will be incubated and a few will be selected for broodstock. Remaining eggs will be incubated to the juvenile stage, tagged with a coded wire tag (CWT), and released to the San Joaquin River to out-migrate.

Duration of collection: Activities may vary depending upon conditions, location of collections, life stages to be collected and SJRRP needs, but are anticipated to occur annually as follows:

- Eggs and juveniles will be collected from source stocks September through May.
- Redd grates and emergence trapping would occur September through March.
- Returning adults (for broodstock or transport) would be collected January through October.

Feather River Fish Hatchery: Spawning, egg selection, and egg collection will occur in September and/or October during the FRFH spawning season. Individuals will only be collected that are in excess of what FRFH needs to meet its production targets, so that SJRRP collections will not impact FRFH production obligations.

Butte Creek: Collections on Butte Creek would occur throughout the outmigration period in order to capture the maximum genetic diversity for the source population in the SCARF broodstock. Collections may extend through March, which is expected to encompass at least 95 percent of the juvenile outmigration period.

San Joaquin River: The duration of collection is based on the life stage targeted for collection. Depending on river conditions and facility needs, adults may be collected at two different time periods, either prior to over-summering in the system, or in the late summer/early fall just prior to spawning. Juvenile collections within the Restoration Area will occur throughout the outmigration period in order to capture the genetic diversity for the source population in the SCARF broodstock. Collections may begin as early as November of each year and could extend through May, which is expected to encompass at least 95 percent of the juvenile outmigration period.

Encounters, sorting and handling, with ESA listed fish, adults and juveniles: Many of the broodstock collection activities will be conducted opportunistically through coordination and collaboration with existing hatchery programs and research projects. Given that spring-run Chinook salmon are the primary target of these activities, encounters with non-target ESA-listed species are likely to be minimal. Non-listed Central Valley fall-run Chinook salmon may be encountered during the proposed broodstock collection activities, however the timing and location of collections and the genetic sampling of collected individuals will help to minimize these encounters.

Feather River Fish Hatchery: The SJRRP staff will assist with the spawning activities at FRFH to track each cross made, ensuring that egg collections for the SJRRP are from crossed parents exhibiting the spring-run Chinook salmon phenotype. Ovarian fluid samples will be collected from adult females to determine the presence of pathogens. Once preferred crosses of eggs are determined, SJRRP staff will segregate the permitted number of eggs for transport to a quarantine facility for pathology studies. Eggs are preferred for collection because of the ability to target genetically diverse individuals and collect temporal diversity, while maintaining low risk to the donor population. Furthermore, collection at this life stage provides greater survival to adulthood in a controlled environment when compared to rearing in the wild, thereby reducing population level impacts. Eggs also provide the least amount of risk associated with disease transfer due to their ability to withstand disinfection and many pathogens are not vertically transmitted from parent to ova.

As previously mentioned, broodstock collection activities at the FRFH for the SJRRP are conducted opportunistically during routine hatchery operations. Only non-listed Central Valley fall-run Chinook salmon are likely to be encountered during these activities. However, only fish tagged during the springtime (exhibiting the spring-run phenotype) will be used as broodstock, reducing the likelihood that fall-run Chinook salmon are used as broodstock. Therefore, ESA-listed species are not likely to be impacted by the broodstock collection activities at FRFH.

Butte Creek: Juvenile collections on Butte creek will utilize existing juvenile monitoring activities so as to minimize potential disturbance to the population. These monitoring activities include the RST and side diversion trap at the Parrot-Phelan diversion near Chico. Collections on Butte Creek will occur throughout the outmigration period in order to capture the genetic diversity for the source population in the SCARF broodstock. Collections will begin in December of each year and extend through March, which is expected to encompass at least 95 percent of the juvenile outmigration period. A small number of various sized juveniles would be randomly selected to prevent collecting siblings. Juveniles would be held in tanks or cages near the collection site until the target number of individuals is collected. After collection, broodstock would be transferred and held for quarantine and fish health assessment prior to being transported to the SCARF.

In some cases, capture locations may allow the capture of both fall- and spring-run Chinook salmon. However, Central Valley fall-run Chinook salmon are not listed under the ESA and encounters with other ESA-listed salmonids during broodstock collections in Butte Creek are not anticipated. If, after initial collections, it becomes evident that size selection would be useful to eliminate fall-run Chinook salmon individuals from the sample, then that may be used. In these scenarios, larger yearling spring-run Chinook salmon may be targeted, as they are most readily distinguished from fall-run Chinook salmon. Collected fish will be genetically tested and PIT tagged to verify spring-run Chinook salmon origin sometime after they reach a minimum fork length of 65 millimeters and may not occur until after juveniles are transferred to SCARF or the Interim Facility.

San Joaquin River: The San Joaquin River above the Merced River does not have a persistent population of Chinook salmon or steelhead, although some strays likely enter the river each year. Beginning in 2012, the SJRRP has annually trapped some of these fall-run Chinook salmon strays below barriers in the Restoration Area and released them in a reach containing suitable spawning habitat below Friant Dam to study behavior and habitat use. However, lack of river connectivity for volitional outmigration of juveniles and migration of returning adults will prevent a self-sustaining population from establishing prior to SJRRP channel and passage improvement projects being completed. Because the San Joaquin River spring-run are going to be reintroduced to a portion of the river without existing fall- or spring-run populations, many of the normal concerns with hatchery operations (*e.g*., introgression, predator attraction (Collis *et al.* 2001), behavioral influences) should not be a concern for other Chinook salmon in the river during the initial stages of the reintroduction. As more significant numbers of naturalized fish return to the system, these potential impacts may be realized. However, the Conservation Program will implement the reintroduction with the intent of minimizing these impacts. The continued reintroductions are likely to benefit the naturalized Chinook salmon elsewhere in the system by bolstering their numbers and their genetic diversity. When the naturalized populations are well enough established that they do not require the support of the hatchery, SCARF operations will be discontinued.

While the reintroduced salmon will not initially encounter other spring-run salmon in the river, they are likely to interact with fall-run Chinook salmon, steelhead, and other salmonids while outmigrating or rearing in the San Francisco Estuary and ocean. The reintroduced fish are likely to interact with other listed salmonid populations, including the endangered winter-run Chinook salmon, and threatened steelhead. The reintroduced fish may negatively impact other salmonids through a variety of interactions, most notably induced behavioral changes in wild fish, competition for limited resources, depensatory predation, and disease transfers in areas where they co-occur (Reisenbichler *et al.* 2004). While in freshwater, juvenile Chinook salmon feed predominantly on aquatic insects and other invertebrates and should not be significant predators on other salmonids (Unger 2004, Rundio and Lindley 2007).

Trap and Haul: *Adults*: If volitional adult passage is not possible, adult trapping and collections will occur in reaches below the first passage barrier and fish will be transported to above all passage barriers. Fyke traps/nets, or weirs will be deployed in multiple locations in the SJR, connected sloughs, or at fish passage facilities, dip nets, and hand seines will be used to capture adults that stray into smaller irrigation canals. Genetic tissue sampling from live fish will occur at downstream trapping locations prior to transport into the upper reaches. These fish will be externally tagged prior to release to assess spawning success. Acoustic tags and/or PIT tags may also be used for tracking purposes. Further, these tags can be used after genetic evaluation to track spawning adults.

Juveniles: During years when juvenile fish passage is inhibited (e.g., river is not connected), a trap and haul program may be used to improve survival success of juveniles produced naturally in the system, or as part of streamside spawning efforts. Currently an evaluation of potential trap and haul sites and methodologies is being pursued by the SJRRP. If trap and haul of juveniles occurs, this plan will address adaptive management of any trap and haul program implemented if trap counts are low, or survival in transport is lower than expected.

In general, juvenile Chinook salmon will be captured using outmigrant traps (*e.g*., weirs, surface collector, RSTs) at locations downstream of redd locations during the winter and spring. Collection boxes will be checked for fish and collection devices cleaned of debris daily. Fish will be netted from collection boxes and transfer to an appropriate sized fish transport tank outfitted with diffused oxygen and/or aerators, and water from fish source. Visual inspections of fish and water quality will be made during transport to release site. Once at the release location, the transport tank water will be tempered to within 2 degrees Celsius (°C) of the receiving water by slowly transferring (1°C /hr.) river water to the tanks (*e.g*., increasing the water temperature approximately 1°C per hour). Fish release sites will be based on having suitable water quality conditions and proximity to migration obstacles

1.3.1.2. Proposed mating protocols

Feather River Fish Hatchery: Corresponding individual fish data will be collected from the parents of each cross, including: adipose fin status, head tag number, CWT number, gender, weight, fork length, ovarian fluid sample number, tissue sample number, and corresponding genetic analysis data. These data will be used to select preferred crosses. Ovarian fluid samples will be collected from adult females to determine the presence of pathogens. In accordance with their protocols, the FRFH will segregate eggs from individual crosses into vertical incubator trays.

Once disease status and run timing are known, and once eggs have eyed, the SJRRP will randomly select eyed eggs from segregated lots up to the maximum allowed. If the FRFH is unable to segregate enough eggs from preferred crosses (see criteria above), then the SJRRP may also select eyed eggs, up to the maximum allowed, from the FRFH spring-run Chinook salmon egg trays. However, since the FRFH does not have the space to segregate all crosses it is likely that two to three different crosses may be in one tray.

Eggs are preferred for collection because of the ability to target genetically diverse individuals and collect temporal diversity, while maintaining low risk to the donor population. Furthermore, collection at this life stage provides greater survival to adulthood, thereby reducing population level impacts. Eggs also provide the least amount of risk associated with disease transfer due to their ability to withstand disinfection and many pathogens are not vertically transmitted from parent to ova.

After Fish Health Laboratory clearance, selected broodstock eggs will be transferred from FRFH to the quarantine facility. Up to 70 individuals will be sacrificed for pathology and then pending clearance, the remainder will be transferred to the Interim Facility or SCARF.

<u>San Joaquin River (SCARF Facilities)</u>: Consistent with the standards and guidelines outlined in the 2016 HGMP, all male broodstock at the Interim Facility, SIRF and SCARF, and female broodstock will be examined weekly during the spawning season to determine ripeness, and all fish will be spawned when ripe. To allow the hatchery to identify close relatives and minimize mean kinship, all potential spawners will be genetically analyzed and a relatedness estimate (*e.g.*, Queller and Goodnight 1989) will be developed for all pairings of broodstock fish (Kozfkay *et al.* 2008, Sturm *et al.* 2009), both potential breeding pairs (to evaluate potential mates) and same-sex pairings (to detect full-siblings). Based on the molecular relatedness estimate, a spawning matrix will be constructed following Sturm *et al.* (2009). The matrix will be organized by female, with all potential male mates listed below her in order of preference, based on their coefficient of relatedness (most desirable male is the least genetically-related).

Actual pairings will involve the four males with a low relatedness value when the female is ripe, and no matings will involve fish related at the level of half-sibling or greater. Females to be spawned will be euthanized by a sharp blow to the base of the skull using a blunt object. The ventral wall of the abdominal cavity will be slit open and eggs allowed to freely flow into a metal spawning pan. Milt from males will then be expressed into the pan by stroking the vent area.

Eggs from each female will be divided into four groups of roughly equal size and each will be fertilized by a different male. Each male will be used with no more than four different females. Eggs and fry from each cross should be kept separately until the major period of in-hatchery mortality is passed to allow for evaluation of the success of the cross.

The flaccid eggs will be put into incubation trays. Eggs and fry from each cross will be kept separately until the swim-up stage to allow for evaluation of the success of the cross. As available, and as governed by the recommendations of the hatchery and river monitoring technical teams, precocious males and jacks will be used to ensure representation of alternative life history strategies.

1.3.1.3. Proposed protocols for each release group (annually)

Hatchery produced fish and ancillary broodstock may be released at various life stages based on production targets, hatchery capacity, river conditions, and program needs. The vast majority of releases from the rearing facilities will be the progeny of SJRRP broodstock, but broodstock will also be released to the river for a variety of reasons.

Broodstock Releases: The SJRRP determines each year how many fish should be collected from donor populations as broodstock for the SCARF and Interim Facility. This donor stock collection recommendation is based on experience in previous years with broodstock survival from one life stage to the next, number of age three and four year-old spawners, fecundity, etc. However, these numbers can't always be accurately predicted and the SJRRP, in order to maintain adequate holding capacity for representatives across all brood years, may need to release salmon at various life stages from age-0 juveniles to adult, although the majority of releases are expected to be as age-0 juveniles at either the parr or smolt life stage. Other life stage releases, age-1 to adult, will be conducted to manage facility capacity and for use in studies to inform future decisions and management. Multiple brood years of different life stages may be released during the same calendar year; and a particular brood year may be released at various life stages over a multi-year period. All spring-run Chinook salmon released by the SJRRP will be adipose fin clipped and tagged (CWTs).

The SCARF provides opportunities to study the yearling and adult life stages as part of planned fish releases. Annual releases of yearlings will increase as the SCARF reaches full capacity. Criteria for releasing yearling and older broodstock will be based on:

1. Facility Carrying Capacity – To account for early rearing stage mortality, each year more broodstock will be collected for the Interim Facility-SCARF than may be held when they reach maturity. In addition, in an effort to increase the effective population size of the hatchery population, a ratio of 2:1 (male to female) are used during mating, thus resulting in ancillary females. The carrying capacity of the SCARF allows the spawning of approximately 450 adult females with 900 males annually. Each year up to 5,400 individuals may be collected across all stocks for broodstock development. Estimated rearing mortality accounts for losses of approximately 65 percent. In the spring of their second year, the fish inventory will be evaluated and fish releases will be made based on the anticipated loss in the coming years and the carrying capacity of the facility.

2. Genetic Relatedness Data – The genotype of the excess fish above will be examined, and fish will be selected for release in an effort to maximize the effective population size through reducing family size variance in the hatchery broodstock population.

3. Sex Ratio Data – Chinook salmon are a semelparous species. Early maturing first and second year males typically die, particularly in a captive rearing program. This disproportionate loss of males results in a skewed sex ratio. An uneven sex ratio can reduce the effective population size. Therefore, in a typical year more females will be selected for ancillary release than males due to the anticipated higher precocity rate and loss of first and second year males, and the desire to increase the effective population size by using a 2:1 (male to female) spawning ratio.

4. Incorporating Captive Reared Adults into Spawning Population – In effort to minimize hatchery induced selection, adults from the broodstock population will be released directly into the San Joaquin River to allow natural spawning. Adult broodstock would be transported from the Interim or SCARF facilities using a transport tank, typically from February through September. Adults would be released in Reach 1 and when possible, adjacent to available holding pool habitat. Transfer from transport tank to the river will be achieved when possible by using methods such as water-to-water transfer or released directly from the tank using a pipe or shoot. Direct netting of fish would be minimized to the extent possible to reduce injury and fish stress. Yearling releases would be performed similarly to other juvenile releases and would be conducted with those releases as feasible.

<u>Juvenile Releases</u>: The fish will be released directly from the hatchery whenever possible when there is adequate flow in the river side-channel, and connectivity with the lower San Joaquin River outside the Restoration Area. Additional release locations may be necessary based on the condition of the river. Additional potential release sites are presented in Table 10.2 of the HGMP (CDFW 2016a). To minimize straying, juveniles would be released as far upstream as feasible based on river connectivity and expected survival out of the Restoration Area.

Juveniles will generally be released to the Restoration Area between February and April. Selection of sites will be made based on environmental conditions given the water year type. Shaded sites or sites with suitable water temperatures (<18ºC), depths (>1.5 m), and water velocities (~.2 m3/sec) will be selected. Temperature, depth, dissolved oxygen, and water velocity will be measured throughout the extent of the holding and release activities. When fish cannot be released adjacent to the hatchery due to barriers to outmigration, fish will be released below the last barrier. If required, fish may be held for up to several days to encourage further imprinting and acclimation.

Transportation procedures for the purpose of fish releases will vary depending on life stage to be released. Eggs will be place in a specialized Styrofoam shipping container and will be cooled and kept moist using non-chlorinated ice and transported in a dark environment. Upon arrival at the release site, eggs will be rehydrated and tempered to the receiving water by increasing the egg temperature 1ºC per hour until matching the receiving water temperature.

Juvenile and adult fish will transported to the release site using the following general guidelines (Carmichael *et al.* 2001):

1. Reduce the number of stressors

2. Reduce the severity of stressors
3. Minimize the duration of stressors
4. Minimize plasma ion disturbances
5. Minimize increases in metabolic rate

Fish will be released from the SCARF either directly to the San Joaquin River using a volitional release channel or transported to a release site using a standard fish transport tank. The transport tank will be filled with raw hatchery water supply immediately prior to transport. The transport water will be oxygenated using compressed oxygen cylinders with oxygen stones and impellor driven aerators. Dissolved oxygen levels will be monitored and maintained near saturation during transport. Transport water may be supplemented with sodium chloride to provide a physiologically isotonic concentration to minimize ionic disturbances. When possible, fish will be moved in and out of the transport tank without netting using a shoot attached to the transport tank to minimize stress and loss of slime. When possible, the release site will be near the SCARF and predicted spawning ground. However, releases may occur much farther downstream within the Restoration Area to avoid migratory barriers and transport time may be as long as 2 hours if necessary. Water will be tempered to two degrees Celsius of the river location receiving the fish before transferring fish. When possible, releases will occur at night to minimize predation.

Direct Translocation: *Eggs*: Eggs would be obtained from the FRFH. Eggs are preferred for collection because of the ability to target genetically diverse individuals and collect spatial and temporal diversity, while maintaining low risk to the donor population. Additionally, eggs provide the least amount of risk associated with disease transfer to the Restoration Area due to their ability to withstand disinfection and many pathogens are not vertically transmitted from parent to ova. The FRFH offers the opportunity for a consistent source of eggs for the SJRRP. FRFH protocols would be followed for the collection, fertilization and incubation of eggs at the FRFH. Procedures will also include pathology testing of ovarian fluid and potentially kidney/spleen tissues. Health inspection data for IHNV and bacterial kidney disease (BKD) are collected from ovarian fluid of returning adult females annually during spawning.

A number of eggs from a minimum of 50 crosses will be segregated for use by SJRRP. Due to space availability, the FRFH may be unable to segregate all crosses into individual egg trays. Therefore, the maximum number of crosses segregated may change each year. A minimum of 50 crosses will be selected by FRFH personnel for segregation throughout the spawning season to maximize genetic diversity.

In accordance with their permit, the FRFH will segregate eggs from individual crosses into egg trays that SJRRP will later target for collections. Once transfer of eggs has been approved by the CDFW Fish Health Lab based on the disease status, and the spring-run timing has been verified, a near equal number of eyed eggs from each cross will be enumerated by counting, weighing, or by estimating volumetrically up to the maximum allowed. This is the preferred method, since the SJRRP will have the opportunity to select from individual preferred crosses. Eggs from IHNV and BKD negative females will be properly disinfected at (or at the receiving location) FRFH and transported for translocation to the SIRF or additional streamside incubators.

As they develop into juveniles they will be reared at SIRF in 3 to 6-ft diameter circular tanks or may be transferred to in-river holding pens. All juveniles will be tagged (CWT) and clipped (adipose fin) when they reach the appropriate size. Eggs for direct translocation can be moved directly to the SIRF without being quarantined and will not be taken to either the SCARF or Interim Facility. Eggs for direct translocation may be moved directly to the Interim Facility without being quarantined when broodstock operations shift to the SCARF.

If the FRFH is unable to segregate enough eggs for direct translocation from preferred crosses, then the SJRRP may also select eyed eggs, up to the maximum allowed, from the FRFH spring-run egg trays. However, since the FRFH does not have the space to segregate all crosses it is likely that two to three different crosses may be in one tray. The SJRRP acknowledges that selecting eyed eggs using this method may reduce the number of available preferred crosses since a non-preferred cross (*i.e*., BKD or IHNV positive female parent) may be mixed with a preferred cross, thus requiring rejection of the entire tray.

All eggs destined for translocation to the San Joaquin River will be transported when the eggs are the most shock resistant. Trout and salmon eggs become progressively more fragile during a period extending roughly from 48 hours after water-hardening until they are eyed. The eggs must not be moved until this critical period has passed. During the eyed stage, eggs would be addled, cleaned measured, counted, and transported (Piper *et al.* 1986). Transport should occur between the eyed stage and several days prior to hatching.

Eggs will be placed in a specialized shipping container (*e.g*., Styrofoam cooler) to reduce excessive movement and limit damage to the egg membrane. Eggs will be segregated in wet cheesecloth, then placed in the shipping container, kept cool and moist using wet ice, and transported in a dark environment. Ice will be in a separate compartment of the shipping container, so as not to be in direct contact with the eggs. The ideal temperature for transport is between 5–10°C. A standard vehicle will be used to transport eggs. In order to ensure all spring-run Chinook salmon released are tagged, eggs will not be directly translocated into the San Joaquin River. Eggs will be transported to the SIRF for incubation and rearing to a size suitable for tagging.

<u>Juveniles</u>: An alternative method would be to take juveniles directly from raceways at the FRFH after eggs have hatched. If the SJRRP is unable to accept translocation fish until after egg trays hatch and juveniles are rearing in swim up troughs or raceways, then the SJRRP would select translocation juveniles from the spring-run raceways prior to any marking or tagging that would designate them as Feather River spring-run releases. Any juveniles released into the San Joaquin River will be adipose clipped and coded wire tagged. Tagging of direct translocation fish would occur at the SIRF where adequate holding and tagging facilities would be located. Prior to collections, the SJRRP will coordinate with FRFH staff and work closely with them during collections. The SJRRP will follow FRFH standard procedures and practices. Prior to transfer, fish will require a pre-transfer fish health inspection from the CDFW Fish Health Lab which will include the sacrifice of twenty fish per release group for analysis.

Any juveniles requiring transport directly to the San Joaquin River or another facility (*i.e*., SIRF) would be moved by transport tank. Transport will usually occur between January and April. The tank would be filled with water from the source stream or facility just prior to transport. Transport times would depend on the location, but may be as long as six hours. Before transferring fish, the water would be tempered to within 2°C of the water temperature at the receiving facility.

Once the juvenile spring-run Chinook salmon reach an appropriate size, they will be marked (adipose fin clipped), tagged (CWT), and released directly to the river. Pre-health assessment requirements, as defined by CDFW pathologists, will be followed for juveniles. Up to 20 fish per rearing system, but not more than a total of 80 fish, will be euthanized for fish health inspection. Additionally, up to 10 percent of juveniles may be held back and later released as yearlings.

Acclimation (Y/N) and duration of acclimation: Whether transferred directly from the SIRF, FRFH, or reared from eggs, juveniles released into the San Joaquin River would either be held in net pens or in transport tanks for acclimation and imprinting before being released to the river. Fish that are raised primarily on San Joaquin water will not require imprinting time. The required acclimation period will be determined as necessary by temperature differential (i.e., a holding time necessary to temper at rate not greater than 1°C /hour and not more than 5°C/day). These limitations are based on the following research: Tomasso 1993, DeTolla *et al.* 1995, and Eldridge *et al.* 2015. Holding times for acclimation may be reduced at the discretion of NMFS to increase predicted survival depending on river conditions (*e.g*., if fish in holding tanks are exhibiting signs of confinement stress). After the acclimation period, these fish will be released to predetermined locations along the San Joaquin River.

Volitional release (Y/N): The large-scale releases will occur either as direct volitional release from the SCARF or transported to offsite locations if migratory conditions in the Restoration Area do not support outmigration through the entire Restoration Area. Fish will be transported from the Interim Facility, SIRF, or SCARF using a transport tank. The tank will be filled with raw San Joaquin River water immediately prior to transport. Release sites will be within the Restoration Area, downstream of migratory barriers, and transport time will vary according to release site. Water will be tempered to near the temperature of the receiving water and will not exceed two degrees Celsius of the river location receiving the fish before releasing fish. When possible, releases will occur at night to minimize predation.

External mark(s): SCARF production/releases are 100 percent marked (adipose fin clipped), allowing for accurate evaluation of program contribution to natural production and effects of the program on the natural populations in the San Joaquin basin.

Internal marks/tags: All fish released will be tagged using CWTs. The tags (visually indicated by the removed adipose fin) will allow fish to be identified as belonging to a particular SCARF cohort. All captive broodstock will be tagged using 12 mm PIT tags after reaching a minimum length of 65 mm. Additional tagging methods may also be used including disc tags, genetic sampling for parental based tagging, or other agency approved marking methods.

Maximum number released: The proposed fish release levels will be based on: (1) the success of the Conservation Program, (2) quantities of fish from the source populations and (3) the success of the captive rearing program. The projected releases in Table 3 reflect the anticipated production level of the Interim Facility and up to the maximum production capabilities for which the SCARF was designed. The actual carrying capacity of the river system is currently under investigation and will be based on available rearing, holding, and spawning habitat. However, channel improvement and habitat enhancement projects for the SJRRP are planned to continue until 2030 (SJRRP 2015), and these projects will increase the carrying capacity of the system as the reintroduced population grows. Release levels over time will be tailored to accommodate the identified carrying capacity.

Broodstock Releases: In an effort to appropriately manage the broodstock population and in response to river conditions, releases may include up to 2,500 ancillary broodstock annually, primarily as yearlings (age 1+) or at age 2+ or older, as necessary for broodstock population management. Initially, up to ten percent of the broodstock offspring may be released as yearlings to simulate proportions in natural populations. The actual percentage of yearling releases may change over time based on information gained on the relative survival of release groups, facility operation needs, or new information regarding the proportion of yearling migrants in wild populations.

Adults may be released to the river as part of restoration and ongoing holding and spawning habitat assessments studying fish behavior as well as habitat availability and suitability of river conditions. The number of yearlings and adults released annually from hatchery production will be based on the recommendations of the Fisheries Management Workgroup in consultation with the Conservation and Genetics subgroups of the SJRRP.

Juvenile Releases: The number of juveniles produced and released from the Interim Facility or SCARF will increase over time as the facility reaches maximum production. However, actual production will vary year to year based on broodstock survival, fecundity and other factors. In some years, there may be a need to release juveniles to the river based on these unpredictable factors.

Table 3. Projected juvenile releases and associated broodstock source population(s)

Brood Year of Collected Donor Stock	Offspring Release Year	Target Number of Juveniles Released	Broodstock Source Population
2012	2016	48,350	FRFH
2013	2017	151,875	FRFH
2014	2018	200,000	FRFH
2015	2019	600,000	FRFH
2016	2020	700,000	FRFH
2017	2021	960,000	FRFH, Butte Creek, San Joaquin River
2018+	2022+	1,000,000	FRFH, Butte Creek, San Joaquin River

Additionally, to increase the broodstock effective population size, SJRRP increased collections to double the number of males. Because of the 50:50 ratio (males to females), and the unknown sex at time of collection, the doubled collection number produced an excess of the same number of females, that will need to be released to the river as ancillary broodstock. Target releases are expected to be approximately 150,000 juveniles in 2018 and should reach maximum production of up to 1,250,000 juveniles by 2021. In an effort to appropriately manage the broodstock population, and in response to river conditions, releases may include up to 1,000 ancillary broodstock.

Release location(s): After the acclimation period, fish will be released to predetermined locations along the San Joaquin River. Fish will be released as high in the system as possible, given water quality and passage conditions lower down in the system, or other logistical considerations.

Time of release: Juveniles will be released into the San Joaquin River intermittently from October through April, however most releases will typically take place between January and April depending on river conditions and fish size. Adult releases into the San Joaquin River will take place intermittently from February through October.

Fish health certification: Diagnostic procedures for pathogen detection will follow American Fisheries Society professional standards as described in the American Fisheries Society Bluebook (AFS-FHS 2007) and the California Department of Fish and Wildlife Fish Health Policy for Anadromous Fish Hatcheries (February 19, 2014).

If disease is identified, appropriate treatments will be prescribed by a CDFW Fish Pathologist as appropriate, and follow-up examinations will be performed as necessary. Fish health assessments will be conducted CDFW Fish Health Lab staff at critical points during fish husbandry in effort to prevent disease outbreaks. These include:

1. Analysis of ovarian fluid from female spawners
2. Analysis during quarantine and at least 30 days prior to transfer to SCARF
3. Analysis immediately prior to transfer to SCARF
4. Analysis prior to release to the wild
5. Analysis for diagnostic purposes during disease outbreaks

Pre-release health assessments include smolt index, fat index, plasma protein, blood hematocrit, *etc*., and are based on the work of Adams *et al.* (1993). Treatment methods prescribed by fish pathologists for disease outbreaks and treatment protocols will be carried out by hatchery staff. Depending on the cause of any outbreak, treatment methods may vary.

The transfer of out-of-basin fish to the Conservation Facilities requires preventative measures to avoid introduction of infectious disease. Some fish pathogens found in California are capable of severely impacting wild fish populations and disease issues can, and have, threatened captive rearing or broodstock programs.

Fish in hatcheries are particularly susceptible to disease due to high fish densities and the added stressors of the hatchery environment. The Conservation Facilities lie in close proximity to the San Joaquin Fish Hatchery, a major producer of rainbow trout for regional recreational fishing. A Bio-security Protocol is strictly adhered to in order to prevent disease transfer between the facilities (see Section 7 of the HGMP; Börk *et al.*, 2016). The three pathogens of highest concern

IHNV, BKD, and Whirling Disease (*Myxobolus cerebralis*). Transfer of a virulent pathogen to the trout hatchery or Interim Facility and SCARF, could result in the need to destroy the entire fish inventory for facility disinfection.

Therefore, careful fish health inspections are necessary prior to all fish transfers into a State hatchery facility. For broodstock collections, 60 individuals are sampled for a fish health assessment at the time of collection. After the quarantine period, another 10 are sampled for a pre-transfer health assessment prior to transferring to the rearing facility. These inspections include quarantining fish to investigate all instances of sick, moribund, and dead animals in an attempt to immediately identify the cause of the problem. In addition, a total of 60 fish from multiple brood years may also be euthanized for an annual facility fish health certification. To prevent introduction of pathogens to the Conservation Facilities, all eggs or fish collections from a given lot may be destroyed if these pathogens are identified during health assessments. After completion of the full-scale SCARF, and pending approval from CDFW Hatchery Coordinator and Fish Health Lab, the Interim Facility may be used for temporary holding, research, and quarantine prior to pathology clearance and transfer to the SCARF.

Fish will be euthanized during disease outbreaks to aid in the identification of pathogens and allow administering proper treatment. Six fish will be euthanized for each occurring epizootic event. In addition, to prevent potential disease outbreaks, diseased and or moribund fish will be removed from the healthy population and, if necessary, euthanized.

USFWS will work with CDFW Pathology to determine which quarantine facilities are appropriate for use. If sufficient quarantine cannot be provided by any of the backup facilities or another appropriate site, then proposed fish collections will cease. Quarantine facilities may also be used for short term holding and potentially longer-term holding, if the need arises. Under such circumstances, culture tanks will be made available at the facilities for that specific purpose.

Silverado Fisheries Base: Located in Yountville, California, Silverado would be the standard quarantine facility for all fish transfers. CDFW operates Silverado for the purpose of juvenile fish and egg quarantine. Previously, all eggs and juveniles going to the Interim Facility or SCARF have been sent to Silverado for quarantine and pathology and the SJRRP anticipates using Silverado for future quarantine. Typically, salmon can be housed at the facility between mid-November and mid-May of each year; however, CDFW has extended this holding period in the past by installing appropriate water refrigeration systems.

Interim Facility and SIRF: After completion of the full-scale SCARF, the current Interim Facility may be used as a quarantine facility pending approval by CDFW Fish Health Lab and/or for research. The Interim Facility will have the capacity to incubate eggs, rear juveniles, and hold adults prior to transfer to the SCARF. Additionally, the SIRF may be used for quarantine purposes. The SIRF uses its own water supply line and allows for isolated incubation and the holding and/or quarantine of fish to all but eliminate the risk of disease transfer to SCARF broodstock.

Alternative Quarantine: If other quarantine facilities are not available, then collections will be transferred to Center for Aquatic Biology and Aquaculture (CABA), located in Davis, California, as a backup. CABA's fish culture tanks utilize a secure source of well water which is generally considered free of fish pathogens. CABA has a capacity for hatching a minimum of 40,000 Chinook salmon eggs at one time and is capable of rearing them to approximately five grams.

1.3.1.4. Proposed adult management

Anticipated number or range in hatchery fish returns originating from this program: Though survival rates vary between hatchery programs, the SCARF will seek to achieve 85 percent survival from egg to hatching to match that experienced at FRFH in recent years (Cavallo *et al.* 2009) and 75 percent or better survival from egg to smolt stages over the duration of the program. Finally, the SCARF will aim to achieve greater than 49 percent survival from smolt to adult (Pollard and Flagg 2004).

During the fall of 2013, experimental fall-run Chinook broodstock were spawned at age-3 at the Interim Facility. Approximately 187,500 eggs were produced and survival to the eyed-stage was approximately 81 percent. However, egg to emergence was approximately 50 percent. The lower survival rate was likely due to the higher water temperatures (up to 62°F) that occurred during spawning. The high temperatures accelerated fungus growth, which reduced survival. Also, for reasons unknown, a high number of fry became emaciated and died, and never successfully transferred to the commercial diet. The high water temperatures were due to the ongoing regional drought, and, in response, the Conservation Program installed water chilling and water recirculation equipment. Also, there may have been a problem with the feed or particular batch of feed.

Spawning again occurred in the fall of 2015 at the Interim Facility with the first mature pairs of spring-run Chinook salmon broodstock. Approximately 84,400 eggs were produced which resulted in a survival to the eyed-stage of 77 percent and a survival from spawn to emergence of 63 percent. From emergence to juvenile releases, survival increased to 95.5 percent with a total survival from spawn to release of 60.2 percent. The number of emaciated fish was greatly reduced compared to the previous spawn. This was despite the ongoing drought conditions which resulted in ambient water temperature reaching 67 degrees Fahrenheit (°F). Water recirculation equipment was used to successfully reduce temperatures to between 55-58°F. In the fall of 2016, the Interim Facility will spawn the first age-4 adults, and it is anticipated that average body weight will increase and, as a result, fecundity and egg survival will continue to improve.

With a target release of 1,000,000 juvenile spring-run Chinook salmon once the SCARF is operational, up to 367,500 adults could return to the San Joaquin River Basin given the survival targets described above. However, actual escapement will likely be much less due environmental factors such as flows, temperature, predation, etc.

Removal of hatchery-origin fish and the anticipated number of natural-origin fish encountered: When determining the number of broodstock to collect, the Program considers the viability and extinction risk of the source populations, as well as how collections would affect those factors. The number of eggs or juveniles to collect annually is determined by permitting restrictions and the rearing capacity of facilities at the time of the collection. The target number for collection is described in the Program's annual DSCP. As broodstock and production capacity increase, collections will be expanded beyond the current Feather River population, to additional source populations including Butte Creek and the San Joaquin River.

Once the experimental population is established, efforts will be made to minimize the influence of hatchery-origin fish on wild fish in the experimental population, which includes progeny of repatriated, recolonizing, or returning spring-run Chinook salmon spawners. This will be achieved by maintaining a four-year mean Proportionate Natural Influence (PNI) above 0.67, consistent with Hatchery Scientific Review Group (HSRG) recommendations (HSRG 2004). PNI is the proportion natural-origin spawners in the broodstock (pNOB) divided by the sum of the proportion of effective hatchery-origin spawners on spawning grounds (pHOS) and pNOB (HSRG 2004).

The HSRG developed guidelines for “Integrated” hatcheries, with the goal of ensuring that natural selection outweighs domestication selection while a population is augmented by hatchery production. The HSRG did not explicitly consider the unique problems presented in a reintroduction effort and does not have explicit goals for such programs. While the HSRG recommendations would apply to a reintroduction after a wild population has been established, the recommendations are not appropriate for the early years of a reintroduction and should not be the goals for the initial stages of such efforts.

The Conservation Program’s goals, during the Reintroduction Period (2012-2020) and Interim Period (2020-2025), are different for two primary reasons. First, the HSRG work is predicated on the existence of natural population, and there is no natural population in the Restoration Area. A natural population must be established by the hatchery before the HSRG recommendations can be used to evaluate hatchery practices. Second, in a reintroduction, it is desirable that the genetics of the broodstock dominate for the first two generations to avoid founder effects and to ensure that as much diversity as possible is captured from the source populations (Fraser *et al.* 2008), before natural selection becomes the primary selective force. This contrasts with a typical hatchery situation, where the HSRG recommendations seek to minimize the hatchery influence on the natural population. After a natural origin population is established and begins adapting to the new river system, the HSRG recommendations will become applicable to the Program. The timing of the applicability of the HSRG recommendations will depend on the success of the reintroduction effort, but will almost certainly be applicable after the Interim Period and may begin to be applicable at the middle or end of the Reintroduction Period.

Appropriate uses for hatchery fish that are removed: In order to produce adequate numbers of adult broodstock, an ample number of spring-run Chinook salmon may be collected, which may result in surplus broodstock. Over the lifespan of the program, surplus fish will periodically be removed from the broodstock facility and preferably released to the San Joaquin River. Broodstock releases would depend on river conditions and suitability for spring-run Chinook salmon. Surplus fish may be released for reintroduction, research purposes, or held in the Conservation Facility for other research purposes. Instream research goals will depend on the life stage at the time of release. Research fish will be monitored for false migration pathways, predation, spawning behavior, and other life history traits. In some instances, surplus fish may be and have been euthanized, depending on permit conditions.

The Conservation Program will dispose of salmon carcasses in two ways. First, some carcasses arising from hatchery mortalities will be frozen and generally disposed of through the hatchery solid waste disposal system, which involves ultimate disposal at the municipal disposal facilities. Second, carcasses derived from mortalities that have undergone adequate depuration following chemical treatment may be used to provide nutrient loading in streams.

Are hatchery fish intended to spawn naturally (Y/N): Yes. The Conservation Program is an Integrated-Recovery Program intended to produce spring-run Chinook salmon for reintroduction purposes in order to restore a self-sustaining population in the San Joaquin River.

Performance standard for pHOS (proportion of naturally spawning fish that are of hatchery-origin): Hatchery produced adults in natural production areas should not exceed appropriate proportion of the total natural spawning population. The appropriate portion will vary based on the phase of reintroduction and the performance of the Conservation Program, with interim targets established by the Conservation Facility Subgroup (CFSG), but the four-year average pHOS should be trending down beginning in 2032. The four-year mean pHOS should be less than 15 percent ten years after the reintroduction period. Origin of adults will be based on physical marks, genetic analysis, otolith analysis, and/or identifying tags of a representative sample of the population.

Performance standard for stray rates into natural spawning areas: Returning adults may stray into other San Joaquin River tributaries, where they may interbreed with other Chinook salmon. The small numbers of spring-run Chinook salmon in the San Joaquin River tributaries and the lack of genetic analysis on them makes analysis of potential genetic effects very difficult. To minimize straying, juveniles would be released as far upstream as feasible based on river connectivity and expected survival out of the Restoration Area. It is also important to note, straying of returning adults may increase the genetic diversity of recipient populations resulting in potential benefits for San Joaquin Basin tributaries.

1.3.1.5. Proposed research, monitoring, and evaluation

Adult sampling, purpose, methodology, location, and the number of ESA-listed fish handled: Population monitoring and evaluation may include adult monitoring by video, acoustic tracking, visual surveys, and redd and spawning surveys. Adult abundance will be used as a measure for evaluating SJRRP success. Calculations from literature based on smolt to adult survival and ocean survival for fall-run Chinook salmon from the Stanislaus River were used to develop take numbers for broodstock collection and as benchmarks to assess reintroduction success. Adults are expected to return 2–4 years following juvenile releases.

<u>Camera Visual Monitoring</u>: Adults are anticipated to return January through August. A camera system (*e.g.*, VAKI) will be used daily to visually monitor when returning spring-run Chinook salmon adults enter the Restoration Area. The camera will be attached to a fyke net or weir as described in the adult trap and haul section. Spring-run Chinook salmon observed by this method will not be captured or handled. However, if river conditions are not suitable for operating a

camera system, some capture of adults (*e.g*., weir, fyke, or other method) may be necessary for adult monitoring.

Snorkel Surveys and Acoustic Tracking Surveys: Adults in the holding and spawning reaches will be monitored for survival and habitat utilization. Snorkel surveys will be conducted weekly to count and monitor over summering adult spring–run Chinook salmon in available holding pool habitat of the Restoration Area. Surveys will be conducted from February (or when adults first enter holding sub-reaches) through November. Fish will not be handled or captured during holding area observations, and mobile acoustic receivers may be used to track and monitoring fish tagged with acoustic transmitters. This monitoring will include physical habitat monitoring. Additionally, mortalities related to over summer holding will be monitored. As adult holding densities increase over time, density dependent factors affecting survival will be assessed (e.g., disease, stress, illegal harvest). This information will be included in annual reporting for this permit.

Spawning Surveys: Redd surveys and escapement surveys will be used to assess reproductive success of returnees. Genetic information may be collected from carcasses through the collection of tissues from fresh carcasses. Evaluation of adipose fin presence will be used to determine origin (*i.e*., hatchery versus Restoration Program, *etc*.). The head of any fish missing an adipose fin will be collected for CWT extraction and analysis. Escapement may be quantified by marking fresh carcasses using two external tags (*e.g*., individually numbered aluminum tags attached by hog ring to their maxilla). Escapement is defined as the number of individuals that escaped the recreational and commercial fisheries (*i.e*., survived) and were capable of producing offspring (Ross 1997). Although there is no commercial or recreational fishing for salmon permitted in the Restoration Area, evidence of poaching has been observed (*e.g*., picture on social media, hooks on carcasses; Castle *et al.* 2016).

Unique tag codes may be used for each individual to determine what week an individual was originally detected. Once marked, fresh carcasses will be released in flowing water to ensure "mixture" of the marked population. Recapture of marked carcasses in subsequent weeks will be identified as a recapture and their tag codes recorded. After processing marked and unmarked carcasses designated as decayed or skeletons, their tail will be cut off (between adipose and caudal fin) to prevent the unmarked carcasses from being double counted or marked carcasses removed from the mark-recapture study.

To limit the potential of fall-run Chinook salmon superimposing spring-run Chinook salmon redds, redd grates may be deployed. The initial implementation of redd grates will be to determine their effectiveness at deterring superimposition. If effective, redd grates will continue to be used to protect spring-run redds. Further details are included in the attached protocol for limiting introgression and superimposition of fall-run Chinook salmon on spring-run Chinook salmon.

Emergence traps will be used to assess egg survival in a subsample of redds as it relates to habitat conditions over time. If egg survival is lower than established habitat targets (*i.e*., lower than 50 percent), it could limit the SJRRP's success in reintroducing the population. This information will be used to recommend habitat restoration projects that may be needed to improve the spawning habitat conditions to support optimal egg survival.

Juvenile sampling, purpose, methodology, location, and the number of ESA-listed fish handled: Juvenile monitoring may consist of various outmigrant traps, and fry emergence monitoring. To evaluate survival and abundance, RSTs will be used throughout the Restoration Area. RSTs will be installed in the following general areas: near the State Route 99 Bridge, just downstream of the San Mateo Road crossing, and at a yet-to-be-determined location above the Merced River confluence in Reach 5. Once established, RST site locations will remain fixed each year unless changes in river conditions warrant the need to move them or if new RST sites are considered necessary for long-term study purposes.

CWT monitoring outside the Restoration Area (Mossdale Trawls, *etc*.) will be used to assess migration timing to the Delta. Additionally, acoustic and PIT tagging studies will use spring-run juveniles collected under this permit to begin to evaluate reach specific survival and movement patterns following the same protocols used currently for fall-run juvenile outmigration assessment.

Ongoing or future SJRRP studies that may encounter translocated spring-run juveniles include: Predator Assessment in Reach 1 Mine Pit Habitats; Evaluation of Juvenile Trap and Haul Techniques; Fish Assemblage Monitoring and Inventory; Juvenile Chinook Survival and Migration; and, Egg viability Assessment. Study plans for these studies are available in the Annual Technical Report for the San Joaquin River Restoration Program.

Rotary Screw Trap: The RST consists of a funnel-shaped cone that is screened and suspended in the water column between floating pontoons. The cone rotates as water flows past the trap, guiding the fish moving downstream into a live box that is attached to the rear of the trap cone. The RSTs are usually installed at a fixed location and they can continuously sample for extended periods. Fish are confined to the live trap, which will be checked at least once daily to process fish and remove debris. Under high debris loads, the trap will be checked and cleaned more frequently. If conditions in the livebox suggest that in-trap predation is a concern, fish refuge devices will be installed within the livebox to dissipate water velocities and reduce predation. If fish refuge devices seem to be causing mortality or injury to listed fish these features would be modified or removed to reduce their adverse effects. When monitored at the appropriate time interval relative to the number of fish being collected, RSTs result in low mortality rates.

Fyke Net or weir-style trap: Fish weirs are porous barriers built across streams to capture migrating fish in flowing waters and generally have much higher capture efficiency than RSTs. There are many different types of juvenile collection weirs and they can be constructed from a range of materials based on site conditions, but generally they function very similarly. Fyke traps or v-shaped weirs direct downstream migrating fish into a collection box. Similar to RSTs, these traps have very low mortality rates when checked and cleared of debris at least once daily. All juvenile traps (RST, fyke, and weir) will be emptied at least once daily, and more frequently when fish or debris loads require. Daily trap checks will include visual inspection, and traps will be cleaned and maintained as necessary.

Beach Seines: A seine consisting of a length of fine mesh netting with a weighted lead line bottom and floating buoy top line will be set from shore. The seine will be pulled through the water to encircle fish and then closed off against the adjacent shore, entrapping fish. Juvenile Chinook salmon entrapped in the seine purse will be subsequently processed and removed for transport. Seines of various lengths and mesh sizes may be used depending on location and conditions, and the number of personnel required to use the seine in manner that is safe for personnel and fish will vary accordingly. Personnel seining will be careful not to seine debris in a manner that could injure listed fish, and will inspect the seine in the water to be sure that all seined fish are accounted for and processed appropriately.

Emergence traps: Fry emergence monitoring will be conducted in conjunction with the carcass and red monitoring using emergence traps. A stratified random sampling design based on time periods and survey reaches will be used to select redds for emergence monitoring. Water temperature data for each redd will be obtained from the nearest California Data Exchange Center (CDEC) gaging station to estimate emergence timing via accumulated thermal units (ATUs) prior to installing emergence traps. ATUs will be calculated by adding average daily temperatures, 1 ATU = 1 °C for 1 day and assume that emergence will start at approximately 700 ATUs. Emergence traps will be installed on selected redds no more than two weeks (*i.e*., 3 to 14 days) prior to the start of expected emergence to minimize the potential for the traps to influence the hydro-geomorphology within monitored redds.

Emergence traps consist of 0.32 centimeter (cm) nylon mesh covering a steel frame and a 30.48-cm canvas skirt made of Dacron sailcloth buried vertically into the gravel to minimize lateral escapement of fish. Emergence traps are tear-shaped and contain a live-box at the narrower caudal end of each trap, which is oriented downstream. Emergence traps measure 2.42-m long and 1.83-m at the widest point, and had an area of approximately 2.83 m2. The live-box is assembled to collect emerging fry using a 3.79-L wide-mouth polyethylene bottle attached at the bottom to a 15-cm diameter funnel. Holes are cut into both sides of the live-box and 0.32-cm polypropylene mesh is attached with silicone to create a vent, allowing water to escape and minimizing fish mortality. A sock constructed of Dacron sailcloth extended from the downstream end of the trap to the live-box is attached using a hemmed drawstring around the lip of the funnel.

During installation, each emergence trap is placed on top of the distinct egg pocket. Subsequently, rebar measuring 0.95-cm thick by 76.20-cm long is installed around the emergence trap frame and secured to the frame using washers and hose clamps. The rebar is installed approximately 50-cm into the riverbed using a manual post pounder. Thereafter, a trench will be excavated around the edges of the trap at a depth of 30.48-cm or until the substrate becomes too armored for digging to continue. Finally, a canvas skirt is buried within the trench, the excavated area is backfilled, and the live-box is attached to the narrow caudal end of the emergence trap to begin sampling. Emergence traps will be checked and cleaned 2–3 times each week. Emerged alevin or fry captured within the live-box are counted and measured to the nearest mm fork length (mm FL). Other fish species (*e.g*., cottids, petromyzontids) captured in the live-box are identified to species, measured to the nearest mm FL, and enumerated. After processing, all fish are released into the river. When fish are no longer being collected within the emergence trap for one week, the emergence cap is removed and the redd is assessed for nonviable eggs, entombed alevins, and emerged juveniles that did not enter the live-box. This process helps to better assess survival rates or identify the presence of a "false redd" (*i.e*., no eggs were ever deposited at the location).

Marking, Tagging, and Other Procedures Conducted during RM&E Activities:
Handling and Anesthesia: All measuring and marking activities will require netting, removal, and handling. To minimize the likelihood of such affects, Tricaine Methane Sulfonate (MS-222) or carbon dioxide (*e.g*. Alka-Seltzer or compresses cylinders compressed gas) anesthesia will be administered to juveniles when necessary to complete handling procedures. Dosage of MS-222 will range between 25 and 100 parts per million (PPM), based on weight of the fish, ensuring the minimum amount of substance necessary to immobilize each individual for handling and sampling procedures. All processed fish will be allowed to recover before returning to the rearing tanks.

Fin Clip and Genetic Sampling: The entire population of captive reared broodstock will be genotyped for parental based tagging. A small fin clip will be collected from spawned fish and either dried on blotter paper or stored in ethanol. The tissue samples will be sent to the CDFW Tissue Archive in Sacramento where half of the tissue will be archived and half will be sent to a contracting lab for genetic analysis. In the lab, the genetic sample from each fish will be genotyped and identified for sex. The results will be stored in a parent database. Naturally spawned offspring will also be genotyped. Their parents will be located in the database and the stock and cohort of origin recorded.

Code Wire Tagging: CWTs are small (less than 1 mm) lengths of wire implanted into the snout of each juvenile fish using specialized automated equipment. Before spring-run juveniles are released to the river, each individual is tagged. Tagging occurs when the fish are at a minimum of 30 mm in length. Tagging facilities will consist of one or more mobile manual-tagging trailer(s), or an individual tagging station will be used. Inside the tagging trailer, fish are size graded and distributed to tagging stations with corresponding appropriately sized head molds for CWT insertion.

Tagging stations consist of a CWT machine, and quality-control device that ensures the tag is inserted. Calibrating CWT machines for appropriate tag length and insertion depth requires lethal take. The number of fish required for lethal take depends on multiple factors such as: size distribution of fish, the number of fish tagged, the number of days that fish are tagged, and the type of equipment used for tagging. The maximum numbers of take for the CWT process is listed in the take tables below. If the number of fish to be tagged places too high a demand on the three station manual-tagging trailer, another manual-tagging trailer may be brought in from the Merced Hatchery. The SJRRP may also at some point incorporate an automated tagging trailer into its tagging operations.

Passive Integrated Transponder Tag: Broodstock reared at the SCARF also will be tagged using 12 mm PIT tags after fish reach a length of 65 mm. Sterilized PIT tags will be implanted into the peritoneum. PIT tags will be used for monitoring individual fish throughout captivity. Reared juveniles would be measured and weighed, implanted with a PIT tag, and tissue would be collected for genetic analysis (as mentioned in Section 1.3.7.3.2 above). To minimize the potential for detrimental effects, MS-222 anesthesia would be administered to juveniles during measuring and weighing activities and PIT tag implantation.

External Tags: Captured fish may be tagged externally, below the dorsal fin, with a uniquely numbered disc or anchor tag (*e.g*., T-bar, dart, disc), to easily identify fish after release. Different color tags may be used to distinguish between gender, and release date. Adult fish will be anesthetized during all tagging activities using MS-222 or carbon dioxide.

Acoustic Tags: Juvenile spring-run Chinook salmon may be tagged with Juvenile Salmon Acoustic Telemetry System (JSATS) or other appropriate acoustic technology (e.g. tag transmitters appropriately sized for the individual fish). Tagging will be conducted in the Interim Facility, SCARF, SIRF or the mobile processing trailer. JSATS tag placement will involve surgical techniques requiring an approximate ½ inch incision closed by suturing with standard absorbable suture material by staff experienced in the procedure. Fish will likely be allowed to recover for long enough (depending on environmental conditions and discretion of biologists) to ensure no latent mortality from surgical implanting of tags.

Acoustic and Archival Tagging of Adults will either be: (1) surgically implanted through a one-inch abdominal incision and sutured closed, (2) gastrically inserted using a balling gun, or (3) attached to the fish externally by affixing the tag below the dorsal fin rays using stainless steel wire or fishing line inserted through the dorsal musculature would then be attached to the tag harness and excess mounting wire removed for a snug fit. Acoustic tags may be coupled with archival temperature tags by affixing each other with glue or by heat shrink tubing to improve recovery of archival tags. Tagged fish may be anesthetized to surgically implant tags.

Conditions Common to All Section 10(a)(1)(A) Permits that Involve RM&E Activities:
Upon issuance, research and enhancement permits include the following conditions to be followed before, during, and after the research activities are conducted. These conditions are intended to (a) manage the interaction between scientists and ESA-listed salmonids by requiring that research activities be coordinated among permit holders, and between permit holders and NMFS; (b) minimize impacts on ESA-listed species; and (c) ensure that NMFS receives correct information about the effects the permitted activities have on the species concerned.

All research permits issued by NMFS include the following conditions:

1. The permit holder must ensure that listed species are taken only at the levels, by the means, in the areas and for the purposes stated in the permit application, and according to the conditions in this permit.

2. The permit holder must not intentionally kill or cause to be killed any listed species unless the permit specifically allows intentional lethal take.

3. The permit holder must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that

captures a mix of species, the permit holder must process listed fish first to minimize handling stress.

4. In most research conditions, researchers must stop capturing and handling listed fish if the water temperature exceeds 22°C at the capture site. Under these conditions, listed fish may only be identified and counted.

5. The permit holder must use a sterilized needle or scalpel for each individual injection when PIT-tags are inserted into listed fish.

7. The permit holder must obtain approval from NMFS before changing sampling locations or research protocols.

8. The permit holder must notify NMFS as soon as possible but no later than two days after any authorized level of take is exceeded or if such an event is likely. The permit holder must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

9. The permit holder is responsible for any biological samples collected from listed species as long as they are used for research purposes. The permit holder may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

10. The person(s) actually doing the research must carry a copy of the permit while conducting the authorized activities.

11. The permit holder must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

12. The permit holder must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

13. The permit holder may not transfer or assign this permit to any other person as defined in Section 3(12) of the ESA. This permit ceases to be in effect if transferred or assigned to any other person without NMFS's authorization.

14. NMFS may amend the provisions of this permit after giving the permit holder reasonable notice of the amendment.

15. The permit holder must obtain all other Federal, state, and local permits/authorizations needed for the research activities.

16. On or before January 31st of every year, the permit holder must submit to NMFS a post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results.

17. If the permit holder violates any permit condition they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA section 10(d) findings are no longer valid.

"Permit holder" means USFWS or any employee, contractor, or agent of the SJRRP that is acting under the authority of Permit 20571.

1.3.1.6. Proposed operation, maintenance, and construction of hatchery facilities

Salmon rearing and management activities will occur at the SCARF, the Interim Facility, and the SIRF. Each of these facilities has separate water supply lines, so they can be operated independently without risk of disease transfer through the water supply. The Interim Facility is located on the grounds of CDFW's SJH, and has been operational since 2010. The full-scale SCARF will be located next to the Interim Facility along the San Joaquin River adjacent to the SJH in Friant, California about 20 miles northeast of Fresno (Fresno County) and one mile downstream of Friant Dam. The full-scale SCARF is anticipated to be operational in late 2018, at which time both facilities will be operational together. If the SCARF is not fully operational in 2018, the small scale Interim Facility will continue to be used for the captive broodstock program.

Interim Facility: The Interim Facility has been in operation since 2010 and now includes 3-foot and 6-foot diameter circular tanks, three 16-foot diameter circular tanks, and two 20-foot diameter circular tanks. Each tank is covered to prevent escape and predation. It is designed to rear and spawn about 50–100 pairs of adult salmon pairs annually and up to 200,000 juvenile salmon. For spawning and incubation, the Interim Facility includes 12-tray vertical flow incubators (Marisource®, Fife, Washington); deep matrix incubators; and a moist air incubator (ARED, Inc., Wrangell, Alaska). In addition, the Interim Facility includes water recirculation and chilling equipment that allows temperature control during incubation and rearing. The systems are capable of operating on flow-through to 95 percent recirculation and include chillers and water filters including solids filters, biological filters, UV sterilizer, aeration and real-time monitoring of water temperature and dissolved oxygen, with an alarm system to notify staff if parameters are out of range. Once the full-scale SCARF is operational, the Interim Facility may be used for quarantine and or for conducting fish research. The Interim Facility may also be used for the holding and spawning of returning adult spring-run, and the incubation and rearing of their offspring.

SCARF: The SCARF will consist of a hatchery building; a smolt production, captive rearing, and holding facility consisting of different sized containers or vessels, piping, and concrete channels for drains and volitional fish releases. The smolt production area would be an open-air area consisting of twelve 20-foot diameter and four 30-foot diameter circular culture tanks used for smolt production. Ventria (operable openings) on the side of the tanks would allow fish to voluntarily enter the release channel system during periods of fish outmigration. Additionally, six 8-foot, six 20-foot, and three 30-foot diameter circular culture tanks will be used for rearing and holding broodstock. The permanent SCARF will be designed to accommodate the maximum broodstock size of approximately 1,350 adult broodstock that are spawned at the hatchery per broodyear with a ratio of two males per one female. This maximum number of spawners takes into account additional fish from expected losses of initial broodstock collections due to survivability from one life stage to the next, ancillary releases of broodstock juveniles (0-1), yearlings (1+) and adults used for habitat studies on the river, etc.

SIRF: The SIRF includes four self-contained rearing units, each with five 6-ft diameter 500-gallon circular tanks. The systems are capable of operating on flow-through to 95 percent recirculation and include chillers and water filters. These systems could be used to incubate eggs or rear juveniles prior to release to the San Joaquin River. The SIRF could also be used as quarantine for collected broodstock or to temporarily hold adult spring-run Chinook salmon returning to the San Joaquin River until they are ready to be spawned. The incubation trailer at the SIRF includes vertical flow egg incubators, deep matrix incubators filled with either natural river substrate or artificial substrate (*e.g.*, Bioballs), and McDonald-style up-welling incubation jars. The trailer is equipped with a water chiller and recirculation system, filters, UV sterilizer, and an aeration system. There is real-time monitoring of water temperature and dissolved oxygen, with an alarm system to notify staff if parameters are out of range. The capacity of the incubation trailer and rearing tanks are approximately 140,000 juveniles per year.

Since 2012, the SIRF has been used for streamside spawning, egg incubation, and juvenile rearing of fall-run Chinook salmon captured in the San Joaquin River. Beginning in 2016, the SIRF was used to incubate spring-run Chinook salmon eggs and rear juveniles from the FRFH for translocation into the San Joaquin River. It is anticipated that as early as spring of 2018, the SIRF may also be used for the holding and spawning of returning adult spring-run Chinook salmon, and the incubation and rearing of their offspring.

Water source(s) and quantity for hatchery facilities: Water for the Conservation Program facilities (*i.e.*, Interim Facility, SCARF, and SIRF) will be supplied from Millerton Lake behind Friant Dam, which has a total capacity of 520,500 acre-feet (642,027,300 cubic meters). The watershed above Friant Dam drains 1,638 square miles (4,242 square km) on the western slope of the Sierra Nevada in Fresno and Madera counties and is bounded by the watersheds of the Merced and Fresno rivers on the north and the Kings River on the south. The geology of the watershed is primarily granitic. It extends east to the crest of the Sierra Nevada with a general ridge elevation of about 10,000 feet above mean sea level (3,048 meters), and occasional peak elevations greater than 13,000 feet (3,962 meters), and westward to Friant Dam about 25 miles (40 km) north from Fresno at an elevation of about 350 feet (107 meters) (SJRRP 2009).

The SCARF will be located adjacent to the existing CDFW SJH in Friant, California. Water flow at the SJH has been exceptionally reliable in its 65 years of operation, with only one disruption due to an underground pipe break. Water flow at the SCARF is anticipated to be equally as reliable. The SJH has successfully hatched and raised trout at the site since 1955 due to favorable water temperature and water quality conditions. The source water for the SJH is a continuous 35 cubic feet per second (cfs) supply of water that is gravity fed directly from Friant Dam. The water is delivered first to a Fish Release Hydropower Plant via two different pipelines: a 24-inch diameter pipeline from two Friant Dam penstocks, and a 30-inch diameter pipeline that takes water from the Friant Kern Canal near the left dam abutment. The temperature of the water in each pipeline varies throughout the year, and valves are used to control the flows to maintain favorable temperature conditions for the SJH.

The SJH supply water and the adjacent river water are of the same origin and are fairly similar in temperature. During the late summer/fall period when water temperatures are a concern, the entire supply may come from the base of Friant Dam because water from the Friant-Kern Canal is too warm to use. Water supply is typically maintained between 45-55 °F (7.2-12.8 °C) throughout the year, historically dipping as low as 42 °F (5.6 °C) or as high as 58 °F (14.4 °C). However, during the recent drought when Millerton Lake's cool water pool was depleted, the San Joaquin River and temperatures at the hatchery have reached 60°F in 2013, 70°F in 2014, and 67°F in 2015. In response, the Conservation Program installed water recirculation and water chiller systems to maintain temperatures at acceptable levels at the Interim Facility.

The SJH effluent is regulated under Clean Water Act National Pollutant Discharge Elimination System (NPDES) permit No. CA0004812 Order No. R5-2004-0118 (General Order), administered by the Central Valley Regional Water Quality Control Board (RWQCB). The SCARF will submit a Notice of Applicability to be covered under the General Order as a separate facility. Because of planned flow rates at the SCARF to provide sufficient flushing and optimal conditions for fish rearing, temperature increase is anticipated to be minimal and will remain within the guidelines provided by the RWQCB.

Water diversions meet NMFS screen criteria (Y/N): Yes. The SCARF will be designed to conform to NMFS screening guidelines for effluent discharge. The SCARF's intake line will originate in Lake Millerton above Friant Dam, where there are no known listed fish species.

Permanent or temporary barriers to juvenile or adult fish passage: Historically, spring- and fall-run Chinook salmon populations in Central Valley rivers, including the San Joaquin River, were maintained by isolation through temporal and spatial differences in their run timing and spawning locations (Moyle 2002). Construction of Friant Dam blocked the spawning runs of both spring- and fall-run salmon, and channel dewatering and degraded water quality eventually led to extirpation of both runs. Flow management and habitat restoration are intended to eliminate dewatering and improve water quality within the Restoration Area, but Friant Dam still blocks upstream migration of spring-run salmon to their historical spawning reaches, relegating the spring-run to lower river reaches typically used by fall-run fish. Due to temporal overlap between the spring- and fall-run spawning periods, these two runs are vulnerable to spawning interference and genetic interactions in the form of introgression (Tomalty *et al.* 2012). Physically separating the two runs (once populations are established in the San Joaquin River), using temporary weirs will likely be necessary to minimize reproductive interference. For more information regarding the potential environmental effects associated with construction of the SCARF and Related Fisheries Management Actions, see the DEIR completed by CDFW (2013) referenced above.

Hills Ferry Barrier: The Hills Ferry Barrier (HFB) is an existing seasonal weir located approximately 850 feet upstream of the San Joaquin River's confluence of the Merced River. The HFB was not constructed as part of the SJRRP's conservation hatchery program, but it could be used in the future to support hatchery operations. It is currently used to redirect up-migrating adult salmonids during the fall, including fall-run Chinook salmon, into suitable spawning habitat in the Merced River. It impedes passage into the San Joaquin River above the confluence with the Merced River, where habitat and water quality are currently unsuitable for these fish. The HFB is operated every year from mid-September to mid-December. Under the SJRRP, restoration actions would be taken such that habitat in the San Joaquin River upstream of the HFB would be adequate to allow passage. At that point, the HFB may no longer be operated or be removed to allow fall-run Chinook into the Restoration Area or re-operated to serve as a control structure to segregate up-migrating spring- and fall-run Chinook salmon. Such reoperation would involve using the weir only during certain key seasons to minimize hybridization and other interactions between spring- and fall-run Chinook salmon.

The segregation would reduce adverse interactions between spring- and fall-run Chinook salmon, such as hybridization and redd superimposition. The HFB may also be moved downstream towards the confluence with the Merced River to reduce overtopping and bank erosion that occurs at the current location due to mobile sand substrate. The barrier may also be improved to accommodate SJRRP restoration flows. These modifications may involve constructing a permanent concrete sill to stabilize erosion and provide a solid barrier foundation with suitable anchoring points. In addition, methods for removal of invasive water hyacinth (*Eichhornia crassipes*) may be incorporated in the barrier's future design, as well as features for monitoring fish passage through the facility. The HFB may also be used for monitoring of fish populations.

<u>Reach 1A Separation Weir</u>: A structure similar to the HFB may be constructed in Reach 1A of the San Joaquin River (near the location where Hwy 41 crosses the river), just downstream of where most of the spring-run spawning is expected to occur. The necessity for and exact location, design, and operation of the Reach 1A Separation Weir have not yet been defined, but it would generally serve to minimize hybridization between runs and reduce the likelihood for redd superimposition. Once spring- and fall-run Chinook salmon are established in the Restoration Area and the quantity and quality of spawning habitat available to the salmon runs are better understood, an assessment of the necessity for the weir, and if necessary, a suitable location for the weir would be made.

<u>Weirs at Salt and Mud Sloughs and Other False Migration Pathways</u>: Salt and Mud sloughs are tributaries of the San Joaquin River in Merced County. Each year, some percentage of fish are able to make it past the HFB and are then unable to access suitable spawning habitat due to poor habitat conditions (*e.g.*, insufficient flow) and barriers that restrict fish passage. Fish that do migrate past the barrier are frequently entrained in Mud and Salt Sloughs, which typically have greater flow than the main stem San Joaquin River during the fall salmon migration period. These fish do not contribute to the fall-run Chinook salmon escapement numbers, and may therefore be considered "lost" to the tributary populations. Pursuant to the Stipulation of Settlement in NRDC vs. Rodgers, *et al.*, the SJRRP must evaluate the need to construct seasonal barriers to prevent adult anadromous fish from entering false migration pathways in the area of Salt and Mud sloughs. Structures similar to those described for the HFB and Reach 1A Separation Weir may be constructed near the entrance to Salt and Mud sloughs in Reach 5 and may be constructed at various other locations as deemed necessary in the future. The exact

location, design, and operation of these weirs have not yet been defined, but they would serve to prevent migrating salmonids from entering these non-suitable areas.

Consistent with current practices at the HFB, CDFW will manage the accumulation of plants, and debris in the vicinity of the segregation or barrier weir(s). The control methods include manual removal of plant material accumulated behind the weir. The weirs will be checked, and maintenance performed, at a minimum frequency of once per day (or as needed) when the weir(s) are in place.

Instream structures: The majority of the SCARF will be constructed on disturbed and developed lands adjacent to the river; a portion of the volitional release channel will be constructed in riparian forest associated with the San Joaquin River (CDFW 2013). The proposed volitional release channels will be connected to SCARF smolt production tanks, allowing fish to be released from the hatchery directly to the river without the need for transport, in an effort to maximize imprinting and thereby reduce straying. All tanks would have bottom and side drains to convey accumulated waste and permit volitional release of fish, respectively. A series of concrete channels would be constructed and attached to the side drains of the tanks to provide drainage and volitional fish releases to the secondary channel of the San Joaquin River. Operable openings on the side of the tanks would allow fish to voluntarily enter the release channel system during periods of fish outmigration. The volitional release channel would terminate in the secondary channel of the San Joaquin River where outmigrating fish could enter the river and migrate downstream.

Streambank armoring or alterations: Riparian and aquatic vegetation may be lost as a result of construction of SCARF structures in or near the secondary channel. The majority of the SCARF would be constructed on disturbed or previously developed land. However, SCARF construction activities related to the volitional release channel and return flow outfall could temporarily disturb riparian habitat. As described in the DEIR completed by CDFW (2013), implementation of the described mitigation measures will reduce impacts to a less than significant level.

The installation, removal, or repurposing of fish weirs could also potentially create loose soils and increase erosion on the streambanks. Project activities will be done in such a manner as to not increase erosion within the banks of the river during or immediately following rainfall events. All disturbed soils at project activity sites will be stabilized to reduce erosion potential, both during and following installation of equipment (*e.g.*, weirs, fyke nets, traps, *etc*.). After removal of such equipment, soils shall be stabilized and re-contoured, as necessary.

Pollutant discharge and location(s): Solid waste from fish culture tanks from the full-scale SCARF will be separated from the effluent using micro screen filtration, stored in a solid waste sump, dried, and removed from the premises. The Interim Facility is small enough to fall below the NPDES permit requirements. As noted above, the full-scale SCARF will obtain NPDES permit coverage, to ensure effluent discharge will not impact the San Joaquin River. Effluent discharge from the Interim Facility has been monitored since mid-2014. Water quality parameters the samples are analyzed for include total suspended solids (TSS) and biochemical oxygen demand (BOD). Since July 2014, most of the results have been "non-detect" for both

TSS and BOD, except on two occasions when BOD was measured at 1.0 mg/l. Regarding these water quality parameters, the hatchery effluent hasn't had any significant effect on receiving waters.

1.4. 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). For the purposes of this opinion, the action area includes the SJRRP Restoration Area, which is the San Joaquin River below Friant Dam (Figure 1) to the confluence of the Merced River, including select locations on the Mariposa and Eastside bypasses, and the entrances to the following off-channel sloughs: Mud Slough, Salt Slough, and Newman Wasteway. In addition, because the Proposed Action includes broodstock collection from Butte Creek and the FRFH, those locales are also part of the Action Area. Transport routes from the broodstock collection locales, and quarantine facilities (i.e. Silverado and CABA), are also included in the Action Area.

NMFS considered whether the San Joaquin River, the Sacramento/San Joaquin Delta, and the ocean should be included in the Action Area. The potential concern is a relationship between hatchery production and density dependent interactions affecting salmon growth and survival. However, NMFS has determined that, based on best available science and the number of fish released from Conservation Program annually, it is not possible to establish any meaningful causal connection between hatchery production on the scale anticipated in the Proposed Action and any such effects.

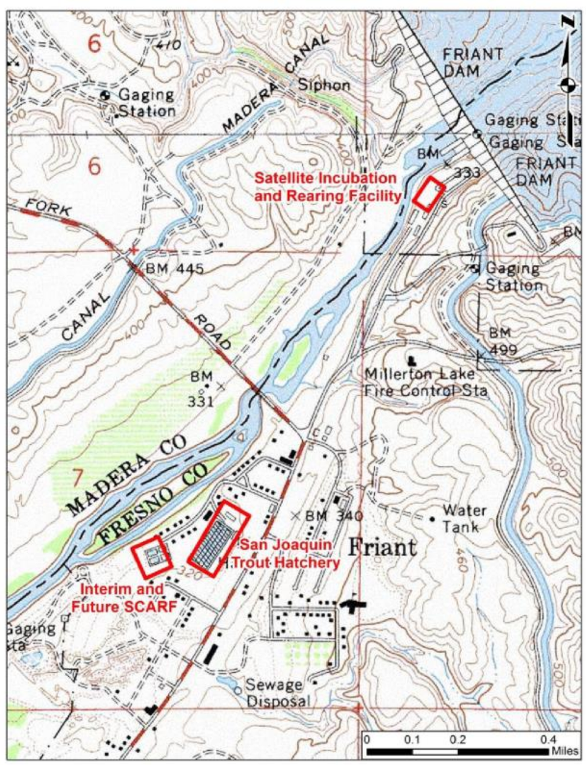

Figure 1. Location of SCARF, Interim Facility, and SIRF

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 habitat upon which they depend. As required by section 7(a)(2) of the ESA, Federal agencies must ensure that their 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 habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking on the affected population and includes non-discretionary reasonable and prudent measures (conditions for monitoring and research) to minimize such impacts.

2.1. Analytical Approach

This opinion includes both a jeopardy analysis and 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.

ESA Section 4(d) protective regulations prohibit taking naturally spawned fish and listed hatchery fish with an intact adipose fin but do not prohibit taking listed hatchery fish that have had their adipose fins removed (70 FR 37160, 71 FR 834, 73 FR 7816). As a result, researchers are not required to have a permit to take hatchery fish that have had their adipose fin removed. Nevertheless, this document evaluates impacts on both natural and hatchery fish to determine the effects of the action on each species as a whole.

This 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).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7214) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether the 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 likely 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. For research actions, exposure equates to capturing and handling the animals (including tagging, etc.); response is the degree to which they're affected by the actions (e.g., injured or killed); and risk relates to what those responses mean at individual, population, and species levels.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

In addition, NMFS has determined that the Proposed Action is likely to affect, but not likely to adversely affect, the SDPS of Southern Resident Killer Whales, as described in Section 2.11.

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that may 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 opinion also examines the status and conservation value of critical habitat in the action area and discusses the current function of the essential physical and biological features that help to form that conservation value.

The ESA defines species to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." NMFS adopted a policy for identifying salmon DPSs in 1991 (56 FR 58612). It states that a population or group of populations is considered an ESU if it is "substantially reproductively isolated from conspecific populations," and if it represents "an important component of the evolutionary legacy of the species." The policy equates an ESU with a DPS. In 1996, NMFS and the USFWS adopted a joint DPS policy, and in 2005 NMFS began applying that policy to *O. mykiss* (steelhead). Hence, CV spring-run Chinook salmon constitutes an ESU of the species *O. tshawytscha*; and CCV steelhead constitutes a DPS of the species *O. mykiss*. The generation of a nonessential experimental population of CV spring-run Chinook salmon in the Restoration Area is an additional factor to be considered. These ESUs and DPSs include natural-origin populations and hatchery populations, as described in the species status sections below.

2.2.1. Status of Listed Species

The descriptions of the status of species in this opinion are a synopsis of the detailed information available on NMFS's West Coast Regional website (http://www.westcoast.fisheries.noaa.gov/). The website links to more detailed information about life history information, distribution and Federal Register Notices. Table 4 below lists the federally listed species ESUs or DPSs in the action area that may be affected by the proposed action.

Table 4. Information pertaining to ESA listing and critical habitat designation of affected species.

Species	ESU or DPS	Original Final FR Listing	Current Final Listing Status	Critical Habitat Designated
spring-run Chinook salmon[5] (*Oncorhynchus tshawytscha*)	Central Valley ESU (and nonessential experimental population)*	9/16/1999 64 FR 50394 Threatened	6/28/2005 70 FR 37160 Threatened	9/2/2005 70 FR 52488
steelhead[6] (*O. mykiss*)	California Central Valley DPS	3/19/1998 63 FR 13347 Threatened	1/5/2006 71 FR 834 Threatened	9/2/2005 70 FR 52488

* Section 10(j) Nonessential Experimental Population Designation (78 FR 79622)

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species status: spatial structure, diversity, abundance, and productivity (McElhany *et al.* 2000). These viable salmonid population (VSP) criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

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[5] **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

[6] **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

“Diversity” refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany *et al.* 2000).

“Abundance” generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

“Productivity,” as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany *et al.* (2000) use the terms “population growth rate” and “productivity” interchangeably when referring to production over the entire life cycle. They also refer to “trend in abundance,” which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species’ populations has been determined, NMFS then assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species’ viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extirpations from mass catastrophes and spatially close to allow functioning as meta-populations (McElhany *et al.* 2000).

In addition to evaluating the species’ viability, we will discuss factors limiting their recovery and continuing threats they face. Factors that may limit recovery are the improper physical, biological, or chemical conditions (*e.g*., inadequate spawning habitat, habitat connectivity, high water temperature, competition, *etc*.) experienced by the fish at the population, intermediate (*e.g*., stratum or major population grouping), or ESU levels that result in reductions in VSP parameters (abundance, productivity, spatial structure, and diversity). Threats are the human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may be caused by the continuing results of past events and actions as well as by present and anticipated events and actions.

A species’ status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species’ status. The present body of scientific information on the status including the abundance, productivity, distribution, and genetic composition of anadromous salmonid populations in California is incomplete (Good *et al.* 2005, Spence *et al.* 2008, Williams *et al.* 2011). Information that is available and considered here can be found in a number of documents including the most recent status reviews: the 2005 Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead (Good *et al.* 2005), and the 2011 Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest (Williams *et al.* 2011). These documents (and other relevant information) may be found at www.westcoast.fisheries.noaa.gov; the discussions they contain are summarized below. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

2.2.2. California Central Valley Steelhead DPS

2.2.2.1. Species Listing and Critical Habitat Designation History

CCV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good *et al.* 2005) 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 (CNFH) 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 (National Marine Fisheries Service 2016b).

2.2.2.2. Critical Habitat and Physical or Biological Features (PBFs) for CCV Steelhead

Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). Designated critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the SJR, including its tributaries; and the waterways of the Delta (70 FR 52488). Currently the CCV steelhead DPS and critical habitat extends up the SJR up to the confluence with the Merced River. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. The southern terminus of designated area of critical habitat for CCV steelhead is the confluence of the Merced River, which is the northern terminus of the San Joaquin River portion of the action area. Therefore, CCV steelhead critical habitat does not occur within San Joaquin River portion of the action area.

2.2.2.3. Life History

Egg to Parr: The length of time required for CCV steelhead 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). A compilation of data from multiple surveys has shown that steelhead prefer a range of substrate sizes between approximately 18 mm and 35 mm (Kondolf and Wolman 1993). 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). Coble (1961) noted that a positive correlation exists between DO levels and flow within redd gravel, and Rombough (1988) observed a critical threshold for egg survival between 7.5 mg/L and 9.7 mg/L. 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. Fry begin exogenous feeding after these activities (Barnhart 1986, NMFS 1996).

The newly emerged juveniles move to shallow, protected areas within the stream margin (McEwan and Jackson 1996). This life stage is referred to as parr. As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas over shallow margin areas (Hartman 1965; Everest and Chapman 1972; Fontaine 1988).Growth rates have been shown to be variable and are dependent on local habitat conditions and seasonal climate patterns (Hayes *et al.* 2008).

In general, productive steelhead juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or boulders. Adequate 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 *et al.* 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).

<u>Smolt migration</u>: Juvenile steelhead will 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 and the Delta primarily as a migration corridor to the ocean. Some rearing behavior is thought to occur in tidal marshes, non-tidal freshwater marshes, and other shallow water habitats in the Delta prior to entering the ocean (National Marine Fisheries Service 2014b).

<u>Ocean behavior:</u> 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. 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, and amphipods, but by biomass the dominant prey items were small fishes (including rockfish and greenling) and euphausids.

<u>Spawning</u>: CCV steelhead generally enter freshwater from August to November (with the of the movement 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 weight from two to twelve pounds (Reynolds et al. 1993). Steelhead about 55 cm (FL) long may produce fewer than 2,000 eggs, whereas steelhead 85 cm (FL) long can produce 5,000 to 10,000 eggs, depending on the stock (Meehan and Bjornn 1991). The average for CNFH 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, Shapolov 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 CNFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for CNFH 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).

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 5. The temporal occurrence of (a) adult and (b) juvenile 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												
[2]Sacramento R. at RBDD												
[3]Mill & Deer Creeks												

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[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]Chipps Island (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 Rotary Screw Trap (RST) data for 2008-2013; [11]Oakdale RST data (collected by FishBio) summarized by John Hannon (Reclamation) ; [12](Schaffter 1980).

2.2.2.4. 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. 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.

Abundance and productivity: 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 1960's 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 1960's in the

Sacramento River upstream of the Feather River. Steelhead counts at the Red Bluff Diversion Dam (RBDD) declined from an annual 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. Two artificial propagation programs were listed as part of the DPS—CNFH and FRFH winter-run steelhead hatchery stocks (Table 6).

Table 6. Expected Annual CCV Steelhead Hatchery Releases (CHSRG 2012).

Artificial propagation program	Clipped Adipose Fin
Nimbus Hatchery (American River)	439,490
Feather River Hatchery (Feather River)	273,398
Coleman NFH (Battle Creek)	715,712
Mokelumne River Hatchery (Mokelumne River)	172,053
Total Annual Release Number	1,600,653

CNFH operates a weir on Battle Creek, where all upstream fish movement is blocked August through February or 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, CNFH 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 CNFH 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 2).

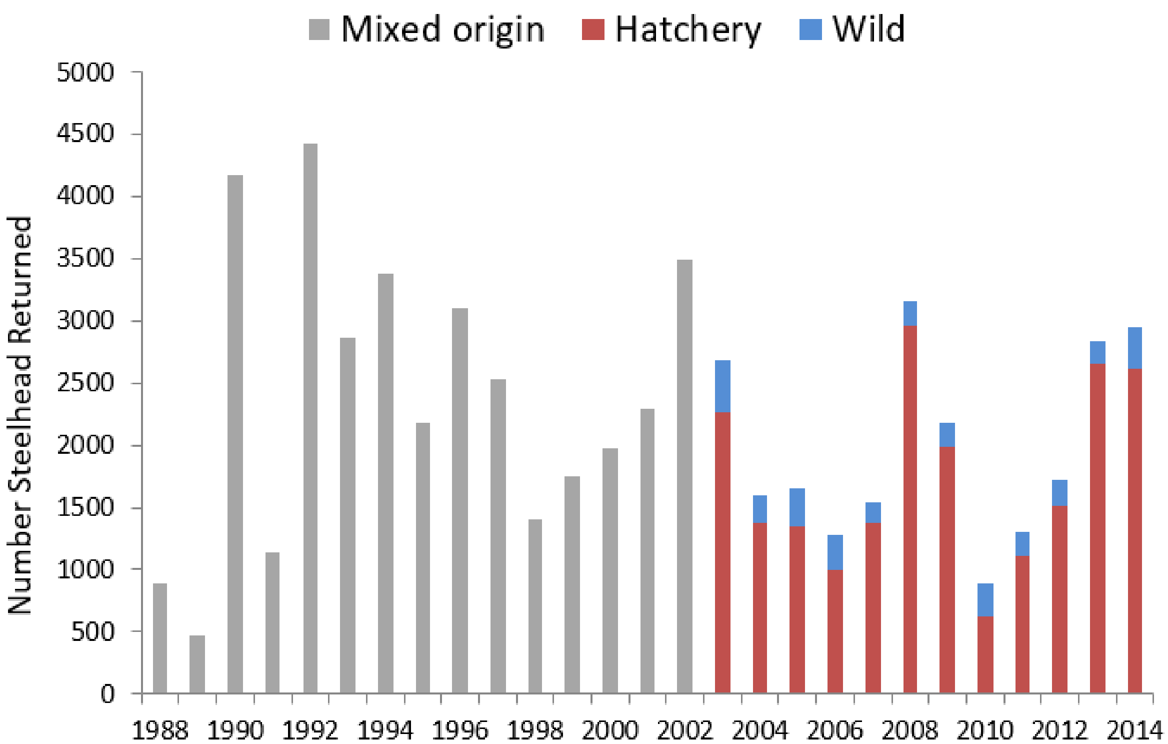

Figure 2. Steelhead returns to CNFH from 1988-2014. Starting in 2003, fish were classified as either wild (intact adipose fin) or hatchery produced (adipose fin-clipped).

Steelhead returns to CNFH have increased over the last four years. After hitting a low of only 790 fish in 2010, 2013 and 2014 averaged 2,895 adult fish (Figure 1). Since 2003, adults returning to the hatchery have been classified as wild (intact adipose fin) 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 averaging 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 annual average of 143 redds have been observed on the American River from 2002-2015 (Figure 3; USFWS unpublished data). Surveys were not conducted in some years on the American River due to high flows and low visibility, and so the timeline is not continuous. An annual average of 178 redds have been counted in Clear Creek from 2001 to 2015 (Figure 4; USFWS unpublished data). 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.

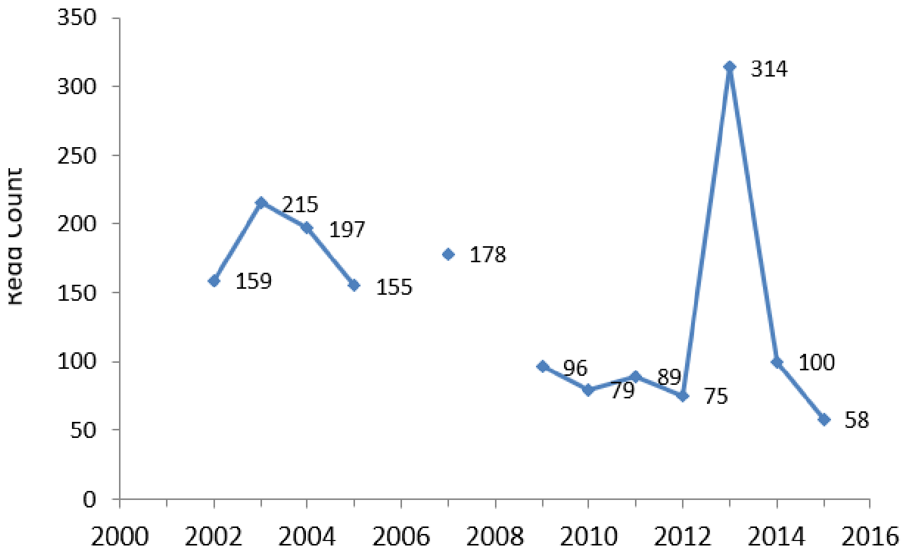

Figure 3. Steelhead redd counts from USFWS surveys on the American River from 2002-2015. Surveys could not be conducted in some years due to high flows and low visibility.

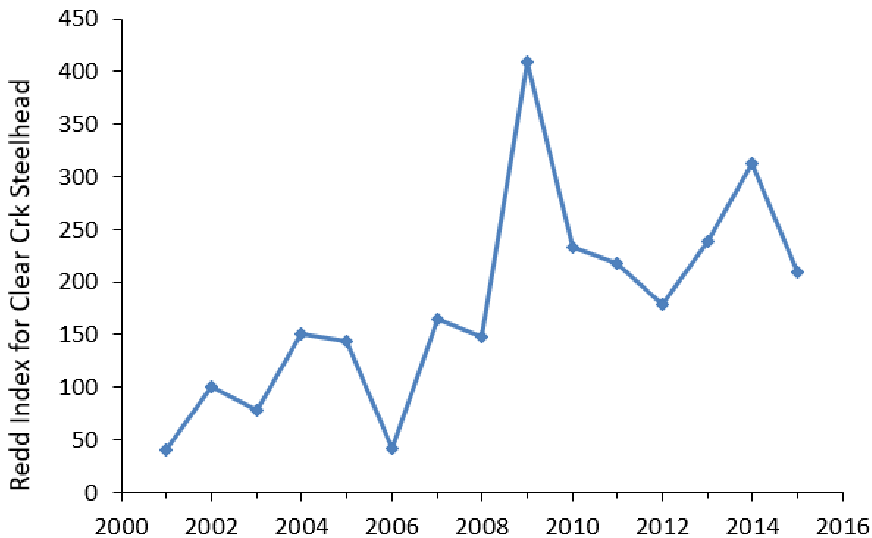

Figure 4. Redd counts from USFWS surveys on Clear Creek from 2001-2015.

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.* 2010), 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 (NMFS 2016).

The returns of steelhead to the FRFH experienced a sharp decrease from 2003 to 2010, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure 5). However, in 2012, 2013, and 2014 returns experienced an increase with 830, 1797, and 1505 fish returning, respectively. Almost all of 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 2000’s.

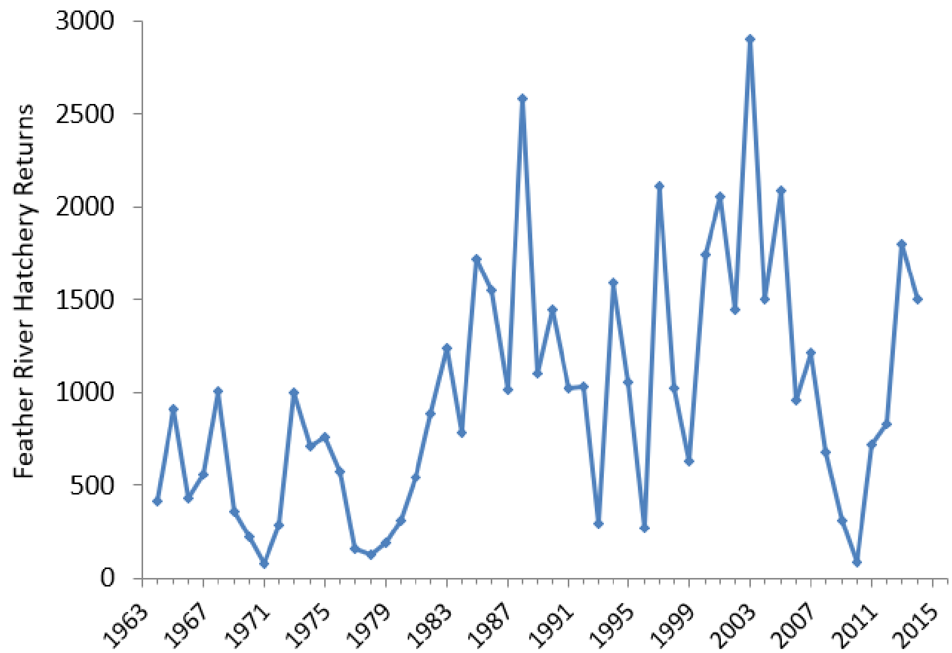

Figure 5. Steelhead returns to the Feather River Fish Hatchery from 1964-2015.

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 caught at the facilities. The overall catch of steelhead at these facilities has been highly variable since 1993 (Figure 6). Variability in catch in this data series is likely due to differences in water year types as Delta exports fluctuate. The percentage of unclipped steelhead seen in the salvage has also fluctuated, but has generally declined since 100 percent clipping at hatcheries started in 1998. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

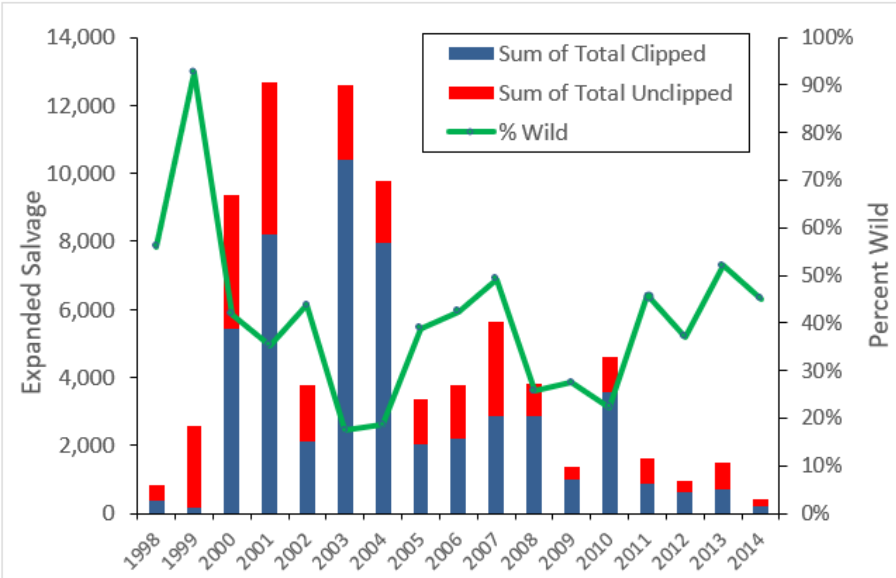

Figure 6. Steelhead salvaged at the Delta fish collection facilities from 1993 to 2014. All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFW, at: ftp.delta.dfg.ca.gov/salvage.

The years 2009 and 2010 showed poor returns of steelhead to the FRFH and CNFH, 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 (unclipped) 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.

Both adult and juvenile abundance data is limited for this DPS. Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2015 that no clear trend is present, other than the fact that the numbers are still far below those seen in the 1960's and 1970's. Returns of natural origin fish are very poorly monitored, but the little data that are available suggest that the numbers are very small, though perhaps not as variable from year to year as the hatchery returns. While we currently lack data on naturally-produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data (Table 5). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners, or 2,771 females), 9.7 million eggs are expected to be produced naturally annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 630,403 naturally produced outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million listed hatchery juvenile CCV steelhead each year (Table 7).

Table 7. Abundance geometric means for adult CCV steelhead natural- and hatchery-origin spawners (CHSRG 2012, Hannon and Deason 2005, Teubert *et al.* 2011, additional unpublished data provided by the NMFS SWFSC)

Population	Years	Natural-origin spawners	Hatchery-origin spawners	Expected number of outmigrants[ab]
American River	2011-2015	208	1,068	145,145
Antelope Creek	2007	140	0	15,925
Battle Creek	2010-2014	410	1,563	224,429
Bear Creek	2008-2009	119	0	13,536
Cottonwood Creek[f]	2008-2009	27	0	3,071
Clear Creek	2011-2015	463	0	52,666
Cow Creek	2008-2009	2	0	228
Feather River	2011-2015	41	1,092	128,879
Mill Creek	2010-2015	166	0	18,883
Mokelumne River	2006-2010	110	133	27,641
Total	**-**	**1,686**	**3,856**	**630,403**

[a] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant

[b] Based upon number of natural-origin spawners

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (*e.g.*, predation, floods, fishing, *etc*.).

Productivity is difficult to measure, and there is much uncertainty. The Mossdale trawls on the San Joaquin River conducted annually by the 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, this trawl data indicates that the level of natural production of steelhead has remained very low since the 2011 status review (Figure 7). 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 percent 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.* 2011). Because hatchery releases have been fairly constant, this implies that natural production of juvenile steelhead has been declining in the Central Valley.

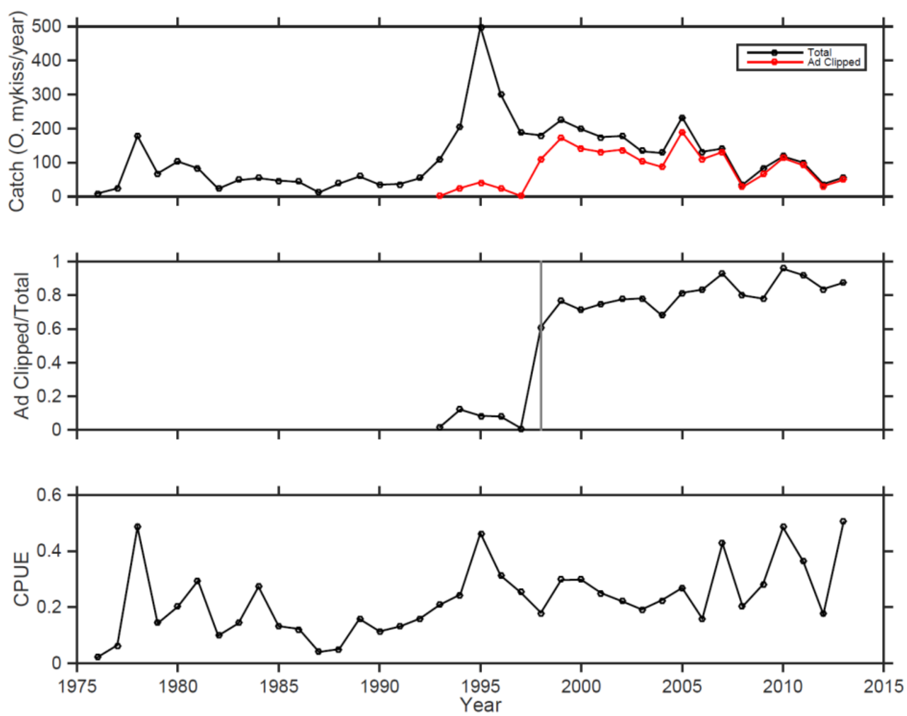

Figure 7. Top: Catch of steelhead at Chipps Island by the USFWS midwater trawl survey. Middle: Fraction of the catch bearing an adipose fin clip. 100% of steelhead production has been marked starting in 1998, denoted with the vertical gray line. Bottom: CPUE in fish per million m-3 swept volume. CPUE 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.

In the Mokelumne River, EBMUD has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011b). 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.

Additionally, on the Mokelumne River, it appears that many fish can reach a size large enough to smolt at age 1, but the slower-growing fish are better served to mature as young-of-year (YOY) and spawn at age 1 rather than risk the extra freshwater mortality associated with waiting to smolt at age 2 (since much less time must elapse before the age 1 spawning opportunity compared to age 2 emigration). However, once the first spawning opportunity has passed and even slow growing fish are large enough to have a moderate chance of survival in the ocean, it takes too long and exposes fish to too much risk of freshwater mortality to grow to a large enough size to spawn with much success as a resident female at an even older age.

These results suggests that restoration activities for CCV steelhead should focus on habitat improvements that both increase parr survival and growth in natal rivers, especially in the summer and fall period, and improve smolt survival in the lower river reaches, the Delta, and Bays.

<u>Spatial structure:</u> 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 steelhead most likely was much higher than that experienced by salmon because steelhead were undoubtedly more extensively distributed. 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, 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 CCV steelhead DPS. 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 accounts of steelhead in the Tulare Basin (Latta 1977).

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005, National Marine Fisheries Service 2016b). 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 Fish Sciences 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 2012, FISHBIO 2013a). In addition, 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 2013c). 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 San Joaquin River at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (CDFW 2013).

Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adult intercepted at the CNFH 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 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-San Joaquin River 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 San Joaquin 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 San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of CV spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for CV spring-run Chinook salmon could also benefit CCV steelhead (National Marine Fisheries Service 2016b).

Diversity: *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 higher risk of extinction (Lindley *et al.* 2007). There are four hatcheries (CNFH, FRFH, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of 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 therefore are not presently considered part of the CCV steelhead DPS.

Life-History Diversity - Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, defined by 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 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 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) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002; McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of Central Valley streams, presently located above impassible dams (Lindley *et al.* 2006).

Juvenile 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 and leaving at an earlier age but a smaller size (Peven *et al.* 1994, Seelbach 1993). Hallock *et al.* (1961) aged 100 adult 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 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 CDFW using rotary screw traps to capture emigrating juvenile steelhead (Johnson and Merrick 2012). Fish in the fry stage averaged 34 and 41 mm FL in Deer and Mill creeks, respectively, while those in the parr stage averaged 115 mm FL in both streams. Silvery parr averaged 180 and 181 mm FL in Deer and Mill creeks, while smolts averaged 210 mm and 204 mm FL, respectively. 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 steelhead have been shown to smolt at a very large size (270 to 350 mm FL), and nearly all smolts are age-1 (Sogard *et al.* 2012).

Summary of DPS 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.* 2005, National Marine Fisheries Service 2016b); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish production and returns, 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 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 San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance, and fluctuating return rates. Lindley *et al*. (2007) developed viability criteria for Central Valley salmonids. Using data through 2005, Lindley *et al.* (2007) 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, as 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 2016b) found that the status of the population appears to have remained unchanged since the 2011 status review (Good *et al.* 2005), when it was considered to be in danger of extinction.

2.2.3. Central Valley spring-run Chinook salmon ESU

2.2.3.1. Species Listing and Critical Habitat History

The CV spring-run Chinook salmon ESU was originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of Chinook salmon occurring in the Sacramento River basin. The FRFH CV 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 CV spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibitions, as all releases are marked by adipose clip. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

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

A final rule was published on December 31, 2013, 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 San Joaquin River as part of the SJRRP (78 FR 79622). Pursuant to ESA section 10(j), for the purpose of this conferencing opinion, the nonessential experimental population of CV spring-run Chinook salmon shall be treated as a species proposed for listing. However, the final 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.

2.2.3.2. Critical Habitat for CV Spring-run Chinook Salmon

Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488). The designated area of critical habitat for CV spring-run Chinook does not extend into the San Joaquin basin, and therefore does not occur within the action area.

2.2.3.3. Life History

<u>Adult migration and holding:</u> 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 (CDFG 1998) 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 8 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 also necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 3ºC (38ºF) to 13ºC (56ºF) (Bell 1990, California Department of Fish and Game 1998b). Boles (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).

<u>Adult spawning:</u> CV spring-run Chinook salmon spawning occurs in September and October and they are semelparous, meaning that they spawn once and then die (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 2007a). 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 from 1.2 feet/second to 3.5 feet/second, and water depths greater than 0.5 feet (YCWA *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, CDFG 2001).

<u>Eggs and fry incubation to emergence:</u> The 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 22 mm and 48 mm (Kondolf and Wolman 1993). The length of time for spring-run Chinook salmon embryos to develop depends largely on

water temperatures. In well-oxygenated inter-gravel environments 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 (NMFS 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) (NMFS 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 within 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 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).

<u>Juvenile rearing and outmigration:</u> 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 juveniles will also 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. Microhabitats 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 mainstems 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). Migration 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 Red Bluff Diversion Dam (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 then migrate downstream as young-of-the-year, juveniles, or yearlings (emigration timing is highly variable). The model 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 later migrated in the spring as yearlings. 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 (1998) 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).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. 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). They are also known to rear in floodplain habitats. Increased juvenile growth and floodplain residency times are positively related to accessible floodplain habitat (Takata *et al.* 2017). Floodplains can be characterized by a greater rate of photosynthesis and phytoplankton productivity which increases the juvenile salmonid food supply (Ahearn *et al.* 1989 in Opperman *et al.* 2010). Floodplains are inherently seasonal but have been largely developed in the central valley, decreasing access to an important rearing habitat for juvenile salmonids.

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).

<u>Estuarine rearing</u>: 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 3m 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.

<u>Ocean rearing</u>: Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high ocean productivity close to shore caused by the upwelling of the California Current. These food-rich waters are important to Chinook salmon 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 of 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 plankton is 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 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 Central Valley 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 8. The temporal occurrence of adult (a) and juvenile (b) CV 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: ■ = High ■ = Medium ■ = 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.

2.2.3.4. Description of 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).

Abundance and Productivity: Historically CV spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (CDFG 1990). CV spring-run 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 CV spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The SJR historically supported a large run of CV 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 (CDFG 1990). Construction of Friant Dam on the SJR began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRFH CV spring-run Chinook salmon population represents the only remaining evolutionary legacy of the CV 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.

Although FRFH CV spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibitions since they are adipose fin clipped. Between 2009 and 2013, the Feather River hatchery annually released an average of 2,178,601 juvenile adipose clipped CV spring-run Chinook salmon in the Sacramento basin (Table 9).

Table 9. Average annual CV spring-run Chinook salmon smolt release in the Sacramento Basin (Regional Mark Processing Center 2014).

Artificial propagation program	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Feather River Hatchery	Spring	2,178,601	-
Total		2,178,601	-

On the Feather River, significant numbers of CV 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 (CDWR 2001). However, after 1981, CDFG (now CDFW) ceased to estimate in-river spawning CV spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. CV 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, the moving averages rose back up slightly to just over 2,000 fish (CDFG Grandtab 2016). Genetic testing has indicated that substantial introgression has occurred between fall-run and CV spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (CDWR 2001). Because Chinook salmon have not always been spatially separated in the FRFH, CV spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the CV spring-run Chinook salmon stock (CDFG and CDWR 2012, Good et al. 2005). In addition, CWT information from these hatchery returns has indicated that fall-run and CV spring-run Chinook salmon have overlapped (CDWR 2001).

Monitoring of the Sacramento River mainstem during CV spring-run Chinook salmon spawning timing indicates some natural spawning occurs in the river. Here, 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 to determine, but counts of Chinook salmon redds made in September are typically used as an indicator of CV 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 (USFWS 2003). 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 (CDFG 1998).

CV spring-run Chinook salmon 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 1995, displaying broad fluctuations in adult abundance, ranging from 4,429 in 2009 to 26,663 in 2001 (Table 10). Escapement numbers are dominated by Butte Creek returns (Good *et al.* 2005), 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. During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish and just over 1,000 fish, in 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.

Table 10. CV spring-run Chinook salmon population estimates from CDFW (2016b) and FRFH counts (FRFH unpublished data).

Year	Sacramento River Basin Escapement Run Size	Feather River Hatchery Fish	Feather River Naturally Produced Fish	Tributary Populations
2006	24,059	13,334	4104	10,725
2007	13,084	3,856	5,900	9,228
2008	12,736	861	1,024	11,875
2009	4,572	1,132	333	3,440
2010	6,122	3,160	342	2,962
2011	10,269	4,464	1559	5,805
2012	25,095	6,407	1058	18,688
2013	37,658	18,256	1801	19,402
2014	13,868	6,743	546	7,125
2015	6,391	5,196	159	1,195
5-year Average	18,656	8,213	1,025	10,443

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21^{o}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 CV 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 CV 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 t 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 low level of escapement (NMFS 2016). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2016 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer, and Mill creeks (NMFS 2016). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek, have seen modest 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). Additionally, 2013 escapement numbers increased in most tributary populations, which resulted in the second highest number of CV spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 appears to be lower, with just over 5,000 fish observed for the tributaries combined, which indicates a highly fluctuating and unstable ESU abundance. Even more concerning was returns for 2015, which were record lows for some populations. The next several years are anticipated to remain quite low as the effects of the 2012-2015 drought are fully realized.

A final rule was published to designate a nonessential experimental population of CV spring-run Chinook salmon to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the SJRRP (78 FR 79622; December 31, 2013). The first release of CV spring-run Chinook salmon juveniles into the San Joaquin River occurred in April, 2014, with three subsequent releases occurring annually to date.

The 2016 release included the first generation of CV spring-run Chinook salmon reared entirely in the San Joaquin River in over 60 years, with previous releases consisting of fish being transferred from the FRFH. The SJRRP plans to increase the size of annual releases in coming years (Table 11).

Table 11. Historic Releases and planned juvenile releases for the non-essential experimental population of CV spring-run Chinook salmon into the San Joaquin River (NMFS 2016).

Offspring Release Year	Number of Juveniles Released
2014	60,114
2015	54,924
2016	104,880
2017	89,850
2018	200,000*
2019	600,000*
2020	700,000*

* Planned release

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.

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, 2015 was the lowest on record. Using the Butte Creek carcass surveys, the 2015 CRR for just Butte Creek was only 0.02 (Table 12).

Table 12. CV 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 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

While we currently lack data on naturally-produced juvenile CV spring-run Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The CDFG (1998) published estimates in which average fecundity of spring-run Chinook salmon is 4,161 eggs per female. By applying the average fecundity of 4,161 eggs per female to the estimated 5,734 females returning (half of the most recent five-year average of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the Sacramento River basin portion of the ESU could produce roughly 2.4 million natural outmigrants annually. In addition, hatchery managers are able to produce over two million listed hatchery juvenile CV spring-run Chinook salmon each year for the Sacramento River basin, and are expected to produce several hundreds of thousands of smolts for the experimental San Joaquin River basin. For the SJRRP NEP, it is possible that some of the experimental hatchery fish released in previous years will return to spawn this year. However, the outmigration and ocean survival rate of that group is unknown, and due to high flows, no substantial adult return monitoring has been feasible to date, so no estimate of their abundance is available. Therefore, an estimate of the abundance of the natural outmigrants those fish could produce is also not currently available.

<u>Spatial structure:</u> 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 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 objectives 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 since 1995 Battle Creek, in the basalt and porous lava diversity group, has had a small persistent population, 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, has 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 2013) .

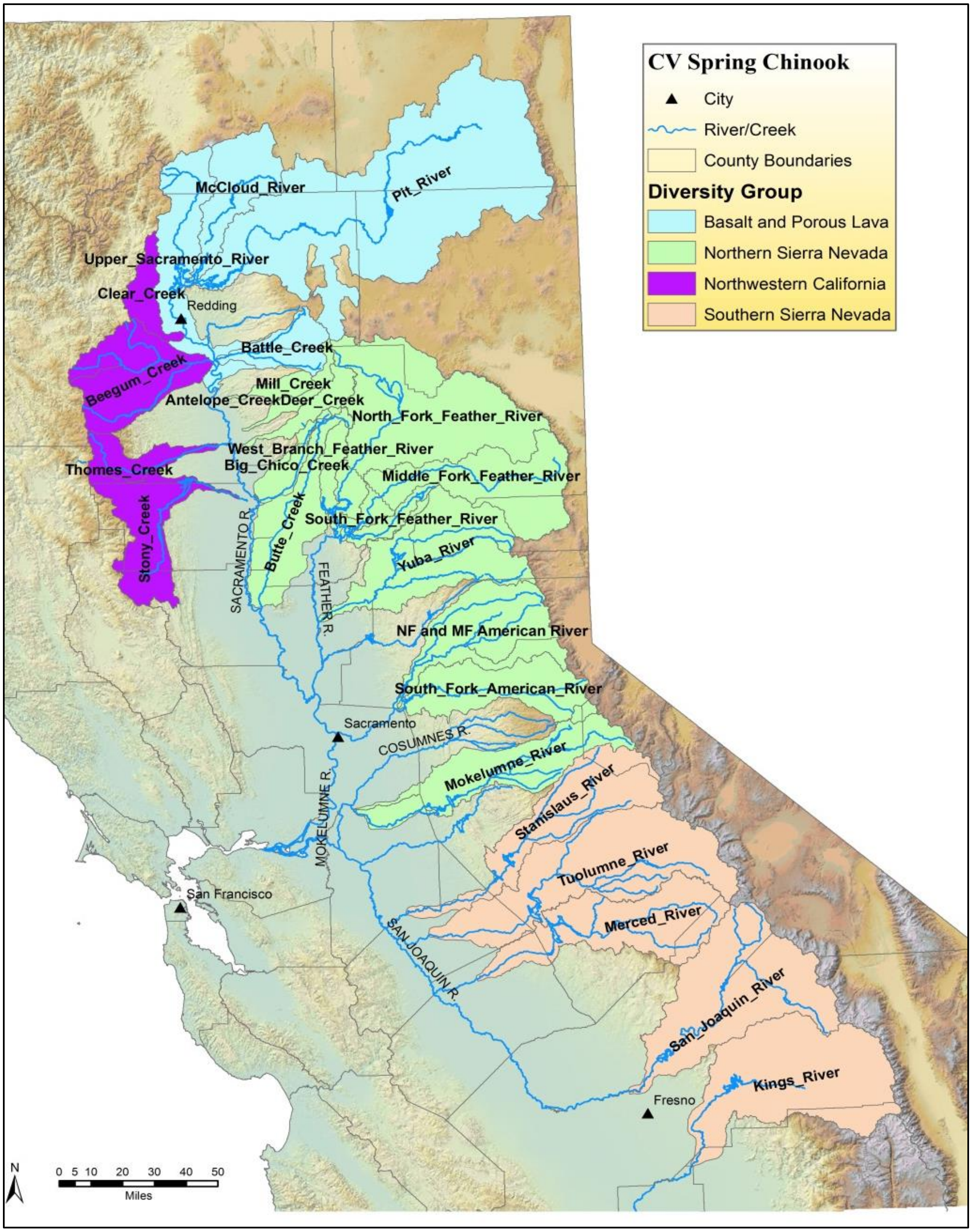

Figure 8. Map of the four diversity groups for the CV spring-run Chinook salmon ESU in California.

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 CV 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 projects 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 San Joaquin River Basin CV 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 San Joaquin River tributaries, most notably the Stanislaus and the Tuolumne rivers (FishBio 2015; Anderson *et al.* 2007; Franks 2014).

As noted above in the abundance section, a nonessential experimental population of CV spring-run Chinook salmon has been created to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the SJRRP (78 FR 79622; December 31, 2013). Annual releases of juvenile CV spring-run Chinook salmon have occurred each year beginning in 2014 (Table 8 above), but no adults have been observed returning to date. The SJRRP's future long-term contribution to the CV spring-run Chinook salmon ESU on the spatial structure of the larger population has yet to be determined.

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 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.* 2007b), and 114 adults were counted at the video weir on the Stanislaus River between February and June in 2013, only 7 individuals did not have intact adipose fins (FishBio 2015). Finally, RST data provided by Stockton 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 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.

Lindley *et al.* (2007) 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 Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014). In addition to maintaining dependent populations, 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, are needed for recovery. It is clear that further efforts will need to involve more than restoration of currently accessible watersheds to make the ESU viable. The NMFS Central Valley Salmon and Steelhead Recovery Plan calls for reestablishing populations into 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).

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). 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 comprised of two known genetic complexes. Analysis of natural and hatchery CV spring-run Chinook salmon stocks in the CV indicates that the northern Sierra Nevada diversity group of CV spring-run Chinook salmon populations in Mill, Deer, and Butte creeks have retained greater genetic integrity relative to the genetic the Feather River population, which has been somewhat compromised. The Feather River CV spring-run Chinook salmon have introgressed with the Feather River fall-run Chinook salmon, and it appears that the Yuba River CV 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 CV spring-run Chinook salmon populations. Efforts like the SJRRP (to reintroduce a spring-run population below Friant Dam), are needed to improve the diversity of the CV spring-run Chinook salmon population.

Summary of ESU viability: Since 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.* (2007) indicated that the CV 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 CV 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 Central Valley Salmon and Steelhead Recovery Plan. 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 CV 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.* (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of CV 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, CV 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.* 2011). 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's 2010 status review (NMFS 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 (NMFS 2016), 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. Since 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.

2.2.4. 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 percent 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 San Joaquin River 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 San Joaquin River and its tributaries.

Adult CV spring-run Chinook salmon are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson *et al.* 2011). CV 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. Environmental Baseline

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The 'Environmental Baseline' includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area and the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation (50 CFR 402.02).

In order to understand what is affecting a species, it is first necessary to understand the biological requirements of the species. Each stage in a species' life-history has its own biological requirements (Groot and Margolis 1991, NRC 1996, Spence *et al.* 1996). Generally speaking, anadromous fish require clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100 percent saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling. Embryo survival and fry emergence depend on substrate conditions (*e.g.*, gravel size, porosity, permeability, and oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 13ºC or less. Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting. Migration of juveniles to rearing areas, whether the ocean, lakes, or other stream reaches, requires free access to these habitats.

The environmental baseline for this opinion is therefore the result of the impacts that many activities (summarized below) have had on the various listed species' survival and recovery. It is also the result of the effects that climate change has had in the region (see Section 2.2.3 for discussion). Many of the past and present impacts on the species themselves (effects on abundance, productivity, *etc*.) are included in the Status of the Species section (see Section 2.2).

2.3.1. Status of the Species in the Action Area

2.3.1.1. Status of Central Valley spring-run Chinook Salmon in the action area

<u>San Joaquin River:</u> 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 (River Mile 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 CV spring-run Chinook salmon occurrence data and other available information suggest CV spring-run Chinook salmon were not recently present within the Restoration Area prior to SJRRP restoration activities.

The SJRRP started releasing juvenile CV spring-run Chinook salmon into the San Joaquin River: 60,114 juveniles from the FRFH in 2014, 54,924 juveniles from the FRFH in 2015, 57,320 juveniles from the FRFH and 47,550 juveniles from the Interim Facility in 2016, and 38,106 juveniles from FRFH and 51,044 juveniles from the Interim Facility in 2017. Some of the hatchery-reared juvenile CV spring-run Chinook salmon could have returned as adults to the San Joaquin River as early as spring 2016, but none were seen; likely due to the drought conditions of 2014 and 2015 causing low juvenile survival throughout the migration pathway to the ocean. No CV spring-run Chinook salmon have been observed returning to date in 2017, but any CV spring-run Chinook salmon that may have returned in 2017 would be unlikely to be detected due to extremely high water conditions.

Returning adult CV spring-run Chinook salmon do return they would be trapped within Reach 5 and hauled to Reach 1 until there is unimpeded passage, which is anticipated to occur in 2024. 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.

When adult CV spring-run Chinook successfully spawn in Reach 1, either after migrating naturally during a flood flow, being released as ancillary broodstock from the SCARF, or being trapped and hauled from Reach 5, juveniles could emigrate through the proposed action area. Ancillary adult broodstock (15 males, 10 females) were released in 2016, and produced three observed redds, but the success of those redds is unknown. Ancillary adult broodstock (60 males, 55 females) were also released in 2017, and produced 15 observed redds. Once the Mendota Pool compact bypass channel is operational, volitional passage will allow CV spring-run Chinook salmon to migrate through the proposed action area unimpeded. At this point, the likelihood of adult CV spring-run Chinook salmon migrating through the proposed action area to spawn in Reach 1 would significantly increase.

<u>Feather River Fish Hatchery:</u> The CV spring-run Chinook salmon ESU includes all naturally spawned populations in the Feather River as well as fish from the FRFH CV spring-run Chinook salmon program. NMFS' Central Valley Technical Recovery Team believes that the existing CV spring-run Chinook salmon population in the Feather River, including the hatchery fish, may be the only remaining representatives of an important component of the ESU, and that the FRFH CV spring-run Chinook salmon stock may play an important role in the recovery of CV spring-run Chinook salmon in the Feather River Basin (Lindley *et al.* 2004, Federal Energy Regulatory Commission 2007).

Before construction of Oroville Dam, CV spring-run Chinook salmon utilized the upper tributaries of the Feather River for spawning. CV spring-run Chinook salmon would ascend the Feather River in the spring and summer as sexually immature fish, and develop to maturity by fall and then spawn. Since the construction of Oroville Dam, fish passage has been halted on the Feather River at the Fish Barrier Dam just downstream of Oroville Dam. For the CV spring-run Chinook salmon that now return to the river, the options are to either spawn naturally in the river, utilizing the remaining habitat in the lower reaches of the Feather River below the Fish

Barrier Dam, or to ascend the fish ladder which begins at the Fish Barrier Dam and enters the FRFH where the fish are then artificially propagated.

CV spring-run Chinook salmon were impacted by a number of past human activities. Dams have eliminated access to historic holding, spawning, and rearing habitat and have resulted in CV spring-run and fall-run Chinook salmon spawning and rearing in the same areas, at the same times. This likely causes increased competition, superimposition of redds, and interbreeding of the two populations. Other anthropogenic activities that have impacted CV spring-run Chinook salmon include modification of the hydrograph, loss of sediment and large wood transport, restriction of lateral movement of the river channel, mining, unscreened water diversions, and riparian vegetation removal.

Adult CV spring-run Chinook salmon enter the Feather River as immature adults from March to June (Painter *et al.* 1977, Reynolds *et al.* 1993, CDFG 1998, Yoshiyama *et al.* 1998, Sommer *et al.* 2001) and spawn in the autumn during September and October (Sommer *et al.* 2001). Spawning occurs in gravel beds that are often located at the tails of holding pools (USFWS 1995) and most CV spring-run Chinook salmon spawn in the upper reaches of the low flow channel (CDWR 2007).

The abundance of CV spring-run Chinook salmon in the Feather River is highly variable by year, and natural in-river spawners should be counted separately from those fish that are spawned in the hatchery (Figure 9).

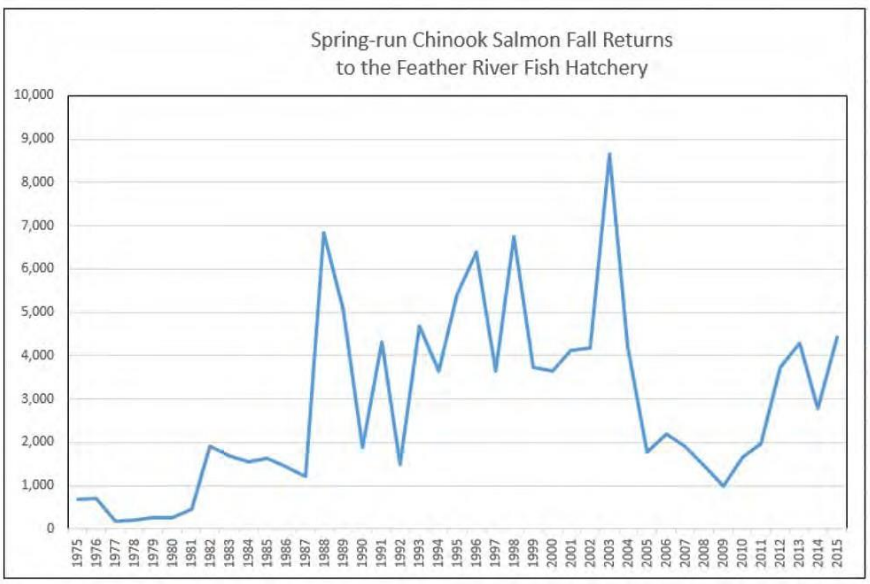

Figure 9. Fall Returns of CV spring-run Chinook salmon to the FRFH*

* Since 2004, FRFH staff keeps the fish ladder open during the spring months and those fish entering the ladder are marked with external tags and returned to the river. When these fish reenter the ladder in September, the hatchery staff can easily identify them as CV spring-run Chinook salmon and reduce the potential for hybridization between spring and fall runs (Brown *et al.* 2004). However, it is not easy to distinguish between CV spring-run and fall-run Chinook salmon in the river.

The diversity of CV spring-run Chinook salmon in the Feather River is highly compromised. Based on the historic geographical separation of CV spring-run and fall-run Chinook salmon during spawning, we would expect the two populations to be genetically separate. From a phenotypic perspective, there is characteristic behavior of an earlier entry into fresh water, as evidenced by the timing of Chinook salmon being in the low flow channel and the hatchery in the spring. However, genetic analysis using neutral microsatellite markers reveals that CV spring-run Chinook salmon in the Feather River are genetically very similar to fall-run Chinook salmon. Garza and Pearse (2008) showed that there are only marginal genetic differences between FRFH "spring-run" Chinook salmon, FRFH fall-run Chinook salmon, and naturally spawning Feather River fall-run. The overall picture was that the Feather River fish are so heavily introgressed with one another that defining features such as run identity (spring-run vs. fall-run) and production source (hatchery vs. natural origin) are not very distinct.

From the perspective of conservation biology, these facts are deleterious to the long-term viability of the species and the Feather River CV spring-run Chinook population. In other rivers that support CV spring-run Chinook salmon populations, namely Butte, Deer, and Mill creeks, we do not see the same flow of genes between CV spring-run Chinook salmon and fall-run Chinook salmon, and the two runs do not appear to interbreed much, if at all.

Between 1967 and 2004, CV spring-run Chinook salmon were differentiated at the FRFH from fall-run Chinook salmon by opening the ladder at the FRFH on September 1. Those fish ascending the ladder from September 1 through September 30 were assumed to be CV spring-run Chinook salmon (Kastner 2003). This practice led to hybridization between CV spring-run and fall-run Chinook from the Feather River (Brown *et al.* 2004). Since 2004, FRFH staff keeps the fish ladder open during the spring months and those fish entering the ladder are marked with external tags and returned to the river. When these fish reenter the ladder in September, the hatchery staff can easily identify them as CV spring-run Chinook salmon and reduce the potential for hybridization between spring and fall runs (Brown *et al.* 2004). However, it is not easy to distinguish between CV spring-run and fall-run Chinook salmon in the river.

<u>Butte Creek:</u> Butte Creek is one of three independent populations CV spring-run Chinook salmon that remains in the Central Valley (Lindley *et al.* 2004). Water conditions in sections of Butte Creek that contain spring-run Chinook salmon habitat are largely managed by the Pacific Gas and Electric (PG&E) De Sabla-Centerville Hydroelectric Project (DSCHP). Since 1999, the DSCHP was operated under a Project Operations and Maintenance Plan developed each spring in consultation with the state and federal fisheries managers for the protection and enhancement of Chinook salmon and steelhead. Under the plan, water is released from reservoirs on the Feather River, first from Round Valley Reservoir, followed by the release of water from Philbrook Reservoir as high temperatures occur during the summer. The operations have been variably successful, and Butte Creek has experienced recent returns ranging from below 2,000 adults to nearly 20,000 adults (Figure 10). Preliminary data for 2017 suggests that the adult return for 2017 is likely to be the lowest in the last 20 years. In addition, in February 2017 PG&E announced that it is withdrawing its application to relicense the DSCHP, and so the long term water operations, and the CV spring-run Chinook population that depends on that water, are currently unknown.

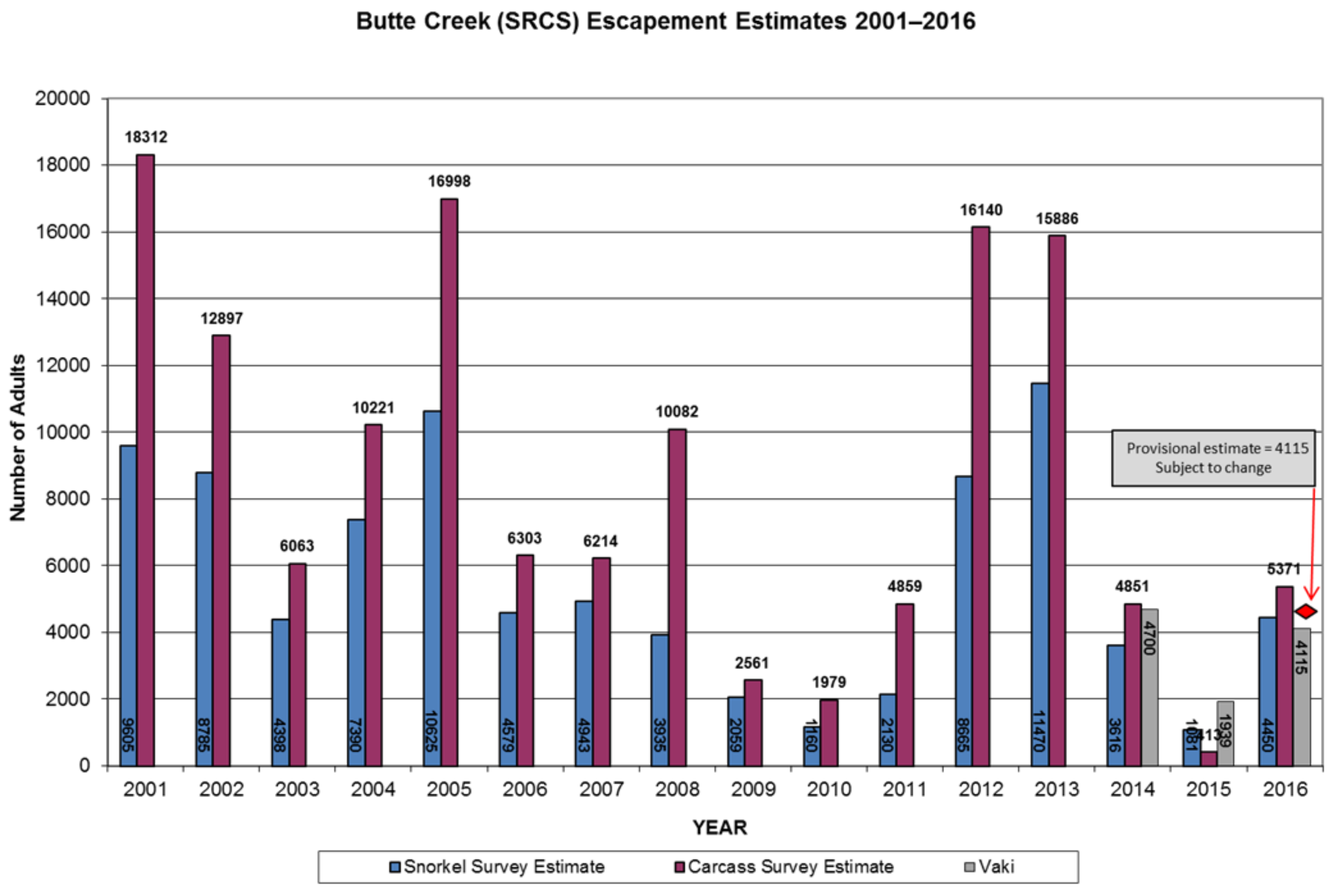

Figure 10. Butte Creek spring-run Chinook salmon spawning escapement 2001–2016. Note: This figure was adapted from personal communication with Clint Garman, CDFW, and the 2016 Butte Creek Spring-run Escapement Survey by CDFW (Garman 2016a).

Butte Creek has a genetically distinct and independent CV spring-run population (NMFS 2009). Genetic analysis of the Butte Creek population shows no hatchery influence despite of the addition of 200,000 juvenile spring-run from FRH in the 1980s to supplement low returns (Garza and Pearse 2008, Moyle *et al.* 2008, CDFW 1998). Based on the analysis thus far, the planted fish appear to have made no significant genetic contribution to the natural Butte Creek population. Aside from the 1986 planting, Butte Creek has not been planted with hatchery fish, and surveys consistently fail to detect significant straying into Butte Creek from other populations (McReynolds *et al.* 2007). Small numbers of fall-run, late fall-run, and/or winter run fish may also spawn annually in Butte Creek, although no introgression with these other runs has been detected.

The CDFW monitors outmigration of spring-run Chinook salmon from Butte Creek during most years beginning in 1995. During the 2015-2016 RST trapping period, fish were trapped at the PPDD location along Butte Creek. This site is directly downstream of the spring-run Chinook salmon spawning habitat and upstream of the fall-run Chinook salmon spawning habitat, although periodically some fall-run Chinook salmon do spawn above this site. The site was sampled with a 2.4 m diameter (8ft) RST. The 2015-2016 trapping period began during the fifth year of an unprecedented drought in California. First emerging fry are typically captured from mid to late November. However, during this trapping season the first fry was not caught until December 11th. The total season catch for 2015-2016 was 7,802 which is substantially lower than the 2014-2015, 2013-2014 and 2012-2013 periods with a catch of 52,142, 105,957 and 381,817 respectively. This is the fewest number of fry captured since juvenile monitoring began at PPDD in the late 1990's. The cessation of trapping for 12 days during January (peak emigration month) and the 2015 adult escapement estimate of 413 adults may explain the relatively few number of fry captured during the 2015-2016 trapping season (Garman 2016b).

2.3.1.2. Status of California Central Valley steelhead in the action area

While the action area includes the San Joaquin River, Butte Creek, and FRFH, activities proposed at Butte Creek and FRFH are not expected to have any detectable effect on CCV steelhead beyond those effects that would have occurred anyway without the proposed action. Therefore, this section only includes the status of CCV steelhead in the San Joaquin River component of the action area, and does not include information for CCV steelhead in Butte Creek, or for FRFH.

San Joaquin River: Historic abundance of CCV steelhead in the action area is difficult to determine, but CCV steelhead were once widely distributed, with abundance estimates of 1 to 2 million adults annually, throughout the Central Valley system as a whole (McEwan 2001). If CCV steelhead were currently present in the action area, the likelihood of survival would be low, as current conditions do not reliably provide suitable rearing or migratory habitat. Three successive years of monitoring in 2012, 2013, and 2014 failed to capture CCV steelhead in Reaches 4B and 5, leading to the belief that CCV steelhead have been extirpated from all reaches of the SJRRP Restoration Area (SJRRP 2012, SJRRP 2015). However, CCV steelhead are capable of accessing Reach 1 during flood conditions when the river or bypasses flow continuously from Friant Dam to the Merced River confluence. Monitoring would continue in the downstream reaches of the SJRRP Restoration Area as part of the CCV steelhead Monitoring Plan (SJRRP 2015).

Presence of anadromous fish upstream of the action area would initially be controlled by the progression of restoration actions within the SJRRP. Over the course of SJRRP proposed construction and restoration actions, the likelihood of salmonid presence in the area would increase due to fish passage improvements in the Restoration Area, and the increase in the regularity and volume of attraction flows. However, the likelihood of CCV steelhead presence in the action area would continue to be low, unless large flood releases were to occur. If CCV steelhead successfully migrate and spawn in Reach 1, juveniles and kelts could emigrate through the action area. Again, CCV steelhead present in the action area during the early stages of proposed action would likely experience low survival rates as the conditions would not yet reliably provide suitable rearing or migratory habitat.

While CCV steelhead are likely extirpated from the action area, SJRRP improvements in fish passage and flows may encourage some straying and recolonization of the area.

2.3.2. Factors Limiting Species Recovery

The best scientific information available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids. NMFS's status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). These include habitat degradation caused by human development and harvest and hatchery practices. Climate change also represents a potentially significant threat to all listed species. Climate change effects in the action area are as described in Section 2.2.4 and highlighted in some species individual status section.

Table 13 is a summary of the major factors limiting recovery of the species considered in this opinion; more details can also be found in the individual discussions of the species' status. Neither the document referenced in Table 11 nor any document referenced in previous sections identifies scientific research as either a cause for any species' decline or a factor preventing its recovery.

Table 13. Major Factors Limiting Recovery (Adapted from NOAA, NMFS, 2011 Report to Congress: Pacific Coast Salmon Recovery Fund FY 2000-2010, accessed at http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/pcsrf/pcsrf-rpt-2011.pdf).

	Estuarine and Nearshore Marine	Floodplain Connectivity and Function	Channel Structure and Complexity	Riparian Areas and Large Woody Debris Recruitment	Stream Substrate	Stream Flow	Water Quality	Fish Passage	Hatchery-related Adverse Effects	Harvest-related Adverse Effects	Predation/Competition/ Disease
CV spring-run Chinook Salmon	•	•	•	•	•	•	•	•	•	•	•
CCV steelhead	•	•	•	•	•	•	•	•	•		•

2.3.3. Factors Affecting the Action Area

The action area encompasses a small portion of the area that may be utilized by the CV spring-run Chinook salmon ESU and the CCV steelhead DPS. Many of the factors affecting these species throughout their range are discussed in the Status of the Species section of this opinion (2.2), and are issues in the action area. This section will focus on the specific factors in the action area that are most relevant to the proposed project rather than a complete re-examination of all factors.

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. Water that is pumped from the Delta via the Delta Mendota Canal forms Mendota Pool at the bottom of reach 2B. Mendota Pool has been dewatered multiple times for construction and maintenance of water conveyance infrastructure. 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 San Joaquin River can exceed 72°F 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 in tailwater sections of the river (Reynolds *et al.* 1993).

Point and non-point sources of pollution resulting from agricultural discharge and urban and industrial development occur upstream of and within the action area. 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 San Joaquin River (USFWS 1995).

The transformation of the San Joaquin River from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the river's sinuosity.

2.4. Effects of the Action

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized first in Section 2.4.1 and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.4.2. The "effects of the action" means the direct and indirect effects of the action on the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur. Effects of the Proposed Action that are expected to occur later in time (i.e., after the 10-year timeframe of the Proposed Action) are included in the analysis in this opinion to the extent they can be meaningfully evaluated. In Section 2.6, the Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects of future state and private activities within the action area that are reasonably certain to occur are analyzed comprehensively to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.4.1. Factors Considered When Analyzing Hatchery Effects

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science. These documents are available upon request from the NMFS Salmon Management Division in Portland, Oregon. “Pacific Salmon and Artificial Propagation under the Endangered Species Act” (Hard *et al.* 1992) was published shortly following the first ESA-listings of Pacific salmon on the West Coast and it includes information and guidance that is still relevant today. In 2000, NMFS published “Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units” (McElhany *et al.* 2000) and then followed that with a “Salmonid Hatchery Inventory and Effects Evaluation Report” for hatchery programs up and down the West Coast (NMFS 2004). In 2005, NMFS published a policy that provided greater clarification and further direction on how it analyzes hatchery effects and conducts extinction risk assessments (NMFS 2005). NMFS then updated its inventory and effects evaluation report for hatchery programs on the West Coast (Jones 2006) and followed that with “Artificial Propagation for Pacific Salmon: Assessing Benefits and Risks & Recommendations for Operating Hatchery Programs Consistent with Conservation and Sustainable Fisheries Mandates” (NMFS 2008a). More recently, NMFS published its biological analysis and final determination for the harvest of Puget Sound Chinook salmon which included discussion on the role and effects of hatchery programs (NMFS 2011).

A key factor in analyzing a hatchery program for its effects, positive and negative, on the status of salmon and steelhead are the genetic resources that reside in the program. Genetic resources that represent the ecological and genetic diversity of a species can reside in a hatchery program. “Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU” (NMFS 2005). NMFS monitors hatchery practices for whether they promote the conservation of genetic resources included in an ESU or steelhead DPS and updates the status of genetic resources residing in hatchery programs every five years. Jones (2011) provides the most recent update of the relatedness of Pacific Northwest hatchery programs to 18 salmon ESUs and steelhead DPSs listed under the ESA. Generally speaking, hatchery programs that are reproductively connected or “integrated” with a natural population, if one still exists, and that promote natural selection over selection in the hatchery, contain genetic resources that represent the ecological and genetic diversity of a species and are included in an ESU or steelhead DPS.

When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as "isolated". Generally speaking, isolated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or steelhead DPS. They promote domestication or selection in the hatchery over selection in the wild and select for and culture a stock of fish with different phenotypes, for example different ocean migrations and spatial and temporal spawning distribution, compared to the native population (extant in the wild, in a hatchery, or both). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany *et al.* 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes: abundance, productivity, spatial structure, and diversity and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS. "Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation" (Hard *et al.* 1992).

A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability, including abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (70 FR 37215, June 28, 2005). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. "Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness and productivity of the ESU". NMFS also analyzes and takes into account the effects of hatchery facilities, for example, weirs and water diversions, on each VSP attribute and on designated critical habitat.

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information on the general type of effect of that aspect of hatchery operation in the context of the specific application in the Sacramento River. This allows for quantification (wherever possible) of the various factors of hatchery operation to be applied to each applicable life-stage of the listed species at the population level, which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.6).

The effects, positive and negative, for two categories of hatchery programs are summarized in Table 14. Generally speaking, effects range from beneficial to negative for programs that use local fish[7] for hatchery broodstock and from negligible to negative when a program does not use

[7] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).

local fish for broodstock[8]. Hatchery programs can benefit population viability but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. The range in effects for a specific hatchery program are refined and narrowed after available scientific information and the circumstances and conditions that are unique to individual hatchery programs are accounted for.

[8] Exceptions include restoring extirpated populations and gene banks.

Table 14. Overview of the range in effects on natural population viability parameters from two categories of hatchery programs. The range in effects are refined and narrowed after the circumstances and conditions that are unique to individual hatchery programs are accounted for.

Natural population viability parameter	**Hatchery broodstock originate from the local population and are included in the ESU or DPS**	**Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS**
Productivity	**Positive to negative effect** Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (*i.e.*, productivity) (NMFS 2004).	**Negligible to negative effect** This is dependent on differences between hatchery fish and the local natural population (*i.e.*, the more distant the origin of the hatchery fish the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (*i.e.*, the greater the isolation the closer to a negligible affect).
Diversity	**Positive to negative effect** Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. Broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** This is dependent on the differences between hatchery fish and the local natural population (*i.e.*, the more distant the origin of the hatchery fish the greater the threat) and the level of isolation achieved by the hatchery program (*i.e.*, the greater the isolation the closer to a negligible affect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance and productivity of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215).	**Negligible to negative effect** This is dependent on the level of isolation achieved by the hatchery program (*i.e.*, the greater the isolation the closer to a negligible affect), handling, RM&E and facility operation, maintenance and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37215).	**Negligible to negative effect** This is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (*i.e.*, the greater the isolation the closer to a negligible affect).

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before formal review and analysis of the Proposed Action can begin.

Analysis of an HGMP or Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on seven factors. These factors are:

(1) the hatchery program does or does not promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS,
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas,
(4) hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean,
(5) RM&E that exists because of the hatchery program,
(6) the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
(7) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

The analysis assigns an effect for each factor from the following categories. The categories are:

(1) positive or beneficial effect on population viability,
(2) negligible effect on population viability, and
(3) negative effect on population viability.

"The effects of hatchery fish on the status of an ESU will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery within the ESU affect each of the attributes" (NMFS 2005). The category of affect assigned is based on an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the Environmental Baseline including the factors currently limiting population viability.

2.4.1.1. Factor 1. The hatchery program does or does not promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS

This factor considers broodstock practices and whether they promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS.

A primary consideration in analyzing and assigning effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological pros and the biological cons of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population tapped to provide hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure. Also considered here is whether the program "backfills" with fish from outside the local or immediate area.

2.4.1.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

NMFS also analyzes the effects of hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds. There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because at this time, based on the weight of available scientific information, we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that there are benefits as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011). Furthermore, NMFS also recognizes there is considerable uncertainty regarding genetic risk. The extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011).

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-induced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risk.

Within-population genetic diversity is a general term for the quantity, variety and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (*e.g.*, Lande and Barrowclough 1987), and diversity loss can be severe if N_e drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase N_e. In very small populations this can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987, Whitlock 2000, Willi *et al.* 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several, such as the Snake River sockeye salmon program are important genetic reserves. However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994). N_e can also be reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985, Withler 1988). Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Fiumera *et al.* 2004, Busack and Knudsen 2007). An extreme form of N_e reduction is the Ryman-Laikre effect (Ryman and Laikre 1991, Ryman *et al.* 1995), when N_e is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents.

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (*e.g.*, sibs, half-sibs, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993, 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Grant 1997, Quinn 1997, Jonsson *et al.* 2003, Goodman 2005), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from other populations can have two effects. Gene flow can increase genetic diversity (e.g., Ayllon *et al.* 2006) which can be a benefit in small populations, but it can also alter established allele frequencies and co-adapted gene complexes, and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007, McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstocks. Additionally, unusual rates of straying into other populations within or beyond the population's MPG or ESU or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (*e.g.*, Vasemagi *et al.* 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze hatchery affects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before finally spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer *et al.* 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Saisa *et al.* 2003, Blankenship *et al.* 2007). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, *e.g.*, differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977, Leider *et al.* 1990, McLean *et al.* 2004, Williamson *et al.* 2010).

Hatchery-induced selection (often called domestication) occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish, typically from the same population. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery selection can range from relaxation of selection, that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery-induced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and, (3) the duration of hatchery program operation (*i.e.*, the number of generations that fish are propagated by the program). On an individual level, exposure time in large part equates to fish culture, both the environment experienced by the fish in the hatchery and natural selection pressures, independent of the hatchery environment. On a population basis, exposure is determined by the proportion of natural-origin fish being used as hatchery broodstock, the proportion of hatchery-origin fish spawning in the wild (Lynch and O'Hely 2001, Ford 2002), and the number of years the exposure takes place. In assessing risk or determining impact, all three levels must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-induced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki *et al.* 2007, Araki *et al.* 2008), showed dramatic fitness declines in the progeny of naturally spawning hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies.
Critical information for analysis of hatchery-induced selection includes the number, location and timing of naturally spawning hatchery fish, the estimated level of interbreeding between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way.
Ecological effects for this factor (*i.e.*, hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer effects from competition for spawning sites and redd superimposition, contributions to marine derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative. To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline *et al.* 1990, Piorkowski 1995, Larkin and Slaney 1996, Gresh *et al.* 2000, Murota 2003, Quamme and Slaney 2003, Wipfli *et al.* 2003). As a result, the growth and survival of juvenile salmonids may increase (Hager and Noble 1976, Bilton *et al.* 1982, Holtby 1988, Ward and Slaney 1988, Hartman and Scrivener 1990, Johnston *et al.* 1990, Larkin and Slaney 1996, Quinn and Peterson 1996, Bradford *et al.* 2000, Bell 2001, Brakensiek 2002).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (*e.g.*, Montgomery *et al.* 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences in that to the extent there is spatial overlap between hatchery and natural spawners, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (*e.g.*, Fukushima *et al.* 1998).

The analysis also considers the effects from encounters with natural-origin that are incidental to the conduct of broodstock collection. NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish volunteering into the hatchery itself, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. Generally speaking, the more a hatchery program accesses the run at large for hatchery broodstock, *e.g.* the more fish that are handled or delayed during migration, the greater the negative effect on natural-origin and hatchery-origin fish that are intended to spawn naturally and to ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock. NMFS analyzes effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations. NMFS wants to know, for example, if the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder. NMFS also analyzes changes to riparian habitat, channel morphology and habitat complexity, water flows, and in-stream substrates attributable to the construction/installation, operation, and maintenance of these structures. NMFS also analyzes the effects of structures, either temporary or permanent, that are used to remove hatchery fish from the river or stream and prevent them from spawning naturally, effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations.

2.4.1.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

NMFS also analyzes the potential for competition, predation, and premature emigration when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct interactions when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish or through indirect means, when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (SIWG 1984). Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, when hatchery fish take up residency before naturally produced fry emerge from redds, and if hatchery fish residualize. Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making them more susceptible to predators (Hillman and Mullan 1989, Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989, Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Competition may result from direct interactions, or through indirect means, as when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). Specific hazards associated with competitive impacts of hatchery salmonids on listed naturally produced salmonids may include competition for food and rearing sites (NMFS 2012). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and, density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Although newly released hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-induced developmental differences from co-occurring natural-origin fish life stages are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons *et al.* 1994). Pearsons *et al.* (1994) reported small-scale displacement of juvenile naturally produced rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and naturally produced juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. They also may prey on younger, smaller-sized juvenile salmonids. Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts from residual Chinook and coho hatchery salmon on naturally produced salmonids is definitely a consideration, especially given that the number of smolts per release is generally higher, however the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas

in the vicinity of hatchery release points may be necessary to determine the significance or potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.
The risk of adverse competitive interactions between hatchery-origin and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990, California HSRG 2012).
- Operating hatcheries such that hatchery fish are reared to sufficient size that smoltification occurs in nearly the entire population.
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing naturally produced juveniles.
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location and timing if substantial competition with naturally rearing juveniles is determined likely.

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[9] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (direct consumption) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish and by the progeny of naturally spawning hatchery fish and by avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

[9] "Action area" means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986, Hawkins and Tipping 1999, Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999, Naman and Sharpe 2012). Hatchery steelhead timing and release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe *et al.* 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (Coho salmon and cutthroat, predominately) than their hatchery counterparts.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (SIWG 1984). Due to their location in the stream or river, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (Pearsons and Fritts 1999, HSRG 2004) but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Horner 1978, Hillman and Mullan 1989, Beauchamp 1990, Cannamela 1992, CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak *et al.* 1979, Bachman 1984, Olla *et al.* 1998).

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.

- Operating hatchery programs and releases to minimize the potential for residualism.

2.4.1.4. Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, in the estuary, and in the ocean

Based on a review of the scientific literature, NMFS' conclusion is that the influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions and, while there is evidence that large-scale hatchery production can effect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same thing is true for mainstem rivers and estuaries. NMFS will watch for new research to discern and to measure the frequency, the intensity, and the resulting effect of density-dependent interactions between hatchery and natural-origin fish. In the meantime, NMFS will monitor emerging science and information and will consider that re-initiation of Section 7 Consultation is required in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.1.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. Generally speaking, negative effects to the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces critical uncertainties. RM&E actions including but not limited to collection and handling (purposeful or inadvertent), holding the fish in captivity, sampling (*e.g.*, the removal of scales and tissues), tagging and fin-clipping, and observation (in-water or from the bank) can cause harmful changes in behavior and reduced survival. These effects should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties over effects of the Proposed Action on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agencies, NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the Proposed Action mix with and are not identifiable from other fish. The effect of masking is that it undermines and confuses RM&E and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking and whether and to what extent listed salmon and steelhead are at increased risk. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

The primary effect of the proposed RM&E activities on ESA-listed species would be in the form of capturing and handling the fish. While the proposed activity would provide a net-benefit by transporting the fish to areas that have access to more suitable habitat, and by providing valuable monitoring and research data, capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects, but the fish do sometimes die from such processes. The following subsections describe the types of RM&E activities being proposed. The activities would be carried out by trained professionals using established protocols. The effects of the activities have been well documented and are discussed in detail below.

<u>Observing/Harassing</u>: For some parts of the proposed studies, listed fish would be observed in-water (*e.g.*, by Vaki Riverwatcher monitoring). Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed because a cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur particularly in cases where the researchers observe from the streambanks or by video, rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

<u>Capturing/Handling</u>: Any physical handling can be stressful to fish (Sharpe *et al.* 1998). The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperature between the location of capture and wherever the fish are held, unsuitable DO conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or DO is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Debris buildup at traps can also kill or injure fish if the traps are not cleared regularly (Sharpe *et al.* 1998). Upon issuance, the section 10(a)(1)(A) permit conditions will stipulate measures that will mitigate or avoid such factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover fairly rapidly from handling.

<u>Weir</u>s: Weirs have long been used to capture migrating fish in flowing waters. Floating weirs create a temporary barrier in a channel and direct migrating fish through a single opening where they can be enumerated. Capture of adult salmonids by weirs is common practice in order to collect information regarding; (1) the number of adult salmon and steelhead entering a watershed; (2) the run timing of adult salmon and steelhead in a watershed; (3) the age, sex and length composition of the salmon that have achieved escapement into a watershed; and (4) the genetic composition of fish passing through the weir (*i.e.*, hatchery versus natural). Such

information pertaining to the run size, timing, age, sex and genetic composition of salmon and steelhead returning to the respective watershed can provide managers valuable information to refine existing management strategies.

A resistance board weir consists primarily of an array of rectangular panels made of evenly spaced pickets aligned parallel to the direction of flow. The upstream end of each panel is hinged to a rail that is anchored to the substrate and the downstream end of the panel is lifted above the surface by a resistance board that planes upward in flowing water. When all components are installed, the resulting barrier inhibits fish from migrating upstream except through the passing chute, yet allows water to pass. A passing chute on one of the panels guides fish into a livebox where they can be visually counted, electronically counted or captured, before being allowed to pass upstream.

Resistance board weirs are also easy to maintain because the upstream end of the weir is attached to the river bottom and the downstream floating end collapses under the weight of a person or two. Most debris can be passed down river without interrupting fish monitoring operations. The effects associated with temporary barriers such as resistance board weirs can be minor so long as debris is cleared regularly and live wells or holding areas are checked at least once daily..

Some weirs have a trap to capture fish, while other weirs have a video counting station or DIDSON sonar to record fish migrating through the weir. Weirs with or without a trap, have the potential to delay migration. All weir projects will adhere to the draft NMFS West Coast Region Weir Guidelines. The Weir Guidelines require the following: (1) traps must be checked and emptied daily; (2) all weirs including video and DIDSON sonar weirs must be inspected and cleaned of any debris daily; (3) the development and implementation of monitoring plans to assess passage delay; and (4) a development and implementation of a weir operating plan. These guidelines are intended to help improve fish weir design and operation in ways which will limit fish passage delays and increase weir efficiency

Fyke Traps: Fyke traps are essentially large cylinders, 10 feet in diameter and 19 feet in length. They are open at one end and contain two funnels which act as a one-way passage for fish and direct them into a pot or impounding area. The traps are always fished with the back or open end downstream. The two funnels face the same way, with the small openings upstream, and a fish must swim through both to enter the pot. The funnels and the exterior of the trap are covered with wire mesh netting. Captured fish are removed with a dip net through a door on the top of the pot or impounding area which opens into the pot.

To process fish, the trap should be rolled up the bank very slowly. If it is apparent that there is a large catch, overcrowding of the fish should be avoided by stopping the trap while it is fairly deep in the water. Fish can then be dipped out of the holding area until the density becomes low again. The trap can then be rolled a little farther up the bank or out of the water and the fishing process repeated. If the trap is rolled too far or too fast, there is likely to be a panic during which even medium-sized fish may injure themselves by swimming into the mesh. If the trap is moved slowly, the fish remain relatively calm and the likelihood of injure or mortality is reduced.

Seines and Block Nets: A seine is a net that traps fish by encircling them with a long wall of webbing. Typically, the top edge of a seine has floats, the bottom edge is weighted, and the seine has a brail (wooden pole) on each end. As the net is closed the fish become concentrated in the net. Seines are usually large enough that they are fished by two or more people though can be small enough to be fished by one person. Generally, seines are set in an arc around the targeted fish and then dragged to shore. Seines are effective for sampling littoral areas of lentic habitats. In lotic habitats, seines are most easily used in areas of low velocity, but can be used in high velocity areas if the brails are held in place while someone approaches the net from upstream, herding fish into the net. To be most effective, a seine needs to be deployed quickly enough that the target species cannot escape the encircling net. Accordingly, habitat structure and complexity negatively influence seine efficiency by reducing the speed at which one deploys a seine and by offering escape cover. Small fish can be gilled in the mesh of a seine. Scales and dermal mucus can be abraded by contacting the net. Fish can be suffocated if they are not quickly removed from the net after the net is removed from the water to process the fish. Also, the fish can be crushed by the handler when removing the net from the water.

While capturing fish with seine or block nets, fish may be injured or killed. Small fish may be gilled in the mesh of a seine and potentially injured. Fish can be suffocated if they are not quickly removed from the net after the net is removed from the water to process the fish. Scales and dermal mucus can be abraded if fish contact the net. Also, the fish can be crushed by the handler when removing the net from the water. To reduce the risk of injury to fishes, researchers will utilize seines with knotless nylon mesh to minimize scale and mucus abrasion. Seine tows will be of short duration and distance to prevent suffocation and to ensure that no debris (rocks, logs, *etc.)* are trapped in the seine that may suffocate or crush fish. Researchers will also select the smallest mesh-size seine that is appropriate to achieve sampling objectives to reduce the probability that smaller fish will become gilled in the net.

Rotary Screw Traps: The trapping, capturing, or collecting and handling of juvenile fish using RSTs is likely to cause some stress on ESA-listed fish. However, fish typically recover rapidly from handling procedures. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4°F (18°C) or if DO is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank.

The potential for unexpected injuries or mortalities among listed fish is reduced in a number of ways. In general, traps are checked at least daily and usually fish are handled in the morning. This ensures that the water temperature is at its daily minimum when fish are handled. Also, fish may not be handled if the water temperature exceeds 22.5°C. Great care must be taken when transferring fish from the trap to holding areas and the most benign methods available are used; this often means using sanctuary nets when transferring fish to holding containers to avoid potential injuries. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas.

Dip Nets: Dip nets are bag-shaped nets affixed to a frame attached to a handle. The net is placed under the fish and then lifted from the water in a scooping motion. Dip nets are useful when collecting fish that have been trapped by other methods, such as electrofishing or trap nets. Scales and mucus can be abraded by the net, and fish can be crushed by the frame when the handler is attempting to catch them.

Tissue Sampling/Fin Clipping: Tissue sampling is a common practice in fisheries science characterizing the genetic “uniqueness” and quantifying the level of genetic diversity within a population. Tissue samples should be small (less than 1.0 cm^2), collected from soft pelvic or caudle fin tissues using a pair of sharp scissors. Tissue samples should be preserved in individually labeled vials containing 95 percent ethanol.

Fin clipping is the process of removing part or all of one or more fins to alter a fish’s appearance (and thus make it identifiable).When entire fins are removed, it is expected that they will never grow back. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, severing individual fin rays (Welch and Mills 1981), or removing single prominent fin rays (Kohlhorst 1979). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (*e.g.*, Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly, especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes. Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it and Coble (1967) suggested that fish shorter than 90 millimeters are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped Coho salmon fingerlings have a 100 percent recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are clipped. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality, but other studies have been less conclusive.

Researchers will follow several precautionary measures to reduce the risk of stress and injury to ESA-listed salmonids from tissue sampling and fin-clipping, including: (1) only a very small amount of fin tissue (not more than 1.0 cm^2) will be collected from any fin, but primarily the upper lobe of the caudal fin; (2) fin-clips will be collected only from ESA-listed salmonids which appear to be in good condition and are not exhibiting injuries or abnormal behavior; and (3) all ESA-listed salmonids will be closely observed and allowed to recover fully before being released.

Tagging: Techniques such as PIT tagging, coded wire tagging, and the use of radio transmitters/acoustic tags are common to many scientific research efforts using ESA-listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

A PIT tag is an electronic device that relays passive signals to a radio receiver and allows individuals carrying the tags to be identified whenever they pass a location containing such a receiver without researchers having to recapture and handle the fish again to record its presence in the area. A PIT tag is usually inserted into the body cavity of the fish just in front of the pelvic girdle.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice *et al.* 1987, Jenkins and Smith 1990, Prentice *et al.* 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 kilometers), Hockersmith *et al.* (2000) concluded that the performance of yearling chinook salmon was not adversely affected by gastrically- or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Conner *et al.* 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

CWTs are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain in the animal indefinitely, consequently making them ideal for long-term, population-level assessments. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman *et al.* 1968, Bordner *et al*. 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon; however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher *et al.* 1987, Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally (usually by clipping the adipose fin) when the CWT is implanted (see text above for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead). CWTs are also collected during Escapement Surveys (*i.e.*, carcass surveys) and from hatchery broodstock (post-spawned carcasses).

The other primary method for tagging fish is to implant them with acoustic tags, radio tags, or archival loggers. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting tags is to place them in the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed in the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985, Mellas and Haynes 1985).

Fish with internal tags often die at higher rates than fish tagged by other means because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982, Matthews and Reavis 1990, Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. As with the other forms of tagging and marking, researchers will keep the harm caused by tagging to a minimum by following the conditions in the permits as well as any other permit-specific requirements.

2.4.1.6. Factor 6. Construction, operation, and maintenance, of facilities that exist because of the hatchery program

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles and adults. It can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to riparian habitat, channel morphology and habitat complexity, in-stream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

2.4.1.7. Factor 7. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of HGMP effects in a section 7 consultation. One is where there are fisheries that exist because of the HGMP (*i.e.* the fishery is an interrelated and interdependent action) and listed species are inadvertently and incidentally taken in those fisheries. The other is when fisheries are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed ESU or steelhead DPS, from spawning naturally. "Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

2.4.2. Effects of the Proposed Action

Analysis of the Proposed Action identified three factors that are likely to have a beneficial effects on CV spring-run Chinook salmon and CCV steelhead and on designated critical habitat. All other factors considered are likely to have negligible effects. An overview of the analysis is described below.

2.4.2.1. Factor 1. The hatchery program does promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS

Beneficial effect: One overarching goal of the SJRRP is to restore a spring-run Chinook salmon population to the San Joaquin River, as agreed upon in the Settlement. The historical San Joaquin River was extirpated and remaining CV spring-run Chinook salmon populations are at varying risks of extirpation. A specific goal of the SJRRP Fisheries Management Work Group is to promote and protect genetic diversity within the reestablishing populations while safeguarding against negative genetic effects to out-of-basin source and non-target populations. To capture the most genetic diversity while minimizing impacts to the source populations, broodstock collections will continue every year for at least two generations (*i.e*., six years), as guided by population growth of the wild San Joaquin River population and source population status. Annual broodstock collections will initially be focused on CV spring-run from FRFH and will expand to include collections from wild stocks in Butte Creek (depending on escapement numbers and over all wild population condition), and depending on escapement numbers, returning adults and any stray spring-run that enter the Restoration Area may be available for use as broodstock beginning in 2018.

Reintroductions contribute to preservation and conservation by improving spatial structure, productivity, diversity, and abundance of the CV spring-run Chinook salmon ESU, thereby reducing the likelihood of extinction. By using broodstock collection strategies that are protective of source populations, hatchery management strategies that are protective of the genetic integrity of the broodstock population, and release/collection strategies that are conservative for the genetic integrity of the population that will hopefully develop in the Restoration Area, the SJRRP Conservation Program can have a beneficial effect on the ecological and genetic resources available for the CV spring-run Chinook salmon ESU.

2.4.2.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

Negligible Effect: The SJRRP Conservation Program is different from some conservation facilities in that the program is attempting to reintroduce fish into a location where they were entirely extirpated. Therefore, hatchery fish and the progeny of naturally spawning hatchery fish are unlikely to adversely affect natural-origin fish, since until the reintroduced population becomes established, there are no natural origin fish to adversely affect. The one exception to that would be if returning fish were to stray to extant populations in the Sacramento basin. However, the SJRRP has adopted strategies to reduce straying, including: releasing juveniles as far upstream as feasible based on river connectivity and expected survival, rearing fish in facilities that allow them to imprint on natural odors, and acclimating juveniles at selected release sites.

Once the reintroduced population does become established in the Restoration Area, there is a possibility that continued hatchery operations could adversely affect that population, but the HGMP guidelines are designed to conserve and promote genetics that have withstood any degree of natural selection. Specifically, the HGMP directs to allow natural selection to operate on the population to produce a strain that has its timing of upstream migration, spawning, outmigration, and physiological and behavioral characteristics adapted to conditions in the San Joaquin River. Genetic monitoring of the reintroduced population using parentage analysis should provide the Conservation Program with information on the frequency of outcrossed matings and their relative survival in the Restoration Area and whether to incorporate them into hatchery matings. The mating protocols identified in the HGMP seek to minimize the likelihood for adverse genetic or ecological effects to listed natural fish due to hatchery operations. The Conservation Program will use a combined broodstock and adult spawning approach to minimize both adverse genetic and ecological impacts to natural fish. Ideally, the Conservation Program would not change the genetic characteristics of the source population and would produce offspring for release that display the full range of genetic diversity found in the source population. Over time, selection on the natural population should eliminate outbreeding depression as the reintroduced populations comingle. The duration of the Conservation Program will depend on the SJRRP's success in establishing a self-sustaining population of CV spring-run in the San Joaquin River. Also as indicated in the HGMP, as the natural population establishes, hatchery production would be phased out; less than 15 percent of the Chinook salmon population should be of hatchery origin ten years following full-scale releases from the SCARF. Once the San Joaquin River population is reestablished, a maximum of 10 percent of the naturalized run in the San Joaquin River may be collected to serve as broodstock, unless returns are so low that the naturalized run is unlikely to produce enough offspring to expect an escapement in future years.

2.4.2.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

Negligible Effect: Potential ecological effects of releasing juvenile hatchery-origin spring-run Chinook from the SJRRP Conservation Facilities include predation, competition/displacement, and disease. Deleterious ecological impacts to natural origin spring-run Chinook salmon or other ESA-listed salmonids are not anticipated, primarily due to the lack of natural origin spring-run Chinook salmon close to the release locations, for the early life of the permit. Once the population becomes established, natural origin juvenile fish will be protected by the strategies described in the HGMP. After natural salmon are re-established in the San Joaquin River, consideration will be given to the size of hatchery fish at time of release and timing of release to minimize the risk of predation and competition with the natural fish. Even initially, the spring-run Chinook salmon releases may interact with listed fish during outmigration, rearing in the San Francisco Estuary, in the ocean, and by straying during spawning migration. The reintroduced fish are likely to interact with other listed salmonid populations, including the endangered winter-run Chinook salmon and the threatened CCV steelhead. Again, negative interactions may include induced behavioral changes in wild fish, competition for limited resources, depensatory predation, disease transfers, and interbreeding. The fish release methods can influence all of these potential interactions.

Induced behavioral changes in wild fish, competition for limited resources, and depensatory predation are all aggravated by large releases of native fish. Initially, releases from the SCARF will be small and should present limited risk in these areas. As release sizes increase, allocation of reintroduced fish between the release of eggs and of juveniles should spread out the period over which juveniles are entering the system, reducing the risk to listed species. Further, with the juveniles raised in-hatchery, volitional release should allow for a gradual introduction of the juveniles into the system, further reducing the risk to listed species. Reintroductions will be adaptively managed to minimize impacts on other listed species. In the hatchery facilities, growth during smolt production will be modulated to meet Conservation Program goals for release size and release timing to avoid possible impacts to the wild population. To prevent transfer of disease from the hatchery population to the wild population, a suite of protocol are in place. Those protocols are described in the HGMP.

2.4.2.4. Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean

Negligible effect: Best available information does not indicate that the Proposed Action would exacerbate density-dependent effects on ESA-listed species in the Lower San Joaquin River, in the estuary, or in the Pacific Ocean.

NMFS has been investigating this factor for some time. There is intense debate over the issues of carrying capacity and density-dependent effects on natural populations of salmon. However, there is little definitive information available to directly address the effects of ecological factors on survival and growth in natural populations of Pacific salmon. Thus, many of the ecological consequences of releasing hatchery fish into the wild are poorly defined.

More recently, NMFS has reviewed the literature for new and emerging scientific information over the role and the consequences of density-dependent interactions in estuarine and marine areas. While there is evidence of density-dependent effects to salmon survival, the currently available information does not support a meaningful causal link to a particular category of hatchery programs. Our conclusion, based on available information, is that hatchery production on the scale proposed in this action and considered in this opinion will have a negligible effect on the survival and recovery of the CV spring-run Chinook salmon ESU.

NMFS will continue to monitor emerging science and information and will reinitiate section 7 consultation in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.2.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

Beneficial Effect: The RM&E activities included as part of the proposed action will have a positive effect on ESA-listed species in the upper San Joaquin River Basin. As described in Section 1.3.1.5 above, the proposed action includes a suite of surveys, monitoring actions, and potential studies for various life stages of CV spring-run Chinook salmon that are intended to inform management actions for the SJRRP. Monitoring related to various performance indicators (*e.g.,* fish health, genetic distribution, growth, survival and movement in the natural environment) is a crucial component of the larger SJRRP, which, as previously discussed, is necessary if ESA-listed fish are to be reintroduced in a timely manner into the Restoration Area.

The SJRRP is a largescale restoration program that involves multiple in-stream research and monitoring components to evaluate the effectiveness of the program related to hatchery operations and changes to river conditions. Monitoring for listed fish occurs at multiple life stages, including egg/fry (emergence trapping), juvenile (snorkeling, trapping (rotary screw trap, juvenile weir, fyke net, seine, hand net), acoustic and PIT tag monitoring, and coded wire tag monitoring), adult (snorkeling, trapping (weir, fyke net, fyke trap, seine, hand net), camera visual monitoring, acoustic tracking, and spawning surveys), and post mortem (carcass surveys). Some fish may be acoustic tagged, PIT tagged, and/or disc tagged.

CCV steelhead are not the target species but some may be captured. Because the majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that are likely to be killed by the proposed action. The proposed RM&E activities may remove a maximum of four natural-origin adult CCV steelhead and four natural-origin juvenile CCV steelhead annually. These are very small effects, and most likely the actual effect would be even smaller as the mortality and take is estimated conservatively in order to provide some buffer to allow for unusual and unpredictable events with high levels of take and mortality. Further, the purpose of the proposed take is to remove the fish from a location where they would be attracted to unsuitable habitat, and translocated to a location where spawning should be successful. Therefore, any losses that would be incurred would be in the context of activities that would have a net benefit for the species.

Overall, there would be a very small impact on the species' abundance. Any impact on listed species productivity would likely be positive, as captured fish would be translocated to locations with better access to more suitable spawning habitat. Effects on species spatial structure or diversity would be minimal, but overall the permitted actions are a component of the SJRRP, which aims to increase the spatial diversity of anadromous salmonids in the Central Valley. An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. Results from this research should assist in providing information on occurrence and return timing of listed salmonids in the Restoration Area. Collection of this data is necessary for understanding potential benefits of the SJRRP. All research findings will be used to benefit ESA-listed salmonids through improved conservation and management practices.

2.4.2.6. Factor 6. Construction, operation, and maintenance of facilities that exist because of the hatchery program

Negligible effect: Operations and maintenance activities included in the Proposed Action will have a negligible effect on ESA-listed species in the Upper San Joaquin River Basin. There are no construction activities included in the Proposed Action. Construction of Conservation Facilities has either been previously completed (*i.e*., Interim Facility, SIRF) or is under construction (SCARF). Further information on the potential environmental effects associated with construction of the SCARF can be found in the DEIR completed by CDFW (2013). In either case, construction, operation, and maintenance of the facilities, while related to the proposed action in that they are a component of the SJRRP, are not part of the proposed action of issuing Permit 20571 or approving the HGMP.

2.4.2.7. Factor 7. Fisheries that exist because of the hatchery program

Beneficial Effect: The Pacific Fishery Management Council (PFMC), established by the 1976 Magnuson/Stevens Fishery Conservation and Management Act to manage near-shore ocean fisheries, works with the CDFW to manage the ocean salmon fishery off the California Coast. The PFMC manages fisheries based on a number of objectives detailed in its Salmon Fishery Management Plan and evaluated annually in its Review of Ocean Salmon Fisheries. The Conservation Program is an integrated recovery hatchery, which is not primarily intended to produce adult salmon for harvest but rather to promote recovery. Harvest may be an ancillary benefit as the San Joaquin River population grows. There are active commercial (ocean) and recreational (ocean and inland) fisheries for Chinook salmon in California. As a result, some San Joaquin River spring-run Chinook salmon may be taken in those fisheries. Estimated future harvest rates on fish propagated by the Conservation Program are difficult to calculate. Although ocean (commercial) harvest rates may remain similar to those estimated between 1995 and 2006, ocean harvest rates can vary annually based on the regulations established by the Pacific States Marine Fisheries Commission and CDFW. Although freshwater recreational harvest is currently prohibited, a recreational fishery may develop under 4(d) regulations when salmon begin returning in the significant numbers anticipated in the Settlement.

2.4.2.8. Effects of the Action on Critical Habitat

Negligible effect: This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined that operation of the hatchery program will have a negligible effect on Critical Habitat. Critical habitat for CV spring-run Chinook salmon does not exist in the San Joaquin Basin, and does not exist for CCV steelhead below the confluence of the Merced River. Therefore, the only portions of the action area that could affect Critical Habitat would be in Butte Creek of the FRFH, and activities proposed there would have no effect on PBFs in the Action Area.

2.5. 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 consultations pursuant to section 7 of the ESA.

In addition, 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 actions 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).

2.5.1. Agricultural Practices

Agricultural practices in the San Joaquin River 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 San Joaquin River and Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical 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 San Joaquin River 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).

2.5.2. Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, hydropower generation, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile ESA-listed anadromous species. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (Herren and Kawasaki 2001).

The many existing unscreened water diversions on the Sacramento River pose a threat to early life stages of listed species. A study of 12 unscreened, small to moderate sized diversions (< 150 cfs) in the Sacramento River, found that diversion entrainment was low for listed salmonids (majority were identified as fall-run Chinook based on length-at-date criteria; other ESUs made up much smaller percentages), though the study points out that the diversions used were all situated relatively deep in the river channel (Vogel 2013). In a previous mark-recapture study addressing mortality caused by unscreened diversions, Hanson (2001) also observed low mortality in hatchery-produced juvenile Chinook salmon released upstream of four different diversions throughout the Sacramento River (≤ 0.1 percent of individuals released).

2.5.3. Aquaculture and Fish Hatcheries

More than 32 million fall-run Chinook salmon, 2 million spring-run Chinook salmon, 1 million late fall-run Chinook salmon, 0.25 million winter-run Chinook salmon, and 2 million steelhead are released annually from six hatcheries producing anadromous salmonids in the Central Valley. All of these facilities are currently operated to mitigate for natural habitats that have already been permanently lost as a result of dam construction. The loss of this available habitat results in dramatic reductions in natural population abundance which is mitigated for through the operation of hatcheries. Salmonid hatcheries can, however, have additional negative effects on ESA-listed salmonid populations. The high level of hatchery production in the Central Valley can result in high harvest-to-escapements ratios for natural stocks. California salmon fishing regulations are set according to the combined abundance of hatchery and natural stocks, which can lead to over-exploitation and reduction in the abundance of wild populations that are indistinguishable and exist in the same system as hatchery populations. Releasing large numbers of hatchery fish can also pose a threat to wild Chinook salmon and steelhead stocks through the spread of disease, genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production. Impacts of hatchery fish can occur in both freshwater and the marine ecosystems. Limited marine carrying capacity has implications for naturally produced fish experiencing competition with hatchery production (HSRG 2004). Increased salmonid competition in the marine environment may also decrease growth and size at maturity, and reduce fecundity, egg size, age at maturity, and survival (Bigler *et al.* 1996). Ocean events cannot be predicted with a high degree of certainty at this time. Until good predictive models are developed, there will be years when hatchery production may be in excess of the marine carrying capacity, placing depressed natural fish at a disadvantage by directly inhibiting their opportunity to recover (Northwest Power and Conservation Council 2003).

2.5.4. Increased Urbanization

The Delta, East Bay, and Sacramento urban regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly three million people by the year 2020. 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. The City of Manteca (2007) anticipated 21 percent annual growth through 2010 reaching a population of approximately 70,000 people. The City of Lathrop (2007) expects to double its population by 2012, from 14,600 to approximately 30,000 residents. The anticipated growth would occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. 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. Boat 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 other anadromous fishes using the system. Increased recreational boat operation in the San Joaquin River 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 San Joaquin River and Delta.

2.5.5. Recreation (including hiking, camping, fishing, and hunting)

Expected recreation impacts to salmonids include increased turbidity, impacts to water quality, barriers to movement, and changes to habitat structures. Streambanks, riparian vegetation, and spawning redds can be disturbed wherever human use is concentrated. Construction of summer dams to create swimming holes causes turbidity, destroys and degrades habitat, and blocks migration of juveniles between summer habitats. Impacts to salmonid habitat are expected to be localized, mild to moderate, and temporary. Fishing within the action area, typically for introduced species or non-listed rainbow trout, is expected to continue subject to CDFW regulations. Fishing for spring-run Chinook salmon directly is prohibited in the San Joaquin River. The level of impact to spring-run Chinook salmon within the action area from angling is unknown, but is expected to remain at current levels.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our process for assessing the effect that implementing the proposed action would have on listed species and their critical habitat as a whole. 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) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the Status of the Species and critical habitat (Section 2.2).

2.6.1. Central Valley spring-run Chinook salmon

At the ESU level, the spatial diversity within the CV spring-run Chinook salmon ESU is increasing and spring-run are present (albeit at low numbers in some cases) in all diversity groups. The recolonization of CV spring-run Chinook salmon to Battle Creek and increasing abundance in Clear Creek is benefiting the viability of CV spring-run Chinook salmon.

Similarly, the reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in rivers where they were once extirpated. Active reintroduction efforts, including the SJRRP, show promise and will be necessary to make the ESU viable. The CV spring-run Chinook salmon ESU is trending in a positive direction towards achieving at least two populations in each of the four historical diversity groups necessary for recovery with the Northern Sierra Nevada region necessitating four populations (NMFS 2014).

The largest CV spring-run Chinook salmon ESU population improvements are due to the increase in spatial diversity with historically extirpated populations trending in the positive direction. However, these improvements, evident in the moderate and low risk of extinction of the three independent populations, are certainly not enough to warrant a downgrading of the ESU extinction risk. The recent catastrophic declines of many of the dependent populations, high pre-spawn mortality during the 2012–2015 drought, uncertainty of juvenile survival due to the drought and variable ocean conditions, and the straying rate of FRFH spring-run Chinook salmon to other spring-run Chinook salmon populations are all causes for concern for the long-term viability of the ESU (Williams *et al.* 2016).

As set out in the Environmental Baseline (Section 2.4), the CV spring-run Chinook salmon ESU may be affected by fisheries. The effects of this take are analyzed in separate ESA consultations (NMFS 2000). Fisheries and harvest managers reevaluate exploitation rates and harvest strategies on an annual basis to ensure that fisheries for fall- and late fall-run Chinook salmon provide for the survival and recovery of the listed ESUs.

Climate change is a key aspect of stress for ESA-listed salmonids in the Central Valley. Lindley *et al.* (2007) summarized several studies (Hayhoe *et al.* 2004, Dettinger *et al.* 2004, VanRheenen *et al.* 2004) of how climate change is expected to alter the Central Valley, and based on these studies, described the possible effects to anadromous salmonids. Climate models for the Central Valley are broadly consistent in that temperatures in the future will warm significantly, total precipitation may decline, the variation in precipitation may substantially increase (*i.e.*, more frequent flood flows and critically dry years), and snowfall will decline significantly (Lindley *et al.* 2007). Not surprisingly, temperature increases are expected to further limit the amount of suitable habitat available to anadromous salmonids. The potential for more frequent flood flows might be expected to reduce the abundance of populations, as egg scour becomes a more common occurrence. The increase in the occurrence of critically dry years also would be expected to reduce abundance as, in the Central Valley, low flows during juvenile rearing and outmigration are associated with poor survival (Kjelson and Brandes 1989, Baker and Morhardt 2001, Newman and Rice 2002). In addition to habitat effects, climate change may also impact Central Valley salmonids through community effects. For example, warmer water temperatures would likely increase the metabolism of predators, reducing the survival of juvenile salmonids (Vigg and Burley 1991). Petersen and Kitchell (2001) showed that on the Columbia River, pikeminnow predation on juvenile salmon during the warmest year was 96 percent higher than during the coldest. In summary, climate change is expected to exacerbate existing stressors and pose new threats to all Central Valley salmonids by reducing the quantity and quality of inland habitat (Lindley *et al.* 2007).

2.6.1.1. Hatchery Effects

NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.5.1) and for the Proposed Action at SJRRP Conservation Facilities, all of the factors considered are expected to have beneficial or negligible effects on CV spring-run Chinook salmon.

Proposed Action-related stressors could reduce the abundance and productivity of CV spring-run Chinook salmon; however the level of impacts resulting from the project are generally low. Overall, proposed activities are expected to improve spatial structure and diversity of CV spring-run Chinook salmon. This is primarily due to the fact that the SJRRP Hatchery Facilities are operated as a Conservation Hatchery with the overall purpose of enhancing the natural population of CV spring-run Chinook salmon in the San Joaquin Basin, while promoting the recovery of the species through contribution to reintroduction efforts.

2.6.1.2. Broodstock Collection

Adverse effects associated with the Proposed Action may occur as handling, stress, delayed migration, injury, or mortality. Annual broodstock collections will initially be focused on CV spring-run from FRFH and will expand to include collections from wild stocks in Butte Creek, and depending on escapement numbers, returning adults and any stray spring-run that enter the Restoration Area may be available for use as broodstock beginning in 2018. However, broodstock collection from FRFH would only occur if the hatchery is able to produce more than its own production targets; broodstock collection from Butte Creek would be dependent on annual escapement and would be conservative for the genetic integrity and population abundance of the source population; and broodstock collection from the San Joaquin would follow HGMP protocols that promote genetics that have experienced any degree of natural selection. The SJRRP Conservation Program can have a beneficial effect on the ecological and genetic resources available for the CV spring-run Chinook salmon ESU by using broodstock collection strategies that are protective of source populations, hatchery management strategies that are protective of the genetic integrity of the broodstock population, and release/collection strategies that are conservative for the genetic integrity of the population that will hopefully develop in the Restoration Area. Therefore, any adverse effects associated with this activity are expected to have a low level of impact to the CV spring-run Chinook salmon ESU.

2.6.1.3. Research, Monitoring, and Evaluation

RM&E could also result in potential adverse effects to CV spring-run Chinook salmon. However, the overall impact of RM&E is considered to be negligible, if not beneficial. As previously stated in this opinion, the CV spring-run Chinook salmon currently being reintroduced to the San Joaquin River (and those subject to RM&E activities), are classified as an NEP of CV spring-run Chinook salmon (78 FR 79622, December 31, 2013) for which take prohibitions also do not apply. Therefore, this species and the associated estimated take has been included in this document for informational purposes for conferencing.

Even when comparing the estimate take against the larger population, the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above.

For over two decades, research and monitoring activities conducted on anadromous salmonids in California have provided resource managers with a wealth of important and useful information regarding anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, and acoustic tagging efforts have increased the knowledge of anadromous fish abundance as we as migration timing and survival. By issuing research authorizations including those being contemplated in this opinion NMFS has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions to sustain anadromous salmonid populations, mitigate adverse impacts on endangered and threatened salmon and steelhead, and implement recovery efforts.

2.6.1.4. Other Effects

Added to the Environmental Baseline and the Effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. To the extent those same activities are reasonably certain to occur in the future, their future effects are included in the cumulative effects analysis. Many of the state and private activities identified in the Baseline are anticipated to occur at similar levels of intensity into the future. The Final Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014) describes, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed spring-run Chinook salmon in the San Joaquin River. It is acknowledged, however, that such future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits and that government actions are subject to political, legislative and fiscal uncertainties.

This analysis has considered the potential effects of the Proposed Action, combined with the Environmental Baseline and Cumulative Effects, and determined that the Proposed Action will not appreciably reduce the likelihood of survival and recovery of CV spring-run Chinook salmon ESU.

2.6.2. California Central Valley steelhead

The viability of the CCV steelhead DPS appears to have slightly improved since the previous assessment, when it was concluded that the DPS was in danger of extinction. The modest improvement is driven by the increase in adult returns to hatcheries from their recent lows, but the state of naturally produced fish still remains poor. Improvements to the total population sizes of the three previously evaluated steelhead populations (Battle Creek, CNFH, and FRH), does not warrant a downgrading of the ESU extinction risk. In fact, the lack of improved natural production as estimated by samples taken at Chipps Island, and low abundances coupled with large hatchery influence in the Southern Sierra Nevada Diversity group is cause for concern (Williams *et al.* 2016). As in the previous assessments (Good *et al.* 2005; Williams *et al.* 2011), the CCV steelhead DPS continues be at a high risk of extinction.

As set out in the Environmental Baseline (Section 2.4), extensive habitat elimination and degradation has been a primary factor leading to the threatened status of CCV steelhead. Physical habitat modifications (*e.g.*, dam construction and river straightening and associated riprap applications) and many other anthropogenic effects on habitat have greatly diminished the viability of the DPS. The general baseline stress regime for steelhead in the freshwater, estuarine, and marine environment is similar to that of spring-run Chinook salmon, with an exception that there is no targeted ocean fishery for steelhead. Detailed descriptions of baseline stressors to CCV steelhead are provided in Sections 2.2 and 2.4.

The steelhead DPS may be affected by inland fisheries. Fisheries and harvest managers reevaluate exploitation rates and harvest strategies on an annual basis. Since the recreational fishery is regulated to protect natural-origin steelhead, managers don't consider the impacts significant, although this has not been analyzed through ESA Section 7 consultation. However, because the sizes of CCV steelhead populations are largely unknown, it is difficult to make conclusions about the impact of the fishery (Good *et al.* 2005).

As described for CV spring-run Chinook salmon above, climate change is a key aspect of stress for ESA-listed salmonids in the Central Valley.

2.6.2.1. Hatchery Effects

NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.1) and for the Proposed Action, all of the factors considered are not expected to have significant effects on CCV steelhead.

Proposed Action-related stressors could reduce the abundance and productivity of CCV steelhead; however, the level of impacts resulting from the project are generally low. Proposed activities are not likely to affect spatial structure or diversity of CCV steelhead because the hatchery facilities are located outside of the area currently used by juvenile and adult CCV steelhead.

2.6.2.2. Broodstock Collection

Take may occur as handling, stress, delayed migration, injury, or mortality. However, broodstock collection from FRFH will have no effect on CCV steelhead. CCV steelhead are believed to be extirpated from the SJRRP Restoration Area, and while some may return as conditions improve, take is expected to be low. And although information is limited on the annual abundance of CCV steelhead in Butte Creek, again estimated take is low. Therefore this activity is expected to have a low level of impact to the CCV steelhead salmon ESU.

ESA-listed natural-origin CCV steelhead may be trapped at Butte Creek and in the SJRRP Restoration Area while trapping for spring-run Chinook salmon broodstock; however, the number of steelhead trapped in past years has remained low. Several methods are used to reduce incidental impacts of trapping. See discussion of trapping above (Section 2.5.2) for more information on these methods.

Thus, we expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in adult abundance and productivity. And because these reductions are so slight, the actions in combination would have no appreciable effect on the species' diversity or structure.

2.6.2.3. Research, Monitoring, and Evaluation

RM&E activities could also result in potential adverse effects to CCV steelhead. However, the overall impact of RM&E is considered to be negligible, if not beneficial. The resulting information continues to improve our knowledge of the respective species' life histories, specific biological requirements, genetic make-up, migration timing, responses to human activities (positive and negative), and survival in the rivers and ocean. The collection and dissemination of that information, as a whole, is critical to the species' survival.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above.

Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small). Moreover, again, the small amounts of mortality that could result from this permit are due to efforts to remove the fish from a location without suitable habitat and translocate them to a location where they have access to suitable spawning habitat. Therefore, any losses that would be incurred would be in the context of activities that would have a net benefit for the species.

2.6.2.4. Other Effects

Added to the Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the action area. To the extent those same activities are reasonably certain to occur in the future, their future effects are included in the cumulative effects analysis. Many of the state and private activities identified in the Baseline are anticipated to occur at similar levels of intensity into the future. The Final Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014) describes, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed CCV steelhead in the Sacramento River. It is acknowledged, however, that such future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits and that government actions are subject to political, legislative and fiscal uncertainties.

This analysis has considered the potential effects of the Proposed Action, combined with the Environmental Baseline and Cumulative Effects, and determined that the Proposed Action will not appreciably reduce the likelihood of survival and recovery of CCV steelhead DPS.

2.6.3. Critical Habitat

As noted earlier, we do not have critical habitat for either species present in the SJRRP Restoration Area, and activities in Butte Creek and at FRFH are not expected to have any effect on critical habitat. After reviewing the proposed action and conducting the effects analysis, NMFS has determined that the proposed action will not impair PFBs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes nor will it reduce the overall conservation value of critical habitat in the action area.

2.6.4. Summary

As noted in the status of the species sections, listed species require substantial improvement in the condition of their habitat and other factors affecting their survival if they are to begin to recover. The SJRRP activities, as outlined in the settlement agreement, are designed to facilitate that goal for CV spring-run Chinook salmon and CCV steelhead in the SJRRP restoration area. The actions proposed under Permit 20571 are critical components for the SJRRP. It’s important to note that as the SJRRP progresses, and habitat conditions, connectivity, and flow in the Restoration Area improve, the activities included in Permit 20571 may no longer be necessary. Further, the proposed action will not exacerbate the negative cumulative effects discussed in this Opinion (habitat alterations, *etc*.) and the enhancement component of the Permit would act to increase the likelihood that affected individual fish would be able to reach suitable spawning habitat. In addition, the research and monitoring component of the Permit would serve to limit adverse effects by increasing our knowledge about the species’ requirements, habitat use, and abundance.

The effects of climate change on listed species and their habitats within the action area are likely to continue to be negative. However, given the proposed actions’ short time frames and limited areas, those negative effects, while somewhat unpredictable, are too small to be effectively gauged as an additional increment of harm over the time span considered in this analysis. Moreover, the actions would in no way contribute to climate change (even locally). So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that the proposed actions would have any additive impact to the pathways by which those effects are realized (*e.g*., a slight reduction in salmonid abundance would have no effect on increasing stream temperatures or continuing land development).

In summary, NMFS expects the detrimental effects on the species to be minimal, and expects positive effects of the hatchery and monitoring activities towards increasing diversity, abundance, and spatial structure. Moreover, we expect the actions to provide lasting benefits for the listed fish and that all habitat effects would be negligible. Finally, we expect the proposed actions considered here to generate information we need to manage the affected listed species, and to complete the SJRRP restoration goal of reintroducing listed fish to the Restoration Area.

2.7. 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, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of CV spring-run Chinook salmon or CCV steelhead.

2.8. 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(a)(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 incidental take statement.

As previously stated in this opinion, CV spring-run Chinook salmon are currently being reintroduced to the San Joaquin River, and are classified as an NEP of CV spring-run Chinook salmon (78 FR 79622, December 31, 2013). Therefore, this species has been included in this document for informational purposes for conferencing. The unintentional, incidental take of these fish would be exempt from the prohibitions of section 9 of the ESA. In addition, an incidental take statement is not required under ESA section 7(b)(4) for this conferencing opinion. Activities for CV spring-run Chinook salmon are being monitored as part of this permitting process and the take tables here include CV spring-run Chinook salmon.

In this instance, and for the actions considered in this opinion, there is no incidental take. The reason for this is that all the take contemplated in this document would be carried out under a permit that allows USFWS and CFDW to directly take the animals in question. The actions are considered to be direct take rather than incidental take because their actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot be considered "incidental" under the definition given above. Nonetheless, one of the purposes of an incidental take statement is to lay out the amount or extent of take beyond which individuals carrying out an action cannot go beyond without being in possible violation of section 9 of the ESA. That purpose is fulfilled here by the amounts of direct take laid out in the effects section above (2.5), and in the following section below (2.8.1). Those amounts constitute hard limits on both the amount and extent of take the permit holders would be allowed in a given year. This concept is also reflected in the reinitiation clause below (2.10).

2.8.1. Amount or Extent of Take

As noted above, as a condition of the permit upon issuance, the permit holder must ensure that listed species are taken only: at the levels, by the means, in the areas, and for the purposes stated in the permit application. The amount of take requested, which is the amount of take considered in this biological opinion, is detailed in the permit application, and in the following tables (Tables 15 – 18)

Table 15. Annual Authorized Take by ESU, Life Stage, Origin, and Activity for Broodstock Collection Activities in the SJRRP Restoration Area

Species	Stock/ Listing Unit	Production/ Origin	Lifestage	Sex	Authorized Take	Authorized Indirect Mortality	Take Action	Observe/ Collect Method	Procedures	Details
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	250	0	Broodstock Collection	Net, Fyke	Anesthetize; Finclip - mark; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Otolith; Tissue Sample Scale	Adult weir or hand/dip net may also be used if conditions are appropriate. Fish in excess of broodstock needs may be released as ancillary broodstock. See Releases table for maximum number of ancillary broodstock (by lifestage) that may be released.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	250	0	Broodstock Collection	Net, Fyke	Tag, Acoustic or Sonic (Internal); Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Otolith; Tissue Sample Scale	Adult weir or hand/dip net may also be used if conditions are appropriate. Fish in excess of broodstock needs may be released as ancillary broodstock. See Releases table for maximum number of ancillary broodstock (by lifestage) that may be released.

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	2,700	0	Broodstock Collection	Trap, Screw	Anesthetize; Finclip - mark; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, PIT; Tissue Sample Fin or Opercle	Weir, Beach Seine, hand net, fyke trap, and/or fyke net may also be used if conditions are appropriate. Fish in excess of broodstock needs may be released as ancillary broodstock. See Releases table for maximum number of ancillary broodstock (by lifestage) that may be released.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	280	0	Intentional (Directed) Mortality	Trap, Screw	Tissue sample (other internal tissues)	Total number of fish for pathology - 70 per collection up to 4 collections
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Fry	Unknown	400	0	Broodstock Collection	Trap, Not listed here	Anesthetize; Finclip - mark; Tag, Coded-Wire; Tag, PIT; Tissue Sample Fin or Opercle	Emergence Traps. Fish in excess of broodstock needs may be released as ancillary broodstock. See Releases table for maximum number of ancillary broodstock (by lifestage) that may be released.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Fry	Unknown	600	0	Intentional (Directed) Mortality	Trap, Not listed here	Tissue Sample Fin or Opercle	Emergence Trap genetic sampling
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Egg	Unknown	1,000	0	Broodstock Collection	Hand and/or Dip Net	Anesthetize; Finclip - mark; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, PIT; Tissue Sample Fin or Opercle	Egg extraction from redds by excavation or egg pump, indirect mortality includes mortality from egg to adult lifestage. Fish in excess of broodstock needs may be released as ancillary broodstock. See Releases table for maximum number of ancillary broodstock (by lifestage) that may be released.

Table 16. Annual Authorized Take by ESU, Life Stage, Origin, and Activity for SJRRP Hatchery Source Stock Collection – Feather River Fish Hatchery and Butte Creek

Species	Stock/ Listing Unit	Production/ Origin	Lifestage	Sex	Authorized Take	Authorized Indirect Mortality	Take Action	Observe/ Collect Method	Procedures	Details
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Intact Adipose	Egg	Unknown	5,470	0	Broodstock Collection	Hand and/or Dip Net	Anesthetize; Finclip - mark; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle	FRFH: Eggs collected for broodstock
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Intact Adipose	Juvenile	Male and Female	70	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tissue sample (other internal tissues)	FRFH: Pathology testing for broodstock health prior to transfer to SCARF or iSCARF
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	2,700	0	Broodstock Collection	Trap, Screw	Anesthetize; Finclip - mark; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle	BUTTE CREEK: May collect juveniles via diversion trap. Indirect mortality includes all losses form egg to adult lifestage
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	210	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tissue sample (other internal tissues)	BUTTE CREEK: Pathology testing for broodstock health assessment prior to transfer to the SCARF or iSCARF

Table 17. Annual Authorized Take by ESU, Life Stage, Origin, and Activity for SJRRP Hatchery Releases – Juvenile Production and Ancillary Broodstock

Species	Stock/ Listing Unit	Production/ Origin	Lifestage	Sex	Authorized Take	Authorized Indirect Mortality	Take Action	Observe/ Collect Method	Procedures	Details
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Intact Adipose	Egg	Male and Female	2,080,000	832,000	Juvenile Releases	Hand and/or Dip Net	Anesthetize; Dye Injection (tattoo, photonic); Finclip - mark; Paint, Stain or Dye Immersion; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, PIT; Tissue Sample Fin or Opercle	Indirect Mortality: Based on average egg to release survival during recent years (avg: approx. 60%). Up to 10% of releases may be yearling (1+) age juveniles.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	320	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tissue sample (other internal tissues)	Pre-release health assessment, 20 fish per release group up to 16 release groups
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Intact Adipose	Egg	Unknown	80,000	38,823	Juvenile Releases	Hand and/or Dip Net	Anesthetize; Dye Injection (tattoo, photonic); Finclip - mark; Paint, Stain or Dye Immersion; Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, PIT; Tissue Sample Fin or Opercle	Eggs from Feather River Fish Hatchery translocated reared and released to San Joaquin River. Indirect mortality is estimated form egg to release size.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	100	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tissue sample (other internal tissues)	Pre-release health assessment for translocated fish from Feather River Fish Hatchery

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	2,500	75	Collect, Sample, and Transport Live Animal	Hand and/or Dip Net	Tag, Acoustic or Sonic (External); Tag, Acoustic or Sonic (Internal); Tag, Coded-Wire; Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle	Release of ancillary broodstock into river at age-0 or age-1
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	100	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tissue sample (other internal tissues)	Pre-release health screening of age-0 or age-1 ancillary broodstock
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	2,500	75	Collect, Sample, and Transport Live Animal	Hand and/or Dip Net	Anesthetize; Tag, Acoustic or Sonic (External); Tag, Acoustic or Sonic (Internal); Tag, Floy; Tag, PIT; Tissue sample (other internal tissues); Tissue Sample Fin or Opercle	Release of adult ancillary broodstock
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	25	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tissue sample (other internal tissues)	Pre-release health screening of adult ancillary broodstock
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	1,000	0	Intentional (Directed) Mortality	Hand and/or Dip Net	Tag, Coded-Wire	Sacrificed as part of CWT process to set correct tag depth. This could include up to 25 fish per day that were taken as broodstock from any of the sources (Butte, FRFH, or SJR).

Table 18. Annual Authorized Take by ESU, Life Stage, Origin, and Activity for Research, Monitoring, and Evaluation Activities in the SJRRP Restoration Area

Species	Stock/ Listing Unit	Production/ Origin	Lifestage	Sex	Authorized Take	Authorized Indirect Mortality	Take Action	Observe/ Collect Method	Procedures	Details
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Adult	Male and Female	2,500	50	Collect, Sample, and Transport Live Animal	Hand and/or Dip Net	Anesthetize; Tag, Acoustic or Sonic (External); Tag, Acoustic or Sonic (Internal); Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	We will survey barriers, sloughs, and backwater areas for any fish that get past the trap and collect with dip nets. Capture and transport of returning adults to spawning grounds. Disc tags may be used instead of Floy tag
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Listed Hatchery Adipose Clip	Adult	Male and Female	2,500	50	Collect, Sample, and Transport Live Animal	Hand and/or Dip Net	Anesthetize; Tag, Acoustic or Sonic (External); Tag, Acoustic or Sonic (Internal); Tag, Floy; Tissue Sample Fin or Opercle; Tissue Sample Scale	We will survey barriers, sloughs, and backwater areas for any fish that get past the trap and collect with dip nets. Capture and transport of returning adults to spawning grounds. Disc tags may be used instead of Floy tag
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Adult	Male and Female	2,500	0	Observe/ Harass	Snorkel/Dive surveys		Snorkel / visual observation of adult fish in upper reaches of San Joaquin River
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Listed Hatchery Adipose Clip	Adult	Male and Female	2,500	0	Observe/ Harass	Snorkel/Dive surveys		Snorkel / visual observation of adult fish in upper reaches of San Joaquin River

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Spawned Adult/ Carcass	Male and Female	2,500	0	Observe/ Sample Tissue Dead Animal	Hand and/or Dip Net	Finclip - mark; Tag, Floy; Tissue sample (other internal tissues); Tissue Sample Fin or Opercle; Tissue Sample Otolith; Tissue Sample Scale	Carcass surveys by boat and foot. Hog ring external tags may be used.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Listed Hatchery Adipose Clip	Spawned Adult/ Carcass	Male and Female	2,500	0	Observe/ Sample Tissue Dead Animal	Hand and/or Dip Net	Finclip - mark; Tag, Floy; Tissue sample (other internal tissues); Tissue Sample Fin or Opercle; Tissue Sample Otolith; Tissue Sample Scale	Carcass surveys by boat and foot. Hog ring external tags may be used.
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Adult	Male and Female	2,500	0	Observe/ Harass	Observations at weirs, fish ladders, dams where no trapping occurs		Monitor for returning adults with a weir and VAKI camera unit
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Listed Hatchery Adipose Clip	Adult	Male and Female	2,500	0	Observe/ Harass	Observations at weirs, fish ladders, dams where no trapping occurs		Monitor for returning adults with a weir and VAKI camera unit
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Adult	Male and Female	2,500	50	Collect, Sample, and Transport Live Animal	Net, Fyke	Tag, Acoustic or Sonic (External); Tag, Acoustic or Sonic (Internal); Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	Capture and transport of returning adults to spawning grounds. Fish will only be transported if necessary. Disc tags may be used instead of Floy tags. Additional capture methods (adult weir, seine, fyke trap, hand net) may be used

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Listed Hatchery Adipose Clip	Adult	Male and Female	2,500	50	Collect, Sample, and Transport Live Animal	Net, Fyke	Tag, Acoustic or Sonic (External); Tag, Acoustic or Sonic (Internal); Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	Capture and transport of returning adults to spawning grounds. Fish will only be transported if necessary. Disc tags may be used instead of Floy tags. Additional capture methods (adult weir, seine, fyke trap, hand net) may be used
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Juvenile	Male and Female	120,000	2,400	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Trap, Screw	Dye Injection (tattoo, photonic); Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	Fyke net sampling will also be used. Fish will be counted measured and released. Fin clips may also be taken from a subset of individuals for genetic analysis
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Listed Hatchery Adipose Clip	Juvenile	Male and Female	120,000	2,400	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Trap, Screw	Dye Injection (tattoo, photonic); Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	Fyke net sampling will also be used. Fish will be counted measured and released. Fin clips may also be taken from a subset of individuals for genetic analysis
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Juvenile	Male and Female	750,000	15,000	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Weir (only if associated with fish handling)	Dye Injection (tattoo, photonic); Finclip - mark; Tag, PIT; Tissue Sample Fin or Opercle	This effort will be to assist fish with emigrating out of the system when they are not able to migrate out on their own due to river conditions such as no flow connectivity in low water years. Juveniles will be collected in the weir then transported

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)*	Natural	Fry	Male and Female	60,000	6,000	Capture/ Handle/ Release Fish	Trap, Not listed here		Emergence trap on redds. Assumes 20 redds and up to 3000 fry emerging per redd. Fry are counted a subsample measured and released. Assumes 10% total mortality rate
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	50	2	Capture/ Handle/ Release Fish	Net, Fyke		Incidental capture of steelhead while targeting Chinook salmon
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	50	2	Capture/ Handle/ Release Fish	Net, Fyke		Incidental capture of steelhead while targeting Chinook salmon
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	50	0	Observe/ Harass	Snorkel/Dive surveys		Snorkel / visual observation of adult fish in upper reaches of San Joaquin River. Target is Chinook salmon, but observations of steelhead will be recorded
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	50	0	Observe/ Harass	Snorkel/Dive surveys		Snorkel / visual observation of adult fish in upper reaches of San Joaquin River. Target is Chinook salmon, but observations of steelhead will be recorded
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	50	2	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Hand and/or Dip Net	Anesthetize; Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	While surveying for Chinook salmon at barriers, sloughs and backwater areas we may encounter a steelhead. Any steelhead encountered will be transported under Permit 16608-2R

Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	50	2	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Hand and/or Dip Net	Anesthetize; Tag, Floy; Tag, PIT; Tissue Sample Fin or Opercle; Tissue Sample Scale	While surveying for Chinook salmon at barriers, sloughs and backwater areas we may encounter a steelhead. Any steelhead encountered will be transported under Permit 16608-2R
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	100	0	Observe/ Harass	Observations at weirs, fish ladders, dams where no trapping occurs		Monitor for returning adults with a weir and VAKI camera unit
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	100	2	Capture/ Mark, Tag, Sample Tissue/ Release Live Animal	Trap, Screw	Anesthetize; Tag, Floy; Tag, PIT	Potential incidental capture of steelhead in rotary screw traps targeting Chinook salmon. Fyke net sampling may also be used.
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	100	2	Capture/ Handle/ Release Fish	Weir (only if associated with fish handling)		Steelhead incidentally caught during this effort will be released back to the river where they may continue rearing until the following spring.

* Estimated take of CV spring-run Chinook salmon within the NEP is included for tracking and informational purposes only.

2.8.2. Effect of the Take

In Section 2.8, NMFS determined that the level of anticipated take, coupled with other effects of the Proposed Action is not likely to jeopardize the continued existence of CV spring-run Chinook salmon or CCV steelhead or in the destruction or adverse modification of designated critical habitat.

2.8.3. Reasonable and Prudent Measures

In addition the conditions for monitoring and research described in Section 1.3.1.5 above, NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize effects to listed species. This opinion requires that USFWS and other SJRRP agencies acting under Permit 20571:

1. Minimize the number of hatchery-origin spring-run Chinook salmon that are used as broodstock, to the extent possible, based on the estimated adult escapement and the presence of adequate spawning and rearing conditions in the natural origin broodstock collection locations (i.e. the San Joaquin River and Butte Creek).

2. Ensure that 100 percent of the juvenile spring-run Chinook salmon released from Conservation Facilities are marked (adipose fin-clipped) and tagged (using CWTs), providing a life-long indicator of origin.

3. Implement the hatchery program as described in the HGMP, and monitor hatchery operation and effects on ESA-listed species.

4. An annual report on the status of collections and summary of the coming year's proposed collections will be submitted to NMFS and CDFW. The report will become part of the annual report required for the permit (Section 1.3.9, condition 16 above) to be submitted on the Applications and Permits for Protected Species (APPS) site[10].

2.8.3.1. Terms and Conditions

The terms and conditions are non-discretionary and serve to implement the reasonable and prudent measures (RMPs). Action Agencies must comply with them in order to implement the RMPs (50 CFR 402.14). The Action Agencies have 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 incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) will lapse.

This opinion requires that the Action Agencies:

1. The following terms and conditions implement reasonable and prudent measure 1: *"Minimize the number of hatchery-origin spring-run Chinook salmon that are used as*

[10] https://apps.nmfs.noaa.gov/

broodstock, to the extent possible, based on the estimated adult escapement and the presence of adequate spawning and rearing conditions in the natural origin broodstock collection locations (i.e. the San Joaquin River and Butte Creek)."

a. Develop an annual Donor Stock Collection Plan (DSCP) from a multi-agency technical team to describe the collection plan for each year. The annual DSCP will be submitted to NMFS and CDFW for approval and will be developed prior to any collections from the FRFH or Butte Creek. It will include all the expected collection actions and associated monitoring for the year. The criteria below will evaluate FRFH and Butte Creek donor stock collections each year and the number of individuals targeted by life stage:
   - Interim Facility or SCARF status and capacity available to rear broodstock;
   - Resources available to collect donor stock;
   - Genetics;
   - Availability of donor stock.

2. The following terms and conditions implement reasonable and prudent measure 2: *"Ensure that 100 percent of the juvenile spring-run Chinook salmon released from Conservation Facilities are marked (adipose fin-clipped) and tagged (using CWTs), providing a life-long indicator of origin."*
   a. Create and send NMFS notices of fish releases, which include: approximate dates and times of releases, approximate locations of releases, CWT Codes of all fish to be released, identification of any other markings on the fish, and total fish released.

3. The following terms and conditions implement reasonable and prudent measure 3: *"Implement the hatchery program as described in the HGMP, and monitor hatchery operation and effects on ESA-listed species."*
   a. Conduct surveys, annually, to determine the timing, abundance, and distribution of hatchery origin spring-run Chinook salmon that spawn in the San Joaquin River.

   b. Transport and quarantine of individuals will occur according to the protocols detailed in Permit 20571, the Permit Application, and the HGMP.

   c. Staff will continue to participate in the Fisheries Reintroduction Regulatory Team, as necessary to give updates on and discuss hatchery, monitoring, and broodstock actions.

4. The following terms and conditions implement reasonable and prudent measure 4: *"An annual report on the status of collections and summary of the coming year's proposed collections will be submitted to NMFS and CDFW. The report will become part of the annual report required for the permit (Section 1.3.9, condition 16 above) to be submitted on the Applications and Permits for Protected Species (APPS) site[10]."*
   a. Year-End Report: A year-end report will be submitted on the APPS website by December 31 of each year. This document will summarize the permitted hatchery activities, the actual take of ESA-listed salmonids that occurred during the year, any adaptive processes under review, and any differences between the anticipated actions and what occurred.

USFWS shall provide a comprehensive annual report to NMFS each year through NMFS' site APPS[10] (as described in Term and Condition 4a). USFWS shall also provide the following on an annual or as needed basis: (1) Donor Stock Collection Plan; (2) notices of fish releases (as described in Term and Condition 1a and 2a); and the Year-End Annual Report (as described in Term and Condition 4a). All reports, as well as all other notifications required in the permit, shall be submitted electronically to the NMFS point of contact for this program:

Hilary Glenn (916) 930-3720, Hilary.Glenn@noaa.gov

Written materials may also be submitted to:

NMFS – West Coast Region
Attn: Hilary Glenn
California Central Valley Office
650 Capitol Mall, Suite 5-100
Sacramento, California 95814

2.9. 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 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 (50 CFR 402.02). NMFS has identified one conservation recommendation appropriate to the Proposed Action:

1. The USFWS, in cooperation with the NMFS and other entities, should continue to investigate the level of ecological interactions between hatchery-produced spring-run Chinook salmon and naturally produced Chinook salmon within the San Joaquin River Basin to identify additional methods to minimize these interactions.

2.10. Reinitiation of Consultation

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 incidental take statement 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 to 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.

As noted above, in the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. If any of the direct take amounts specified in this opinion's effects analysis section (2.4) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) and/or (3) will have been met.

In addition, reinitiation is required if implementation of the Proposed Action is to continue beyond December 31, 2023.

2.11. "Not Likely to Adversely Affect" Determinations

NMFS has determined that, while the Proposed Action may affect Southern Resident killer whales, due to their dependence on Chinook salmon as a prey item, the Proposed Action is not likely to adversely affect SDPS Southern Resident killer whales. This determination was made pursuant to Section 7(a)(2) of the ESA implementing regulations at 50 CFR Part 402, and agency guidance for preparation of letters of concurrence[11], and is described here.

The applicable standard to find that a Proposed Action is "not likely to adversely affect" ESA listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial[12]. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are extremely unlikely to occur.

2.11.1. Southern Resident Killer Whales Determination

The Southern Resident killer whale DPS composed of J, K, and L pods was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). The final rule listing Southern Resident killer whales as endangered identified several potential factors that may have caused their decline or may be limiting recovery. These are: quantity and quality of prey, toxic chemicals which accumulate in top predators, and disturbance from sound and vessel traffic. The rule also identified oil spills as a potential risk factor for this species. The final recovery plan includes more information on these potential threats to Southern Resident killer whales (NMFS 2008b). NMFS published the final rule designating critical habitat for Southern Resident killer whales on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters including Puget Sound, but does not include areas with water less than 20 feet deep relative to extreme high water. The PCEs of Southern Resident killer whale critical habitat are: (1) Water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

Southern Resident killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands. By early autumn, the range of the whales, particularly J pod, expands to Puget Sound. By late fall, the Southern Resident killer whales make frequent trips to the outer coast

[11] Memorandum from D. Robert Lohn, Regional Administrator, to ESA consultation biologists (guidance on informal consultation and preparation of letters of concurrence) (January 30, 2006).

[12] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Act consultation handbook: procedures for conducting section 7 consultations and conferences. March 1998. Final p.3-12.

and are seen less frequently in the inland waters. In the winter and early spring, Southern Resident killer whales move into the coastal waters along the outer coast from southeast Alaska south to central California.

Southern Resident killer whales consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their primary prey (review in NMFS 2008b). Ongoing and past diet studies of Southern Resident killer whales conduct sampling during spring, summer and fall months in inland waters of Washington State and British Columbia (i.e., Ford and Ellis 2006; Hanson *et al.* 2010, ongoing research by the Northwest Fisheries Science Center (NWFSC)). Therefore, the majority of our knowledge of diet is specific to inland waters. We know less about the diet of Southern Resident killer whales off the Pacific Coast. However, chemical analyses support the importance of salmon in the year-round diet of Southern Resident killer whales (Krahn *et al.* 2002, Krahn *et al.* 2007). Prey and fecal samples recently collected during the winter and spring indicates a diet dominated by salmonids, particularly Chinook salmon, with the presence of lingcod and halibut (NWFSC unpubl. data). The predominance of Chinook salmon in the Southern Resident killer whales' diet when in inland waters, even when other species are more abundant, combined with information indicating that the killer whales consume salmon year round, makes it reasonable to expect that Southern Resident killer whales predominantly consume Chinook salmon when available in coastal waters.

Adverse effects to Southern Resident killer whales associated with the Proposed Action are not likely to occur. Conversely, Southern Resident killer whales could benefit slightly from hatchery production of CV spring-run Chinook salmon due to an increased forage base of salmon, which is their principal prey item. Without hatchery production, in absence of the historic spawning habitat for Chinook salmon, Southern Resident killer whales would need to expend additional energy to locate and capture available prey. Such a scenario would be expected to decrease the resiliency of Southern Resident killer whale to stochastic events, and further reduce the viability of the DPS. Therefore the hatchery production associated with the Proposed Action will result in beneficial effects to Southern Resident killer whales.

2.11.2. Conclusion

Based on this analysis, NMFS concludes that all effects of the Proposed Action are not likely to adversely affect SDPS Southern Resident killer whales, nor would it adversely affect or modify their designated critical habitat. Effects to Southern Resident killer whales will be beneficial due to an increase in prey items.

2.11.3. Reinitiation

This concludes informal ESA consultation on this action in accordance with 50 CFR 402.14 (b)(1), and MSA consultation in accordance with 50 CFR 600.920 (e)(3). FWS and BOR must reinitiate consultation on this action if new information becomes available, or if circumstances occur that may affect listed species, designated critical habitat, or EFH in a manner, or to an extent, not previously considered.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

The consultation requirement of section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or Proposed Actions that may adversely affect EFH. The MSA (Section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effects include the direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on descriptions of EFH for Pacific Coast salmon (PFMC 2003) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The Proposed Action is the implementation of one hatchery program in the San Joaquin River Basin, as described in detail in Section 1.3. The action area of the Proposed Action includes habitat described as EFH for Chinook salmon. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook salmon.

The area affected by the Proposed Action includes the San Joaquin River from Friant Dam downstream to the confluence of the San Joaquin and Merced Rivers.

As described by PFMC (2003):

> "Freshwater EFH for [C]hinook salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat."

The aspects of EFH that might be affected by the Proposed Action include effects of hatchery operations on ecological interactions in spawning and rearing areas.

3.2. Adverse Effects on Essential Fish Habitat

The Proposed Action generally does not have effects on the major components of EFH. Spawning and rearing locations and adult holding habitat are not expected to be affected by operation of the program, as no modifications to these areas would occur, and no structures that would impede migration are included or proposed to be constructed. Potential effects on EFH by the Proposed Action are only likely to occur in the migration corridor in the San Joaquin River.

As described in Section 2.4.2, water withdrawal for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery program includes designs to minimize each of these effects. Criteria for surface water withdrawal are set to avoid impacts on CV spring-run Chinook salmon and CCV steelhead spatial structure. Further, the amount of water to be removed will be largely returned to the river approximately 0.5 miles from the point of withdrawal and the intake is screened in compliance with NMFS criteria.

The PFMC (2003) recognized concerns regarding the “genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations.” The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations (Section 2.4.1). Hatchery fish returning to the San Joaquin River are expected to largely spawn and rear near the hatchery. Competition is not anticipated as these fish are being reintroduced to the San Joaquin River, an area where salmon and steelhead have been previously extirpated. Some spring-run Chinook from the SJRRP’s Conservation Program will stray into other rivers and tributaries, but not in numbers that would cause the carrying capacities of natural production areas to be exceeded, or that would result in increased incidence of disease or increases in predators. Predation by adult hatchery-origin Chinook salmon on juvenile natural-origin Chinook salmon would not occur due to timing differences and the fact that adult salmon stop feeding by the time they reach spawning areas, and predation by juvenile offspring of hatchery salmon on juvenile natural-origin Chinook salmon would not occur for reasons discussed in Section 2.4.2.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook salmon, NMFS believes that the Proposed Action, as described in the HGMP (CDFW 2016a), and the ITS (Section 2.8) includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. USFWS shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the PFMC (2003) provided an overarching recommendation that hatchery programs:

> "[c]omply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids."

NMFS adopts this recommendation as a specific conservation recommendation for this Proposed Action. The biological opinion explicitly discusses the potential risks of hatchery fish on fish from natural populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on Chinook salmon in the San Joaquin River Basin. In abiding by the Terms and Conditions of the opinion, the NMFS considers the USFWS will be implementing the EFH conservation recommendation.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations, unless NMFS and the Federal agency have agreed to use alternative time frame for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that, in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5. Supplemental Consultation

The USFWS 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)).

4. FISH AND WILDLIFE COORDINATION ACT

The purpose of the Fish and Wildlife Coordination Act (FWCA) is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). 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)).] 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's 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's authority, not just those currently managed under the ESA and MSA.

The following recommendations apply to the proposed action:

1. The USFWS and other SJRRP representatives acting under the permit should continue to implement high priority recovery actions identified 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 so as to meet the purpose of the FWCA. This concludes the FWCA portion of this consultation.

5. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION 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.

5.1. 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 consultation are the applicants and funding/action agencies listed on the first page. Individual copies were made available to the applicants. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

5.2. 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.

5.3. Objectivity

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, 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., and the MSA implementing regulations regarding EFH, 50 CFR 600.

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

Referencing: All supporting materials, information, data, and analyses are properly referenced. They follow standard scientific referencing style.

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

6. REFERENCES

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March 19, 1998 (63 FR 13347). Final Rule: Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California.

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