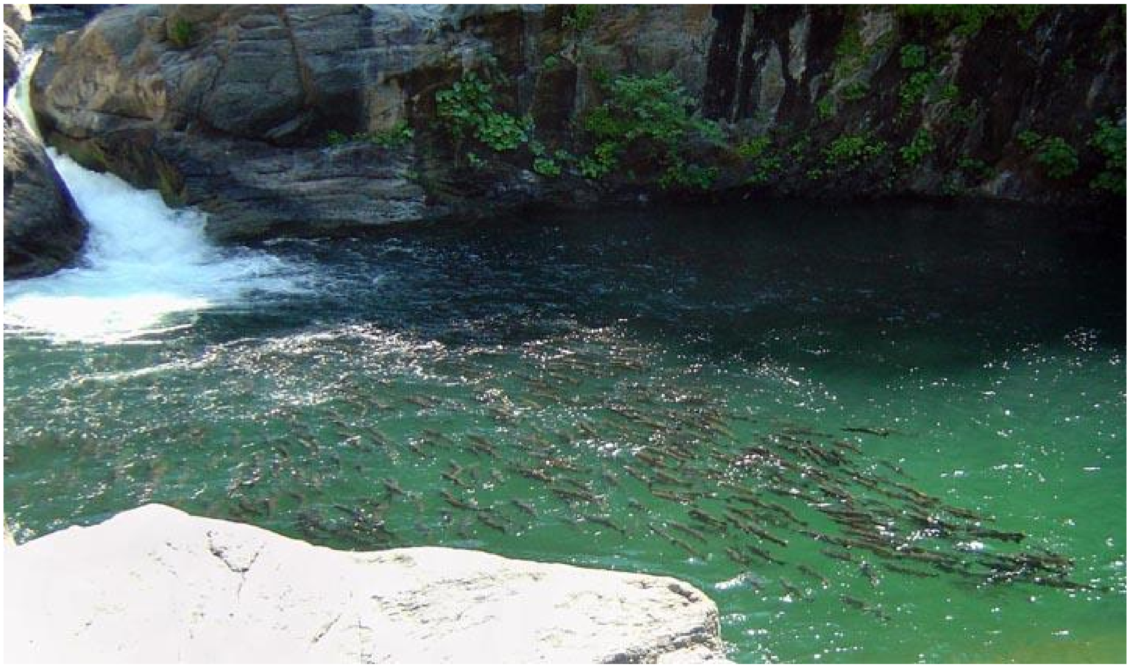
CALIFORNIA CENTRAL VALLEY RECOVERY DOMAIN

5-Year Review:
Summary and Evaluation of
Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit



Spring-run Chinook salmon holding in Quartz Bowl, Butte Creek. Photo credit David Little, Chico Enterprise-Record, CA. 2005

NOAA's National Marine Fisheries Service
West Coast Region

[April 2016]

5-YEAR REVIEW
Central Valley Recovery Domain

Species Reviewed	Evolutionarily Significant Unit or Distinct Population Segment
Chinook Salmon ***(Oncorhynchus tshawytscha)***	**Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit**

1.0 GENERAL INFORMATION

1.1 Preparers and Reviewers

1.1.1 West Coast Region

Preparers:

Naseem Alston[1] (916) 930-3655 Naseem.Alston@noaa.gov

Reviewers:

Maria Rea[1] (916) 930-3600 Maria.Rea@noaa.gov
Scott Rumsey[2] (503) 872-2791 Scott.Rumsey@noaa.gov
Brian Ellrott[1] (916) 930-3600 Brian.Ellrott@noaa.gov

[1]California Central Valley Office, 650 Capitol Mall, Suite 5-100, Sacramento, CA 95814
[2]Protected Resources Division, 1201 NE Lloyd Blvd., Suite 1100, Portland, OR 97232

1.1.2 Southwest Fisheries Science Center

Staff: Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S.T. Lindley.

Issued a Report to NOAA's National Marine Fisheries Service (NMFS), West Coast Region (WCR), titled: *Viability Assessment for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest.* Dated: February 2, 2016.

Southwest Fisheries Science Center (SWFSC), Fisheries Ecology Division, 110 Shaffer Road, Santa Cruz, CA 95060

1.2 Introduction

Many West Coast salmon and steelhead (*Oncorhynchus* sp.) stocks have declined substantially from their historic numbers and now are at a fraction of their historical abundance. There are several factors that contribute to these declines, including: overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices.

These factors collectively led to NMFS listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal Endangered Species Act (ESA).

The ESA, under Section 4(c)(2), directs the Secretary of Commerce to review the listing classification of threatened and endangered species at least once every five years. After completing this review, the Secretary must determine if any species should be: (1) removed from the list; (2) have its status changed from threatened to endangered; or (3) have its status changed from endangered to threatened. The most recent status reviews for West Coast salmon and steelhead occurred in 2010, and prior to that in 2005 and 2006. This document summarizes NMFS's 5-year review of the ESA-listed Central Valley (CV) spring-run Chinook salmon Evolutionarily Significant Unit **(**ESU).

1.2.1 Background on Listing Determinations

Under the ESA, a species, subspecies, or a distinct population segment (DPS) may be listed as threatened or endangered. To identify the proper taxonomic unit for consideration in an ESA listing for salmon we draw on our "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (ESU Policy) (56 FR 58612). According to this policy guidance, populations of salmon that are substantially reproductively isolated from other con-specific populations and are representing an important component in the evolutionary legacy of the biological species are considered to be an ESU. In our listing determinations for Pacific salmon under the ESA, we treated an ESU as constituting a DPS, and hence a ''species.''

Artificial propagation (fish hatchery) programs are common throughout the range of ESA-listed West Coast salmon and steelhead. On June 28, 2005, we announced a final policy addressing the role of artificially propagated Pacific salmon and steelhead in listing determinations under the ESA (70 FR 37204). Specifically, this policy: (1) establishes criteria for including hatchery stocks in ESUs and DPSs; (2) provides direction for considering hatchery fish in extinction risk assessments of ESUs and DPSs; (3) requires that hatchery fish determined to be part of an ESU or DPS to be included in any listing of those units; (4) affirms our commitment to conserving natural salmon and steelhead populations and the ecosystems upon which they depend; and (5) affirms our commitment to fulfilling trust and treaty obligations with regard to the harvest of some Pacific salmon and steelhead populations, consistent with the conservation and recovery of listed salmon ESUs and steelhead DPSs.

To determine whether a hatchery program was part of an ESU or DPS, NMFS convened the Salmon and Steelhead Hatchery Advisory Group (SSHAG), which evaluated all hatchery stocks and programs and divided them into 4 categories (SSHAG 2003):

Category 1: The hatchery population was derived from a native, local population; is released within the range of the natural population from which is was derived; and has experienced only relatively minor genetic changes from causes such as founder effects, domestication or non-local introgression.

Category 2: The hatchery population was derived from a local natural population, and is released within the range of the natural population from which is was derived, but is known or suspected to have experienced a moderate level of genetic change from causes such as founder effects, domestication, or non-native introgression.

Category 3: The hatchery population is derived predominately from other populations that are in the same ESU/DPS, but is substantially diverged from the local, natural population(s) in the watershed in which it is released.

Category 4: The hatchery population was predominately derived from populations that are not part of the ESU/DPS in question; or there is substantial uncertainty about the origin and history of the hatchery population.

Based on these categorical delineations, hatchery programs in SSHAG categories 1 and 2 are included as part of an ESU or DPS (70 FR 37204) although hatchery programs in other categories may also be included in an ESU or DPS under certain circumstances.

Because the new hatchery listing policy changed the way NMFS considered hatchery fish in ESA listing determinations, we conducted new status reviews and ESA-listing determinations for West Coast salmon ESUs and steelhead DPSs using this policy. On June 28, 2005, we issued final listing determinations for 16 ESUs of Pacific salmon and on January 5, 2006 we issued final listing determinations for 10 DPSs of steelhead.

The 2005 listing determination concluded that Feather River Fish Hatchery (FRFH) spring-run Chinook salmon production should be included in the CV spring-run Chinook salmon ESU. In 2010/2011 we conducted a status review of CV spring-run Chinook salmon, and determined that the available information continues to support including the FRFH stock as part of the CV spring-run Chinook salmon ESU.

1.3 Methodology used to complete the review

A public notice announcing NMFS' intent to conduct 5-year status reviews for the 28 ESUs/DPSs of west coast anadromous salmonids was published in the Federal Register on February 6, 2015 (80 FR 6695). This notice initiated a 60-day period for the public to provide comments to NMFS related to the status of the species being reviewed. The West Coast Region (WCR) of NMFS coordinated informally with the State co-managers to ensure they were informed about the status review and had an opportunity to provide any comments or information. No comments relevant to CV spring-run Chinook salmon were provided during the 60-day period.

Following the comment period, three main steps were taken to complete the 5-year status review for the CV spring-run Chinook salmon. First, the SWFSC reviewed any new and substantial scientific information that had become available since the 2010 status review, and produced an updated biological status summary report (herein cited as Williams et al. 2016 and referred to as the "viability report"). The viability report was intended to determine whether or not the biological status of CV spring-run Chinook salmon had changed since the 2010 status review was conducted. Next, the California Central Valley Office (CCVO) reviewed the viability report and assessed whether the five ESA listing factors (threats) changed substantially since the 2010 status review. To assess the five ESA listing factors, several key documents/data were reviewed such as the Federal Register notices identified in Tables 1 and 2 and other relevant publications/personal communication including:

(1) The 5-year Status Review Report for CV spring-run Chinook salmon published in 2011 (NMFS 2011)
(2) Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014)
(3) Discussions with California Department of Fish and Wildlife (CDFW) and the U.S. Fish and Wildlife Service (USFWS) on watershed assessments and recovery action implementation status
(4) Implementation of the reasonable and prudent alternative for the Biological Opinion on the Long-term Operations of the Central Valley Project (CVP) and State Water Project (SWP) (NMFS 2009)
(5) Grandtab (CDFW 2015)
(6) Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin (Lindley et al. 2007)

Finally, the CCVO staff considered the viability report, the current threats to the species, recovery action implementation, and relevant conservation measures before making a determination whether the listing status of the species should be uplisted (*i.e.,* threatened to endangered), be delisted (*i.e.,* recovered), or remain unchanged. In the CCVO a team of four biologists formed the core working group that assimilated information from various sources to support this review and the reviews of Sacramento River winter-run Chinook salmon and California Central Valley steelhead.

1.4 Background – Summary of Previous Reviews, Statutory and Regulatory Actions, and Recovery Planning

1.4.1 Federal Register (FR) Notice citation announcing initiation of this review

80 FR 6695; February 6, 2015

1.4.2 Listing history

The CV spring-run Chinook salmon ESU was originally listed in 1999 as a threatened species (Table 1). Following the development of NMFS' hatchery listing policy, we re-evaluated the status of this ESU, and issued a final listing determination, that the ESU continued to warrant listing as a threatened species and that the FRFH stock of spring-run Chinook salmon should now be part of the ESU (Table 1).

Table 1. Summary of the listing history under the Endangered Species Act for the CV spring-run Chinook salmon ESU

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Chinook Salmon (*O. tshawytscha*)	CV spring-run Chinook salmon	**FR notice:** 64 FR 50394 **Date listed:** 9/16/1999 **Classification:** Threatened	The ESA listing status of this ESU has not been revised since its original listing. On June 28, 2005, NMFS published the final hatchery listing policy (70 FR 37204) and reaffirmed the threatened status of the ESU (70 FR 37160).

1.4.3 Associated rulemakings

The ESA requires NMFS to designate critical habitat for any species it lists under the ESA. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features essential to the conservation of the species, and those features which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation of the species. We originally designated critical habitat for this ESU in 2000, but later withdrew that designation as a result of litigation. In 2005, we issued a new final critical habitat designation for this ESU (Table 2).

Section 4(d) of the ESA directs NMFS to issue regulations necessary and advisable to conserve species listed as threatened. This applies particularly to "take," which can include any act that kills, injures, or harms fish, and may include habitat modification. The ESA automatically prohibits the take of species listed as endangered. In 2002, we promulgated a 4(d) protective regulation for this ESU that applied the section 9 take prohibitions to west coast threatened salmonids and also created several "take limits" to define exceptions for when take prohibitions would apply. This rule was slightly revised when this and other ESUs were re-evaluated as part of the 2005 salmon listing determination process that also considered hatchery populations (see Table 1). In 2013, we included additional 4(d) take exceptions when designating a 10(j) nonessential experimental population (NEP) of spring-run Chinook salmon for reintroduction as part of the San Joaquin River Restoration Program (SJRRP) (Table 2).

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for CV spring-run Chinook salmon.

Salmonid Species	ESU/DPS Name	4(d) Protective Regulations	Critical Habitat Designations
Chinook Salmon *(O. tshawytscha)*	CV spring-run Chinook salmon	**FR notice:** 67 FR 1116 **Date:** 01/09/2002	**FR notice:** 70 FR 52488 **Date:** 09/02/2005
		FR notice: 78 FR 79622 **Date:** 12/31/2013	

1.4.4 Review History

Numerous scientific assessments have been conducted to assess the biological status of this ESU (Table 3).

Table 3. List of previous scientific assessments for CV spring-run Chinook salmon

Salmonid Species	ESU Name	Document Citation
Chinook Salmon *(O. tshawytscha)*	CV spring-run Chinook salmon	National Marine Fisheries Service 1998; West Coast Salmon Biological Review Team 2003; Lindley et al 2004; Good et al 2005; National Marine Fisheries Service 2005; Lindley et al 2007; Williams et al 2011; and Williams et al 2016

1.4.5 Species' Recovery Priority Number at start of 5-year review

On June 15, 1990, NMFS issued guidelines (55 FR 24296) for assigning listing and recovery priorities. For recovery plan development, implementation, and resource allocation, we assess three criteria to determine a species' recovery priority number from 1 (high) to 12 (low): (1) magnitude of threat; (2) recovery potential; and (3) conflict with development projects or other economic activity. NMFS re-evaluated the recovery priority numbers for listed species as part of the FY2013-FY2014 ESA Biennial Report to Congress (http://www.nmfs.noaa.gov/pr/laws/esa/biennial.htm) (NMFS 2015). As a result of the re-evaluation, the recovery potential for CV spring-run Chinook salmon increased, causing the species' recovery priority number to change from 7 to 5. Table 4 lists the current recovery priority numbers for the subject species, as reported in NMFS (2015). Regardless of a species' recovery priority number, NMFS remains committed to continued efforts to recovery all ESA-listed species under our authority.

1.4.6 Recovery Plan or Outline

In 2014, NMFS released a final multi-species recovery plan that addresses all three listed salmonids in the California Central Valley, including the CV spring-run Chinook salmon ESU (Table 4).

Table 4. Recovery Priority Number and Endangered Species Act Recovery Plan for CV Spring-run Chinook Salmon.

Salmonid Species	ESU/DPS Name	Recovery Priority Number	Recovery Plans/Outline
Chinook Salmon *(O. tshawytscha)*	CV spring-run Chinook salmon	5	**Name of Plan:** Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead (July 2014) **Plan Status:** Final http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/california_central_valley/california_central_valley_recovery_plan_documents.html

2.0 REVIEW ANALYSIS

2.1 Delineation of Species under the Endangered Species Act

2.1.1 Is the species under review a vertebrate?

ESU/DPS Name	YES*	NO**
Central Valley Spring-run Chinook Salmon	X	

** if "Yes," go to section 2.1.2; ** if "No," go to section 2.2*

2.1.2 Is the species under review listed as a DPS?

ESU/DPS Name	YES*	NO**
Central Valley Spring-run Chinook Salmon	X	

** if "Yes," go to section 2.1.3; ** if "No," go to section 2.1.4*

2.1.3 Was the DPS listed prior to 1996?

ESU/DPS Name	YES*	NO**	Date Listed if Prior to 1996
Central Valley Spring-run Chinook Salmon		X	

** if "Yes," give date go to section 2.1.3.1*
*** if "No," go to section 2.1.4*

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

In 1991 NMFS issued a policy to provide guidance for defining ESUs of salmon and steelhead that would be considered for listing under the ESA (56 FR 58612; November 20, 1991). Under this policy a group of Pacific salmon populations is considered an ESU if it is substantially reproductively isolated from other con-specific populations and it represents an important component in the evolutionary legacy of the biological species. In listing the CV spring-run Chinook salmon ESU, NMFS treated the delineated ESU as a DPS, and hence a "species", under the ESA. The 1996 DPS policy affirmed that a stock of Pacific salmon is considered a DPS if it represents an ESU of a biological species and concluded that NMFS' ESU policy was a detailed extension of the joint DPS policy. In summary, therefore, the ESU meets the 1996 DPS policy standards.

2.1.4 Summary of relevant new information regarding the delineation of the Central Valley Spring-run Chinook Salmon ESU boundary

The ESU boundary for CV spring-run Chinook salmon contains the Sacramento River Basin downstream of impassible barriers. The ESU includes all naturally spawned populations of CV spring-run Chinook salmon in the Sacramento River and its tributaries, including the Feather River. 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. More information is needed when considering whether or not the presence of these fish would warrant a change to the ESU boundary. Additionally, there may be interest in modifying the ESU boundary in the future when spring-run Chinook salmon are successfully reintroduced into the San Joaquin River Basin and/or into Central Valley habitats upstream of currently impassable barriers. Based on this review, NMFS is not recommending a change to the boundary of this ESU.

NMFS concluded to include FRFH spring-run Chinook stock in the listed ESU in 2005 (70 FR 37160), which was reaffirmed in the 2010 review. As part of this 5-year review, we have re-evaluated the status of this hatchery stock and concluded that it should remain part of the CV spring-run Chinook salmon ESU.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

ESU/DPS Name	YES	NO
Central Valley Spring-run Chinook Salmon	X	

The ESA requires recovery plans to incorporate (to the maximum extent practicable) objective, measurable criteria which, when met, would result in a determination in accordance with the provisions of the ESA that the species can be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). NMFS issued a final approved recovery plan for this ESU in 2014. The plan contains recovery criteria that are objective and measurable, and reflect the best available and most-up-to-date information on the biology of this ESU and its habitat and address both biological parameters as well as the 5 listing factors. The biological recovery criteria in 2014 recovery plan are based on the Viable Salmon Population criteria developed by McElhany et al. (2000).

2.2.2 Adequacy of Recovery Criteria

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

ESU/DPS Name	YES	NO
Central Valley Spring-run Chinook Salmon	X	

The biological recovery criteria in the recovery plan are based on the best available information.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

ESU/DPS Name	YES	NO
Central Valley Spring-run Chinook Salmon	X	

The recovery plan contains threat abatement recovery criteria that address each of the five listing factors.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information

The recovery plan for the Central Valley contains the following ESU-level and population-level recovery criteria for CV spring-run Chinook salmon.

ESU-Level Recovery Criteria

- ❑ One population in the Northwestern California Diversity Group at low risk of extinction
- ❑ Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction
- ❑ Four populations in the Northern Sierra Diversity Group at low risk of extinction
- ❑ Two populations in the Southern Sierra Diversity Group at low risk of extinction
- ❑ Maintain multiple populations at moderate risk of extinction

In order to meet the recovery criteria for this ESU and thereby delist the species, there must be at least eight populations at a low risk of extinction distributed throughout the Central Valley, as well as additional populations at a moderate risk of extinction. As described in Williams et al. (2016) and below in Section 2.3, these recovery criteria are not currently being met.

Population-Level Extinction Risk Criteria

The criteria for assessing the extinction risk at the population level are identified in Table 5 and are summarized below. Estimators for the various extinction risk criteria are presented in Table 6 (from Lindley et al. 2007). The average run size is computed as the mean of the three most recent generations. Mean population size is estimated as the product of the mean run size and the average generation time. Population growth (or decline) rate is estimated from the slope of the natural logarithm of spawners versus time for the most recent 10 years of spawner count data. The fraction of naturally-spawning fish of hatchery origin is the mean fraction over one to four generations.

Low Risk Extinction Criteria

- ❑ Census population size is >2,500 adults -or- Effective population size is >500
- ❑ No productivity decline is apparent
- ❑ No catastrophic events occurring or apparent within the past 10 years
- ❑ Hatchery influence is low

Moderate Risk Extinction Criteria

- ❑ Census population size is 250 to 2,500 adults -or- Effective population size is 50 to 500 adults
- ❑ Productivity: Run size may have dropped below 500, but is stable
- ❑ No catastrophic events occurring or apparent within the past 10 years
- ❑ Hatchery influence is moderate or hatchery operates as a conservation hatchery using best management practices

In the recovery plan, CV spring-run Chinook salmon populations are prioritized based on their potential or known extinction risk. Of highest priority are "Core 1" populations, which have been identified based on their known ability or potential to meet the low extinction risk criteria. "Core 2" populations are assumed to have the potential to meet the moderate risk of extinction criteria.

Table 5. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids, including the CV spring-run Chinook ESU. Overall risk is determined by the highest risk score for any category.

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

a - Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
b - Decline within last two generations to annual run size ≤ 500 spawners, or run size > 500 but declining at ≥ 10% per year. Historically small but stable population not included.
c - Run size has declined to ≤ 500, but now stable.
d - Catastrophes occurring within the last 10 years.
e - Decline < 90% but biologically significant.
f - See Williams et al. (2011) for assessing hatchery impacts.

Table 6. Estimation Methods and Data Requirements for Population Metrics. S_t denotes the number of spawners in year t; g is mean generation time, assumed as three years for California salmon (from Lindley et al. 2007)

Metric	Estimator	Data	Criterion
$\hat{S}_t$	$\sum_{i=t-g+1}^{t} S_i/g$	$\geq$ 3 years spawning run estimates	Population decline
N_e	$N \times 0.2$ or other	varies	Population size
N	$\hat{S}_t \times g$	$\geq$ 3 years spawning run estimates	Population size
Population growth rate (% per year)	slope of $\log(S_t)$ v. time $\times 100$	10 years S_t	Population decline
c	$100 \times (1 - \min(N_{t+g}/N_t))$	time series of N	Catastrophe
h	average fraction of natural spawners of hatchery origin	mean of 1-4 generations	Hatchery influence

2.3 Updated Information and Current Species Status

2.3.1 Analysis of Viable Salmonid Population Criteria

Summary of Previous Biological Review Team Conclusions

At the last listing determination, Good et al. (2005) reported that a majority of the biological review team (BRT) felt that the CV spring-run Chinook salmon ESU was likely to become endangered, while a minority thought that it was in danger of extinction. The major concerns of the BRT were the low diversity, poor spatial structure, and low abundance of this ESU. The BRT recognized that the ESU once contained many large populations that have been extirpated.

Brief Review of Technical Recovery Team Documents and Findings

The Central Valley Technical Recovery Team delineated 18 or 19 historic independent populations of CV spring-run Chinook salmon, and a number of smaller dependent populations, that are distributed among four diversity groups (Lindley et al. 2004). Of these independent populations, only three are extant (Mill, Deer, and Butte creeks) and they represent only the Northern Sierra Nevada diversity group. The three extant populations passed through prolonged periods of low abundance before increasing in abundance moderately (Mill, Deer creeks) or robustly (Butte Creek) in the 1990s. All independent populations in the Basalt and Porous Lava group and the Southern Sierra Nevada group were extirpated, and only a few dependent populations persist in the Northwestern California group.

Using data through 2005 and the criteria in Table 5, Lindley et al. (2007) found that the populations in Mill, Deer, and Butte creeks were each at or near low risk of extinction. The ESU as a whole, however, could not be considered viable because there were no extant populations in the three other diversity groups. In addition, Mill, Deer, and Butte creeks are close together geographically, decreasing the independence of their extinction risks due to catastrophic disturbance.

Abundance and Trends

As shown in Figure 1, overall, most CV spring-run Chinook salmon escapement have increased slightly in recent years (2012-2014), however, as shown in Figure 2, abundance dropped dramatically in 2015. Abundance and trend statistics for this ESU related to the viability criteria are presented in Table 7. Until 2015, Mill Creek and Deer Creek populations both improved from high extinction risk in 2010 to moderate extinction risk due to recent increases in abundance. Butte Creek continued to satisfy the criteria for low extinction risk. Additionally, since 1996, partly due to increased flows provided in upper Battle Creek, the CV spring-run Chinook salmon population began and are continuing to naturally repopulate Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the CV spring-run Chinook salmon population in Clear Creek has been increasing, and currently meets the moderate extinction risk score. Returns in 2015, were much lower than the increases observed in 2012 to 2014, and are described further below.

In contrast, since 2007, the dependent (Core 2) populations of Cottonwood, Antelope, and Big Chico creeks, have continued to remain very low, with often zero or near zero returns in recent years. New data for the lower Yuba River suggests that the population's size, based on VAKI counts, meets the low extinction risk criteria for abundance, ranging from a few hundred to a few thousand, however the population is likely at high extinction risk due to hatchery influence.

The Feather River population continues to have high returns (1,000-20,000), but is heavily influenced by the FRFH. The population spawning in-river is difficult to determine because they are not counted when entering, and monitoring during spawning results in difficulties distinguishing between races. The returns to the FRFH collected for propagation have remained fairly consistent, generally between 1,000 to 4,000 fish.

The Sacramento River aerial redd surveys continue to indicate that a small population of CV spring-run Chinook salmon, spawning in September, may exist. Although the origin of these spawners is unknown, redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the Red Bluff Diversion Dam (RBDD), ranging from 3 to 105 redds; 2012 observed zero redds, and 2013, 57 redds in September (CDFW 2015).

For many decades, CV spring-run Chinook salmon were considered extirpated from the Southern Sierra Nevada diversity group in the San Joaquin River Basin, despite their historical numerical dominance in the Basin (Fry 1961, Fisher 1994). More recently, there have been reports of adult

Chinook salmon returning in February through June to San Joaquin River tributaries, including the Mokelumne, Stanislaus, and Tuolumne rivers (Franks 2014, Workman 2003, FishBio 2015). These spring-running adults have been observed in several years and exhibit typical spring-run life history characteristics, such as returning to tributaries during the springtime, over-summering in deep pools, and spawning in early fall (Franks 2014, Workman 2003, FishBio 2015). For example, 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FishBio 2015). Additionally, in 2014, implementation of the spring-run Chinook salmon reintroduction plan into the San Joaquin River has begun, which if successful will benefit the spatial structure, and genetic diversity of the ESU. These reintroduced fish have been designated as a 10(j) NEP when within the defined boundary in the San Joaquin River (78FR79622). Furthermore, while the SJRRP is managed to imprint CV spring-run Chinook salmon to the mainstem San Joaquin River, we do anticipate that the reintroduced spring-run Chinook salmon are likely to stray into the San Joaquin tributaries at some level, which will increase the likelihood for CV spring-run Chinook salmon to repopulate other Southern Sierra Nevada diversity group rivers where suitable conditions exist.

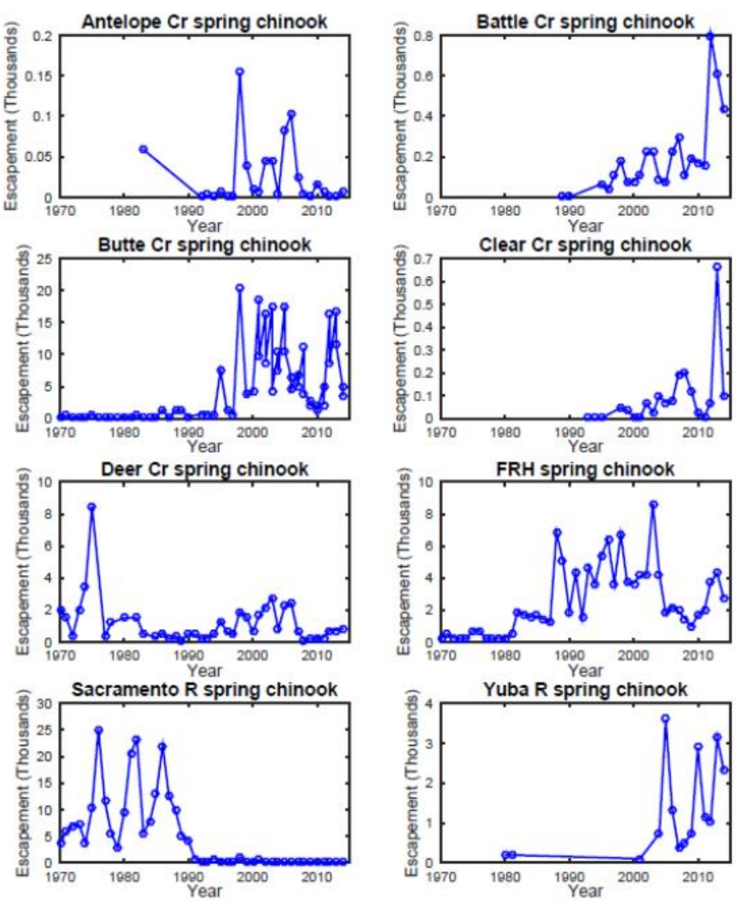


Figure 1. Escapement for CV spring-run Chinook salmon over time in thousands of fish (1970 to 2014). Note: Beginning in 2009, Red Bluff Diversion Dam estimates of CV spring-run Chinook salmon in the Upper Sacramento River were no longer available.

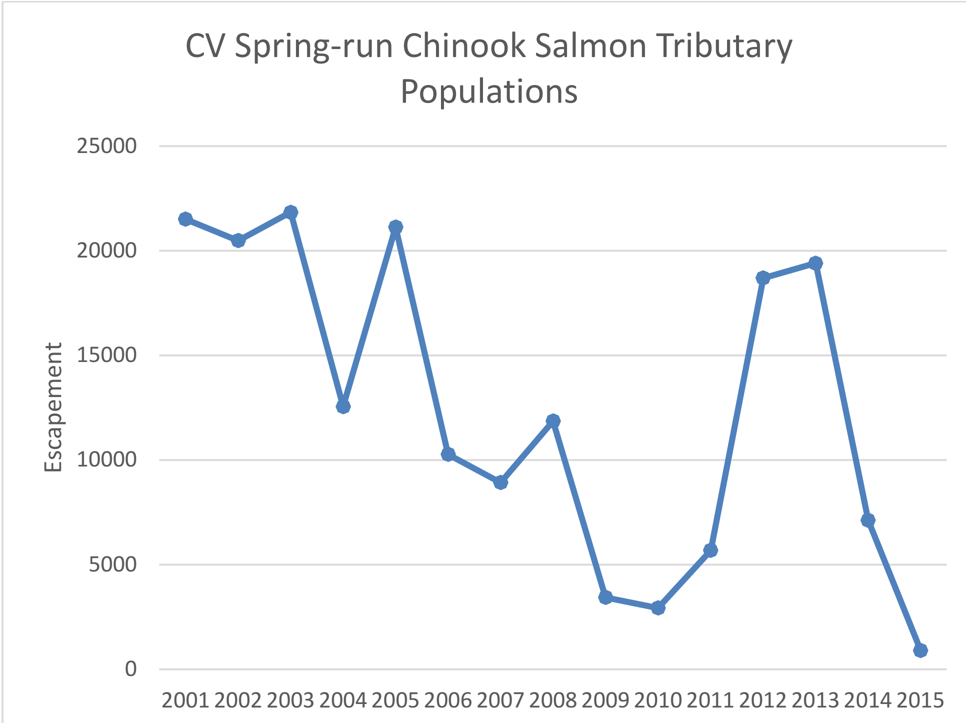


Figure 2. Combined escapement for Central Valley spring-run Chinook salmon tributary populations (Butte, Mill, Deer, Battle, Clear creeks) since 2001. Butte Creek numbers drive the curve and are taken from carcass survey counts.

Table 7. Viability metrics for Central Valley spring-run Chinook salmon ESU populations. Total population size (N) is estimated as the sum of estimated run sizes over the most recent three years for Core 1 populations (bold) and Core 2 populations. The mean population size ($\hat{S}$) is the average of the estimated run sizes for the most recent 3 years (2012 to 2014). Population growth/decline rate (10 year trend) is estimated from the slope of log-transformed estimated run size. The catastrophic metric (recent decline) is the largest year-to-year decline in total population size (N) over the most recent 10 such ratios.

Population	**N**	**$\hat{S}$**	**10-year trend (95% CI)**	**Recent Decline (%)**
Antelope Creek	8.0	2.7	-0.375 (-0.706, -0.045)	87.8
Battle Creek	1836	612	0.176 (0.033, 0.319)	9.0
Big Chico Creek	0.0	0.0	-0.358 (-0.880, 0.165)	60.7
Butte Creek	20169	6723	0.353 (-0.061, 0.768)	15.7
Clear Creek	822	274	0.010 (-0.311, 0.330)	63.3
Cottonwood Creek	4	1.3	-0.343 (-0.672, -0.013)	87.5
Deer Creek	2272	757.3	-0.089 (-0.337, 0.159)	83.8
Feather River Fish Hatchery	10808	3602.7	0.082 (-0.015, 0.179)	17.1
Mill Creek	2091.0	697.0	-0.049 (-0.183, 0.086)	58.0
Sacramento River[a]	-	-	-	-
Yuba River	6515	2170.7	0.67 (-0.138, 0.272)	9.0

[a] Beginning in 2009, estimates of spawning escapement of Upper Sacramento River spring chinook were no longer monitored. Historically, this estimate was derived by the total Red Bluff Diversion Dam (RBDD) counts minus the spring run numbers in the upper Sacramento tributaries. Beginning in 2009, RBDD gates were partially operated in the up position and in 2012 they were entirely removed and thus spring run estimates no longer available.

Productivity

Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation. The majority of CV spring-run Chinook salmon are found to return as three-year-olds, therefore looking at returns every three years is used as an estimate of the CRR. In the past the CRR has fluctuated between just over 1.0 to just under 0.5, and in the recent years with high returns (2012 and 2013), CRR jumped to 3.84 and 8.68 respectively. CRR for 2014 was 1.85, and the CRR for 2015 with very low returns was a record low of 0.14. Low returns in 2015 were further decreased due to high temperatures and most of the CV spring-run Chinook salmon tributaries experienced some pre-spawn mortality. Butte Creek experienced the highest pre-spawn mortality in 2015, resulting in a carcass survey CRR of only 0.02.

Spatial Structure

The extirpation of CV spring-run Chinook salmon from three of the four historically utilized diversity groups has greatly decreased the ESU's spatial structure. The northern Sierra Nevada diversity group populations (Mill, Deer, and Butte creeks) have been the only persisting populations. Restoration and more recently consistent returns in Battle Creek (basalt and porous lave diversity group) and Clear Creek (northwestern California diversity group), have begun to improve the spatial structure of the ESU. Additionally, the reintroduction efforts into the San Joaquin, and the spring-running Chinook salmon returning to the San Joaquin tributaries is promising for even further improvement to spatial structure.

Diversity

As described above, since the majority of CV spring-run Chinook salmon returns have been in one diversity group, genetic and behavioral diversity has been decreased compared to historical levels. Populations continuing to return to the other three diversity groups have the potential to increase the diversity of the ESU.

Some concerns remain with the spring-run Chinook salmon hatchery that is part of the ESU, as there has been and continues to be some introgression with other CV spring-run Chinook salmon populations as well as fall-run Chinook salmon. The majority of the FRFH spring-run Chinook salmon broodstock and in-river spawning population on the Feather River are first generation hatchery-produced fish (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013). The proportion of natural-origin fish in the broodstock is estimated to be 18 percent and 6 percent in 2010 and 2011 respectively (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013). Thus, the minimum criteria of greater than 10 percent of natural-origin fish in the broodstock is not being met annually (CA HSRG 2012). The proportion of hatchery-origin spring- or fall-run Chinook salmon contributing to the natural spawning spring-run Chinook salmon population on the Feather River remains unknown due to overlap in the spawn timing of spring-run and fall-run Chinook salmon, and lack of physical separation. However, the hatchery component is likely to be high. For example, 78 percent and 90 percent of spawners in the 2010/2011 spring-/fall- run Chinook salmon carcass survey were estimated to be from the FRFH respectively (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013).

FRFH-origin spring-run Chinook salmon adults have been recovered in other CV spring and fall-run Chinook salmon populations outside of the Feather River. Up until 2015, at least half of the FRFH spring-run Chinook salmon production has been trucked to release sites such as the San Francisco Bay, which leads to the returns straying to other watersheds at a relatively high rate, posing genetic risk to those other Central Valley salmon populations (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013). The annual spawning run size of CV spring-run Chinook salmon on the Yuba River follows the annual abundance trend of the FRFH spring-run Chinook salmon population. On Battle Creek, as high as 29 percent of CV spring-run Chinook salmon in 2010 were estimated to have originated from the FRFH (USFWS 2014). On Clear Creek, up to five percent of CV spring-run Chinook salmon carcasses above the segregation weir in 2010 to 2013 were from the FRFH (unpublished data, USFWS, Red Bluff FWO). A significant number of FRFH spring-run Chinook salmon strays have been observed in the Keswick Dam fish trap, with a high in 2015, of 114 fish. This indicates a likelihood that they could be interbreeding with natural-origin CV spring- or fall-run Chinook salmon in the Sacramento River (Rueth 2015). A prolonged influx of FRFH spring-run Chinook salmon strays to other CV spring-run Chinook salmon populations even at levels of less than one percent is undesirable and can cause the receiving population to shift to a moderate risk after four generations of such impact (Lindley et al. 2007). More information on the incidence of FRFH spring-run straying is desirable to more accurately estimate the extent to which spawning and introgression is occurring between fall- and spring-run Chinook salmon populations outside of the Feather River.

Viability Discussion

The status of the CV spring-run Chinook salmon ESU has probably improved on balance since the 2010 status review, through 2014, with two of the three extant independent populations of improving from high extinction risks to moderate extinction risks. The third, Butte Creek, has remained at low risk, and all viability metrics had been trending in a positive direction, up until 2015. The Butte Creek spring-run Chinook salmon population has increased in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Sutter-Butte Bypass for juvenile rearing in the majority of years. Additionally, spring-run Chinook salmon in both Battle Creek and Clear Creek continue to repopulate those watersheds, and now fall into the moderate extinction risk category for abundance. In contrast, most dependent spring-run populations have been experiencing continued and somewhat drastic declines.

The CV spring-run Chinook salmon ESU has experienced two drought periods over the past decade. From 2007 to 2009, and now 2012 to 2015, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon (Michel et al. 2015). The impacts of the recent drought years and warm ocean conditions on the juvenile life stage (see Ocean Conditions discussion below) will not be fully realized by the viability metrics until they manifest in potential low run size returns in 2015 through 2018 (Williams et al. 2016). This is already being realized with very low returns in 2015.

The recent drought impacts on Butte Creek can be seen from the lethal water temperatures in traditional and non-traditional spring-run Chinook salmon holding habitat during the summer. A large number of adults (903 and 232) were estimated to have died prior to spawning in the 2013 and 2014 drought respectively (Garman 2015). Pre-spawn mortality was also observed during the 2007 to 2009 drought with an estimate of 1,054 adults dying before spawning (Garman 2015). In 2015, late arriving adults in the Chico vicinity experienced exceptionally warm June air temperatures coupled with the PG&E flume shutdown resulting in a fish die off. Additionally, adult spring-run Chinook salmon in Mill, Deer, and Battle creeks were exposed to warm temperatures, and pre-spawn mortality was observed. Thus, while the independent CV spring-run Chinook populations have generally improved since 2010, and are considered at moderate (Mill and Deer) or low (Butte Creek) risk of extinction, these populations are likely to deteriorate over the next three years due to drought impacts, which may in fact result in severe declines.

Continued introgression between fall- and spring-run Chinook salmon in the FRFH breeding program and straying of FRFH spring-run Chinook salmon to other CV spring-run Chinook salmon populations where genetic introgression would be possible is unfavorable. However, beginning in 2015, and expected to continue, the FRFH released all spring-run Chinook salmon production into the Feather River rather than releasing in the San Francisco Bay which is hypothesized to reduce straying (CA HSRG 2012).

At the ESU level, the spatial diversity within the CV spring-run Chinook salmon ESU is increasing, with presence (albeit at low numbers in some cases) in all four diversity groups. The continued repopulation and increasing abundance of spring-run Chinook salmon to Battle and Clear creeks is benefiting the viability of the ESU. Similarly, the reappearance of phenotypic spring-run Chinook salmon to the San Joaquin River tributaries may be the beginning of natural recolonization processes in rivers where they were once extirpated. Reintroduction planning on the upper Yuba River shows promise, and will be necessary for the ESU to reach viable status. Just as necessary is the active reintroduction efforts below Friant Dam on the mainstem San Joaquin River.

In summary, the status of the CV spring-run Chinook salmon ESU has probably improved since the 2010 status review. The largest improvements are due to extensive restoration, and increases in spatial structure with historically extirpated populations trending in the positive direction. Improvements, evident in the moderate and low risk of extinction of the three independent populations, however, are certainly not enough to warrant the delisting of the ESU. The recent declines of many of the dependent populations, high pre-spawn and egg mortality during the 2012 to 2015 drought, and uncertain juvenile survival during the drought, and ocean conditions, as well as the level of straying of FRFH spring-run Chinook salmon to other CV spring-run Chinook salmon populations are all causes for concern for the long-term viability of the CV spring-run Chinook salmon ESU.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

The last listing determination, Good et al. (2005), and last 5-year Status Review (NMFS 2011) described the major threats to CV spring-run Chinook salmon as falling into three broad categories[1]: loss of historical spawning habitat, degradation of remaining habitat, and genetic threats from the FRFH spring-run Chinook salmon program. The first two categories are discussed below in section 2.3.2.1, and genetic threats resulting from the hatchery program are discussed below in section 2.3.2.5. Also discussed in section 2.3.2.5 are the increasing concerns due to continued severe drought conditions. This section includes discussion of the five listing factors, and concludes with a summary discussion of whether the threats associated with these listing factors have substantially changed in magnitude since the 2010/2011 status review (Table 8).

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Loss of Historical Spawning Habitat

Loss of historic spawning habitat for CV spring-run Chinook salmon remains a major threat, as most of that habitat continues to be blocked by the direct or indirect effects of dams. Since CV spring-run Chinook salmon were originally listed as threatened in 1999, spawning habitat for those fish has been expanded very little compared to the hundreds of miles of habitat blocked by dams. The removal of Saeltzer Dam on Clear Creek in 2000 opened up 10 miles of habitat. A partial low flow barrier on Cottonwood Creek was fixed in 2010, improving access to 30 miles of habitat. Additionally, the removal of Wildcat Dam in 2010 provided easier passage up to Eagle Canyon Dam in North Fork Battle Creek.

The Battle Creek Salmon and Steelhead Restoration Project (Restoration Project) will, upon completion, remove five dams on Battle Creek, install fish screens and ladders on three dams, and end the diversion of water from the North Fork to the South Fork. When the Restoration Project is completed, a total of 42 miles of mainstem habitat and 6 miles of tributary habitat will be restored and available to anadromous salmonids. Delays in completion, due to construction issues and funding shortages, have resulted in delays to benefits from the Project. Completion is currently expected to be in 2020.

Efforts to reintroduce CV spring-run Chinook salmon to historic habitat are underway in the San Joaquin River. 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 Chinook salmon. The San Joaquin River Restoration Settlement Act required an ESA 10(j) NEP with additional 4(d) exceptions. The first required flow releases from Friant Dam in support of the SJRRP occurred in October 2009. The first release of CV spring-run Chinook salmon into the San Joaquin River occurred in April, 2014. A second release occurred in 2015, and future releases are planned to continue annually in the spring. A conservation hatchery and captive broodstock program was initiated in 2012 to support the reintroduction with limited impact on source populations. The 2016 release will include the first generation of spring-run Chinook salmon reared entirely in the San Joaquin River in over 60 years. Key near-future SJRRP milestones include providing additional channel

[1] These are also the three major threat categories that were identified in the 1998 proposed rule to list Central Valley spring-run Chinook salmon as endangered (63 FR 11482). The ESU was ultimately listed as threatened in the 1999 final rule (64 FR 50394) based on information that was not considered in the proposed rule.

capacity in the San Joaquin River and complete the Friant-Kern Canal and Madera Canal Capacity Restoration projects during 2015 to 2022. Other high priority channel and structural construction activities are currently planned to begin 2022 to 2030 to realize the full intent of the SJRRP (SJRRP 2015).

The 2009 CVP-SWP biological opinion includes a phased fish passage program that is intended to expand habitat for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to areas upstream of Shasta Dam on the Sacramento River. Efforts thus far have focused on winter-run Chinook salmon and a pilot reintroduction plan for that species is scheduled for implementation starting in 2017. This reintroduction work will help with subsequent planning and implementation for reintroducing CV spring-run Chinook salmon upstream from Shasta Dam.

In the Yuba River watershed, government agency and non-government groups are engaging in a collaborative, science-based initiative to contribute to the recovery of CV spring-run Chinook salmon by enhancing habitat in the Yuba River downstream of Englebright Dam and reintroduction into their historic habitat in the North Yuba River upstream of New Bullards Bar Dam. This Yuba Salmon Partnership Initiative represents a promising opportunity to rebuild CV spring-run Chinook salmon in the lower Yuba River, as well as begin a pilot reintroduction program within 5-7 years and a full-scale reintroduction which could potentially begin within 10-15 years, under ideal circumstances.

Developed parallel to the Oroville Hydroelectric License, California Department of Water Resources (CDWR), Pacific Gas and Electric Company (PG&E), and NMFS entered into a Habitat Expansion Agreement (HEA) to select the most promising and cost-effective action(s) to expand spawning, rearing, and adult holding habitat sufficient to accommodate an estimated net increase of 2,000 to 3,000 CV spring-run Chinook salmon in the Sacramento River Basin. The expansion is to be accomplished through enhancements to existing accessible habitat, or improving access to habitat (including historical habitat currently blocked), to fully mitigate for any presently unmitigated impacts due to the blockage of fish passage of all fish species caused by the Feather River Hydroelectric Projects. The HEA calls for the development of a Habitat Expansion Plan (HEP). NMFS determined that the most recently proposed HEP (in 2010) did not meet the HEA criteria. Discussions are ongoing regarding the development of a new HEP.

Although the loss of historical spawning habitat remains a major threat to the ESU, the release of CV spring-run Chinook salmon into the San Joaquin River is an unprecedented step towards alleviating this threat. Collectively, the habitat expansion and reintroduction efforts taking place in the Sacramento and San Joaquin basins hold a tremendous amount of promise. If each effort is successful, the ESU will be on its way to recovery.

Degradation of Remaining Habitat

Previous status reviews for CV spring-run Chinook salmon (Myers et al. 1998, Good et al. 2005, NMFS 2011) have indicated that the remaining spawning and rearing habitat for this species is severely degraded. Threats to CV spring-run Chinook salmon habitat include, but are not limited to: (1) operation of antiquated fish screens, fish ladders, diversion dams, and inadequate flows on streams throughout the Sacramento River Basin including on Deer, Mill, and Antelope creeks; (2) levee construction and maintenance projects that have greatly simplified riverine habitat and have disconnected rivers from the floodplain; and (3) water delivery and hydroelectric operation on Butte Creek, Battle Creek, the main-stem Sacramento River (CVP), and the Feather River (SWP).

Cummins et al. (2008) attributed the much reduced biological status of Central Valley anadromous salmonid stocks, including CV spring-run Chinook salmon, to habitat effects related to the construction and operation of the CVP-SWP:

> "*Construction and operation of the CVP and SWP have altered flows, reduced water quality, and degraded environmental conditions and reduced habitat for fish and wildlife in the Central Valley from the headwaters to the Delta. This includes the native anadromous fish of the Central Valley -- winter, spring, fall and late-fall chinook, steelhead and sturgeon. Adult runs that once numbered in the millions have been reduced to thousands or less.*
>
> *The transformation of the natural Sacramento/San Joaquin river systems into a massive water storage and delivery system includes dams and diversions that have blocked access for anadromous salmonids to much of their historical habitat. Development of the CVP and State Water Project has significantly modified the natural hydrologic, geomorphic, physical and biological systems. The modified river system significantly impacts the native salmon and steelhead production as a result of fragmented habitats, migration barriers, and seasonally altered flow and habitat regimes*."

The degradation and simplification of aquatic habitat in the Central Valley has greatly reduced the resiliency of CV spring-run Chinook salmon to respond to additional stressors, such as an extended drought, which has been occurred every year since the last status review. The impacts of the extended drought will unfold over the next several years as fish return from the ocean.

One conservation measure with the potential to greatly improve habitat and increase the ability of CV spring-run Chinook salmon to cope with future stressors, is NMFS's 2009 biological opinion on the long-term operations of the CVP and SWP (NMFS 2009). The CVP/SWP biological opinion contained a reasonable and prudent alternative, which has mandatory actions that are intended to avoid jeopardy to anadromous fish, including CV spring-run Chinook salmon, and avoid destruction of critical habitat, resulting from the long-term operations of those projects. Actions in the CVP/SWP biological opinion that are intended to improve CV spring-run Chinook salmon habitat include:

- implementing multiple actions on Clear Creek to provide more suitable flows and water temperatures, and increase the availability of spawning habitat through gravel additions;
- implementing Keswick Dam release schedules and procedures designed to provide more suitable water temperatures for holding and spawning - through discussions with NMFS, in 2010, U.S. Bureau of Reclamation (Reclamation) began implementation of an improved

Shasta Reservoir storage plan and year-round Keswick Dam release schedule to provide cold water, although continued drought has made meeting temperature criteria difficult;
- modifying gate operations at RBDD – beginning in 2012, operation has included gates-out year-round (to improve upstream migration for adults as well as downstream survival of juveniles);
- providing funding to help complete the Battle Creek Restoration Project (project is briefly describe above);
- providing funding to support the Central Valley Improvement Act (CVPIA) Anadromous Fish Screen Program (AFSP);
- providing significantly increased acreage of seasonally inundated floodplain habitat to improve juvenile rearing in the lower Sacramento River basin – formal planning began in 2011, with completed actions expected to be completed by 2023; and
- implementing multiple actions to improve flow and habitat conditions in the Delta.

Other recent or ongoing programs and projects that have provided benefits to the habitat or range of the CV spring-run Chinook salmon ESU, or are expected to do so in the near future, are discussed below.

Central Valley Improvement Act programs. The CVPIA established the Anadromous Fish Restoration Program (AFRP) in 1992 with the goal of making "all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis". The AFRP is administered jointly by Reclamation and USFWS. Approximately $8 million of CVPIA restoration funds are provided annually for the purpose of protecting, restoring, and enhancing special-status species and their habitats in areas directly or indirectly affected by the CVP.

Between 2010 and 2015, AFRP funded several projects benefitting CV spring-run Chinook salmon:

1) Fish passage project at Ward Dam on Mill Creek in 2015
2) Fish passage project at Hammer Dam (removal) on Cottonwood Creek in 2014
3) Gravel augmentation and other habitat enhancement activities on Clear Creek
4) Fish Passage at the lower falls on Deer Creek
5) Riparian Enhancement Pilot Project on five acres of Hammon Bar on the Yuba River (involving planting cottonwood and three species of willow pole cuttings in 2011 and 2012)

The AFSP and Ecosystem Restoration Program (ERP) conducted a fish entrainment monitoring study at 11 diversions on the Sacramento River (ranging from 9 cfs to 128 cfs) from 2009 through 2012 to obtain critical fish entrainment monitoring data in order to better understand the potential effects of diversions on fish losses and to assist resource managers in evaluating which diversions are most important to screen. Since 2010, the CVPIA AFSP has provided cost share funding to complete 15 fish screen projects on the Sacramento River resulting in the screening of diversions with a total capacity of 1,241 cubic feet per second. Twelve of the fish screen projects completed from 2010 to 2013 were part of a fish entrainment monitoring study that was conducted from 2009-2012.

Additionally, the purpose of section B13 of the CVPIA is to increase availability of spawning and rearing habitat for Sacramento River Basin salmonids. One project was completed in 2014, a side channel rehabilitation at Painter's Riffle. A Restoration Project programmatic biological opinion was completed in 2015, analyzing the proposed project, which will provide improvements and increases to spawning and rearing habitat each year in the upper Sacramento River.

Ecosystem Restoration Program. The ERP has completed seven years of an ambitious 30-year plan to restore ecological health and improve water management in the San Francisco Bay and Sacramento-San Joaquin Delta. Starting under the CALFED Record of Decision in 2000, the California Department of Fish and Game (now CDFW) now fulfills the role of the State's Implementing Agency for the ERP, and is currently managing more than 85 ongoing and approximately 10 newly funded projects. The objectives of the ERP are: 1) to prepare comprehensive ecosystem restoration plans for the Sacramento and San Joaquin rivers, 2) support scientific reviews, and 3) coordinate fish screen and fish passage projects with the AFRP, CVPIA, and other stakeholders to achieve CDFW fish passage goals.

The ERP has protected or restored more than 38,900 acres of habitat, most of which directly or indirectly benefits CV spring-run Chinook salmon. In 2014 the ERP released its updated Conservation Strategy to help guide the program's future work; which may result in habitat improvements for CV spring-run Chinook salmon.

California WaterFix and California EcoRestore. The purpose of the California WaterFix (CWF) is to modernize the state's aging water delivery system and provide additional opportunities to protect sensitive fish species. A proposed CWF water conveyance system would include new points of diversion in the north Delta in concert with improvements to the current through-Delta water export system in the south Delta. Actions under discussion include operation of a dual conveyance system and measures to reduce other stressors to the Delta ecosystem and sensitive species. CWF is in a developmental stage, its implementation is uncertain, and any new benefits or threats to CV spring-run Chinook salmon resulting from the plan would not occur for many years.

California EcoRestore is an initiative to help coordinate and advance habitat restoration in the Delta in the short term (next four years). The initial goal of California EcoRestore is to advance 30,000 acres of Delta habitat restoration. This restoration is unassociated with any habitat restoration that may be required as part of the construction and operation of any new Delta water conveyance (e.g., California WaterFix). The projects for California EcoRestore are still in developmental stages, so any new benefits or threats to CV spring-run Chinook salmon resulting from the plan would not occur for many years.

Flood Management. For the most part, levee maintenance actions continue to adversely simplify habitats and disconnect river systems from historic floodplains. Over the past five years, changes in levee maintenance practices have included "self-mitigating" features such as vegetative rock, constructing levee toe benches that allow for the planting of riparian vegetation, grading rock sizes to reduce piscivorous predator habitat and installing instream woody material to create shoreline refugia for emigrating juveniles. Physical habitat monitoring has shown the riparian mitigation is in itself successful; however, fishery monitoring has not demonstrated these features to be effective when compared to natural bank conditions. Additional monitoring and research is needed, as initial acoustic fish tracking studies have shown these designs may create a hydraulic effect that causes fish to migrate to the opposite side of the river channel.

Butte Creek. Recent conservation actions have improved habitat conditions for Butte Creek spring-run Chinook salmon. Completion of the Willow Slough Weir Project (new culverts and a new fish ladder) in 2010 improved fish passage through the Sutter Bypass. In addition, real-time coordinated operations of the DeSabla Centerville Federal Energy Regulatory Commission (FERC) Project No. 803 have been implemented in recent years to reduce the water temperature-related effects of the project on CV spring-run Chinook salmon adults during the summer.

Feather River – HEA/HEP and Oroville Dam FERC License Settlement. Through the Oroville FERC License Settlement, CDWR has committed to constructing a weir to segregate the spawning of CV spring-run and fall-run Chinook salmon, and implementing low-flow channel habitat improvements. Those habitat changes have yet to occur and there have been no major changes to CV spring-run Chinook salmon habitat in the Feather River in recent years. Additionally, through a parallel process, development of an HEA and HEP are underway, which is expected to enhance sufficient degraded habitat (or provide access to historical habitat) to accommodate an increase of 2,000 to 3,000 CV spring-run Chinook salmon in the Sacramento River Basin.

Battle Creek Restoration Project. As described above, the Restoration Project, when completed will restore nearly 50 miles of habitat available to CV spring-run Chinook salmon, however implementation has been delayed and not expected to be completed until at least 2020.

Lower Yuba River Habitat Restoration. The U.S. Army Corps of Engineers initiated a long-term gravel augmentation program in 2010 that is intended to improve spawning habitat in the uppermost reach of the lower Yuba River. Other lower Yuba River habitat restoration actions that are reasonably certain to occur in the next several years include implementation of a program to add woody material to the river in an effort to increase habitat complexity, and a side channel enhancement project intended to improve rearing habitat. Other fish passage and fish habitat improvement efforts for the lower Yuba River are currently in discussion and planning stages.

Emergency Drought Actions. NMFS and CDFW developed the Voluntary Drought Initiative to reduce the effects of the drought on priority salmon and steelhead populations in California during the 2014 and 2015 drought. It is a temporary, voluntary program that is only being implemented during State and Federal drought declarations or designations, with the goal of supporting agricultural activities while protecting the survival and recovery of ESA-listed salmon and steelhead. Agreements executed with water users during the drought provided a mechanism for ensuring minimum flow conditions for the survival and migration of adult and juvenile CV spring-run Chinook salmon in Mill, Deer and Antelope creeks.

Additionally, as part of the CVP/SWP biological opinion, the Delta Cross Channel (DCC) gates, which Reclamation uses to periodically send water to the interior Delta, includes requirements for closures of the DCC gates to protect outmigrating winter-run Chinook salmon from being directed to the interior Delta, rather than to the outer estuary and to sea. In 2014, Reclamation requested to open the DCC gates earlier than usual, due to the drought, which prompted new requirements to include protections for outmigrating CV spring-run Chinook salmon.

Summary

As discussed above, there are promising habitat restoration and fish passage programs and other projects being implemented and evaluated that, if successful, would greatly expand CV spring-run Chinook salmon spawning and rearing habitat. Likewise, there has been implementation of Recovery Actions with the potential for substantial habitat improvements. Although some key habitat improvement actions have begun, much work has yet to be implemented. Large scale fish passage and habitat restoration actions are needed for improving the CV spring-run Chinook salmon ESU viability.

While some conservation measures have been successful in improving habitat conditions for the CV spring-run Chinook salmon ESU since it was listed in 1999, fundamental problems with the quality of remaining habitat still remain (see Lindley et al. 2009, Cummins et al. 2008, and NMFS 2014). As such, the habitat supporting this ESU remains in a highly degraded state and it is unlikely that habitat quality has substantially changed since the last status review in 2010 (NMFS 2011). Overall, major habitat expansion and restoration for CV spring-run Chinook salmon has not occurred as of this review, and because of that, the loss of historical habitat and the degradation of remaining habitat continue to be major threats to the CV spring-run Chinook salmon ESU.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes

The available information indicates that the fishery impacts on the CV spring-run Chinook salmon ESU have not changed appreciably since the 2010 status review (NMFS 2011). Attempts have been made (Grover et al. 2004) to estimate CV spring-run Chinook salmon ocean fishery exploitation rates using coded-wire tag recoveries from natural origin Butte Creek fish, but due to the low number of recoveries the uncertainty of these estimates is too high for them to be of value. CV spring-run Chinook salmon have a relatively broad ocean distribution from central California to Cape Falcon, Oregon, that is similar to that of Sacramento River fall-run Chinook salmon, thus trends in the fall chinook ocean harvest rate are thought to provide a reasonable proxy for trends in the CV spring-run Chinook salmon ocean harvest rate. While the fall-run Chinook salmon ocean harvest rate can provide information on trends in CV spring-run Chinook salmon fishing mortality, it is possible that CV spring-run Chinook salmon experience lower overall fishing mortality. If maturation rates are similar between CV spring-run and fall-run Chinook salmon, the ocean exploitation rate on CV spring-run Chinook salmon would be lower than fall-run Chinook salmon in the last year of life because CV spring-run Chinook salmon escape ocean fisheries in the spring, prior to the most extensive ocean salmon fisheries in summer.

The fall-run Chinook salmon ocean harvest rate index peaked in the late 1980s and early 1990s, but then declined (Figure 3). With the closure of nearly all Chinook ocean fisheries south of

Cape Falcon in 2008 and 2009, the index dropped to 6% and 1%, respectively. While ocean fisheries resumed in 2010, commercial fishing opportunity was severely constrained, particularly off California, resulting in a harvest rate index of 16%. Since 2011, ocean salmon fisheries in California and Oregon have had more typical levels of fishing opportunity. The average fall-run Chinook salmon ocean harvest rate between 2011 and 2014 is 45% which is generally similar to levels observed between the late 1990s and 2007. The CV spring-run Chinook salmon spawning migration largely concludes before the mid- to late-summer opening of freshwater salmon fisheries in the Sacramento Basin, and salmon fishing is prohibited altogether on Butte, Deer, and Mill creeks, suggesting in-river fishery impacts on CV spring-run Chinook salmon are relatively minor. Overall, it is highly unlikely that harvest resulted in overutilization of this ESU.

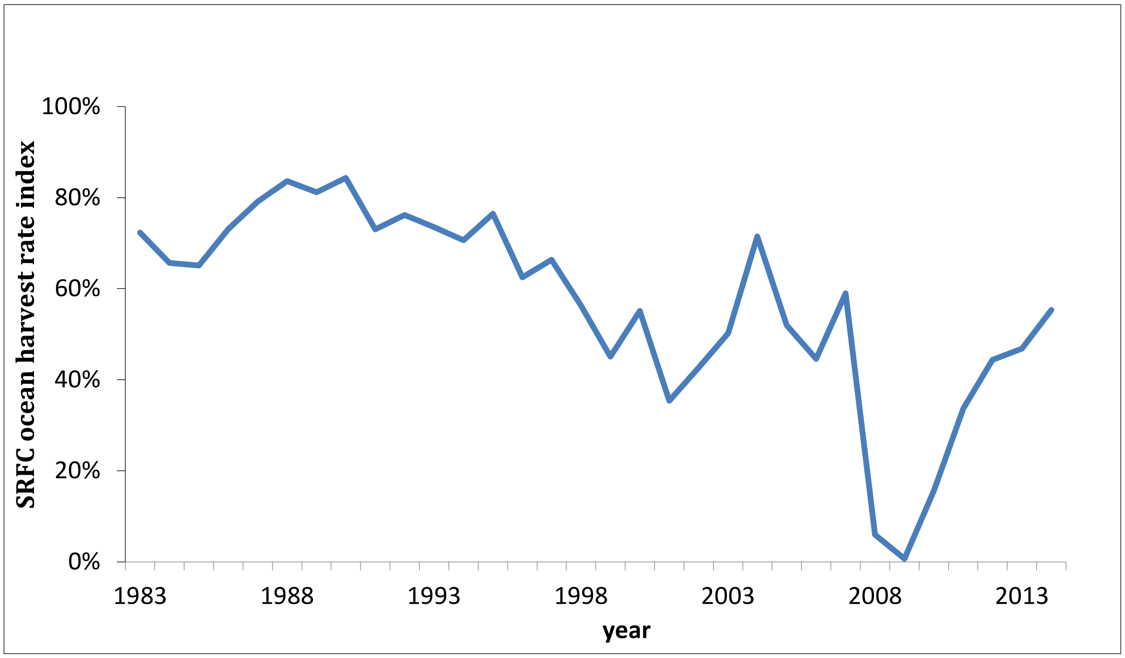


Figure 3. Sacramento River fall Chinook (SRFC) ocean harvest rate index for years 1983–2014 (taken from Appendix B, Table B-7, PFMC 2016).

2.3.2.3 Disease or predation

Naturally occurring pathogens may pose a threat to the CV spring-run Chinook salmon ESU because artificially propagated CV spring-run Chinook salmon are susceptible to disease outbreaks such as the Infectious Hematopoietic Necrosis Virus and Bacterial Kidney Disease. No disease outbreaks at the FRFH affecting CV spring-run Chinook salmon have occurred in the last five years.

Predation is a threat to CV spring-run Chinook salmon, especially in the lower Feather River, the Sacramento River, and in the Delta where there are high densities of non-native fish (e.g., striped bass, small-mouth bass and large-mouth bass) and native species (e.g., pikeminnow) that prey on outmigrating salmon juveniles. Survival studies of juvenile Chinook salmon migrating through the Delta have shown low survival/high predation rates (Williams et al. 2016). The presence of man-made structures in the environment that alter natural conditions likely also contributes to increased predation by altering the predator-prey dynamics often favoring predatory species. In the Sacramento River, removing the gates at the RBDD year-round since 2012 has minimized the impacts of predation at the dam. In the ocean, and even the Delta environment, salmon are common prey for harbor seals and sea lions, although the impacts on CV spring-chinook are unknown.

Disease and predation are persistent problems that can adversely affect CV spring-run Chinook salmon; however, no new information indicates that these threats have changed in severity since the 2005 listing determination or 2010/2011 status review. Although reducing predation at RBDD will benefit CV spring-run Chinook salmon at that location, it is unclear whether the reduction will substantially decrease the overall level of predation throughout the Sacramento River and Delta.

2.3.2.4 Inadequacy of existing regulatory mechanisms

Water Quality Regulation

Laws intended to protect California's water quality include the Federal Clean Water Act and Porter-Cologne Act (California Water Code). Agencies implementing these laws have directed considerable attention to salinity regulation in the Delta in order to ensure that freshwater is available for irrigating agricultural lands and for municipal and industrial uses. Poor water quality in the Delta resulting from agricultural and urban sources is a factor contributing to the ongoing collapse of the Delta ecosystem, which was detected when four pelagic fish species simultaneously and dramatically declined in abundance in 2002. Stronger implementation and enforcement of the Clean Water Act and the Porter-Cologne Act are needed in order to control agricultural (e.g., pesticides) and urban (e.g., ammonium) water pollution throughout the Central Valley.

Since the 2010/2011 status review, overall trends for water quality show improvements in water quality across the Central Valley. Many surface waters are polluted as water is discharged from agricultural operations, urban/suburban areas, and industrial sites. These discharges transport pollutants such as pesticides, sediment, nutrients, salts, pathogens, and metals into surface waters. Although conditions in most streams, rivers, and estuaries, throughout the State are much improved from 40 years ago, the rate of improvements have slowed overtime (SFEP 2015). Contaminants such as Polybrominated diphenyl ethers, and copper have declined over time, however many potentially harmful chemicals and contaminants of emerging concern (pharmaceuticals) have yet to be addressed. Legacy pollutants such as mercury and Polychlorinated biphenyls limit consumption of most fish, and directly and indirectly affect endangered fish populations, as well as their designated critical habitat.

In particular, urban storm water runoff is consistently toxic to fish and stream invertebrates (McIntyre et al. 2014, 2015). The array of toxicity is variously attributed to metals from motor vehicle brake pads; petroleum hydrocarbons from vehicle emissions of oil, grease, and exhaust; as well as residential pesticide use. Urban storm water toxicity has been linked to pre-spawn mortality of Coho salmon (Feist et al. 2011), and has been directly linked to effects at the population level (Spromberg and Scholz 2011, Spromberg et al. 2016). Emphasis on wastewater treatment plant upgrades and new legislative requirements (State Water Resource Control Board and Environmental Protection Agency), development and implementation of total maximum daily load programs (i.e., pathogens, selenium, pesticides, pyrethroids, methylmercury, heavy metals, salts, nutrients), and adoption of new water quality standards (i.e., Basin Plans), all aid in protecting beneficial uses for aquatic wildlife.

In California, approximately 9,493 miles of rivers/streams and some 513,130 acres of lakes/reservoirs are listed as impaired by irrigated agriculture through section 303(d) of the Clean Water Act. Of these, approximately 2800 miles, or approximately 28 percent, have been identified as impaired by pesticides. In recent years, NOAA scientists have investigated the direct and indirect effects of pesticides on individual ESA listed species, the foodwebs on which they depend, and at the population level (Baldwin et al. 2009b, Laetz et al. 2009, Macneale et al. 2010, Scholz et al. 2012).

Water quality pollution poses important challenges for the conservation and recovery of ESA-listed species and their habitat. Innovative and sustainable solutions such as green infrastructure and low-impact design (LID) are needed to manage pollutants as close to the source as possible. If these solutions can be applied at a broader scale, LID technology, policies, and watershed scale programs have the potential to maintain and/or restore hydrologic and ecological functions in a watershed (Spromberg et al. 2016), thereby improving water quality for ESA listed species and the ecosystem on which the species depend.

Species Identification for Regulatory Purposes

The Central Valley is home to four separate ESUs of Chinook salmon. Two of these ESUs are Federally protected (Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon) while two are not (fall-run & late fall-run Chinook salmon). Due to overlapping emigration time of juvenile CV spring-run and fall-run Chinook salmon, juvenile salmon that are captured at the State and Federal fish salvage facilities are often difficult to differentiate. Misidentification of CV spring-run Chinook salmon as fall-run Chinook salmon may lead to less timely Delta regulatory actions necessary to protect the listed species, which continue to delay and or hamper real-time efforts to protect the listed species.

Alternative identification methods under development include: a new genetic approach, which may be implemented in a near real-time framework; evaluation of fine-scale differences in morphological features between races; and analyses of multiple environmental variables in relation to daily salvage patterns of Chinook salmon juveniles to identify potential environmental cues predicting arrival of juvenile pulses at pumping facilities.

Whether as a direct tool in the form of real-time genetic assays of salvaged Chinook salmon juveniles, or as an indirect tool used to measure the accuracy of non-genetic alternative identification systems, genetic methods will clearly be integral in development of future take estimation procedures, and in the assessment of Central Valley Chinook salmon race population statuses in general.

2.3.2.5 Other natural or manmade factors affecting its continued existence

Feather River Fish Hatchery Spring-run Chinook Salmon Program

Recent genetic analysis on this stock (Garza and Pearse 2008) found subtle, but significant, differentiation between the FRFH spring- and fall-run Chinook salmon stocks. In addition, significant linkage disequilibrium in the population sample supported the hypothesis that it is a remnant of the ancestral Feather River spring-run Chinook salmon that has been heavily introgressed with fall-run Chinook salmon. A lack of close clustering relationships was also found between hatchery and naturally spawned population samples for the Feather River, although they were all still relatively closely related. However, the FRFH fall-run and "spring-run" Chinook salmon stocks did cluster together with relatively high bootstrap support, reflecting historic gene flow between them. In mean pairwise FST values, the FRFH stocks were as similar to other fall-run Chinook salmon populations (mean pairwise FST=0.005), indicating that they are not highly divergent from other Central Valley fall-run Chinook salmon (Garza and Pearse 2008).

In 2005, NMFS included the FRFH stock in the listed CV spring-run Chinook salmon ESU because: it represented the only remaining evolutionary legacy of the historic spring-run Chinook salmon population in the Feather River (upstream of Oroville Dam); its genetic linkage to the natural spawning population; it continues to exhibit a CV spring-run Chinook salmon migration timing; and for the potential to develop the hatchery program as a conservation hatchery. Since 2002, CDFW, CDWR, and NMFS have worked to reinforce the expression of a CV spring-run Chinook salmon life history at the FRFH by adopting new broodstock protocols designed to reduce or minimize the introgression of spring-run and fall-run Chinook salmon at the hatchery. A draft Hatchery and Genetics Management Plan has been developed that describes the new management protocols for the spring-run Chinook salmon hatchery program which includes in-river release of juveniles to reinforce homing of juveniles back to the Feather River and to minimize straying into other watersheds. The first 100 percent in-river release of spring-run Chinook salmon occurred in 2015, and is expected to continue in subsequent years. Overall, the adverse impacts of this program on naturally produced CV spring-run Chinook salmon are not likely to have changed substantially since the 2010/2011 review, but the new management efforts are expected to reduce impacts in the future.

Climate Change

Climate experts predict physical changes to ocean, river and stream environments along the West Coast that include: warmer atmospheric temperatures resulting in more precipitation falling as rain rather than snow; diminished snow pack resulting in altered stream flow volume and timing; increased winter flooding; lower late summer flows; a continued rise in stream temperatures; increased sea-surface temperatures; increased ocean acidity; sea-level rise; altered estuary dynamics; changes in the timing, duration and strength of nearshore upwelling; and altered marine and freshwater food-chain dynamics (see Williams et al. 2016 for a more detailed discussion of these and other projected long-term impacts due to climate change). These long-term climate, environmental and ecosystem changes are expected to in turn cause changes in salmon and steelhead distribution, behavior, growth, and survival. While an analysis of

ESU/DPS-specific vulnerabilities to climate change by life stage has not been completed, Williams et al. 2016 summarizes climate change impacts that will likely be shared among salmon and steelhead ESUs/DPSs. In summary, both freshwater and marine productivity and survival tend to be lower in warmer years for most salmon and steelhead populations considered in this assessment. These trends suggest that many populations might decline as mean temperature rises. However, the magnitude and timing of these and other changes, and specific effects on individual salmon and steelhead ESUs/DPSs, remain unclear.

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen et al. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger et al. 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (VanRheenen et al. 2004). Factors modeled by VanRheenen et al. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100% in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (VanRheenen et al. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is typically 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 2006). 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 (9°F) 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 are thermally acceptable by naturally-producing Chinook salmon. This would particularly affect fish that emigrate as fingerlings, mainly in May and June.

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

Precipitation/Drought

The CV spring-run Chinook salmon ESU is highly vulnerable to drought conditions. During dry years, less cold water is available in the storage reservoirs such as Whiskeytown, Shasta, Oroville, and New Bullards Bar to control instream water temperatures downstream. The resulting increased in-river water temperature resulting from such drought conditions is likely to reduce the availability of suitable holding, spawning, and rearing conditions in Clear Creek, and in the Sacramento, Feather, and Yuba rivers. During dry years, the availability of thermally suitable habitats in CV spring-run Chinook salmon river systems without major storage reservoirs (e.g., Battle, Mill, Deer, and Butte creeks) would also be reduced. Multiple dry years in a row could potentially devastate this ESU. While CV spring-run Chinook salmon have historically been able to withstand droughts, the currently diminished abundance, spatial structure, and diversity of the ESU, and the increased frequency and duration of droughts predicted to occur as climate change progresses suggest that CV spring-run Chinook salmon are likely much more vulnerable to drought today than they were historically. Prolonged drought due to lower precipitation, shifts in snowmelt runoff, and greater climate extremes could easily render most existing CV spring-run Chinook salmon habitat unsuitable, either through temperature increases or lack of adequate flows. The previous drought, which occurred from 2007-2009, was likely a factor in the recent widespread decline of all Chinook salmon runs (including CV spring-run Chinook salmon) in the Central Valley (Williams et al. 2011). The period of consecutive dry years 2007-2009 ended with a relatively wet winter during water year 2010 (October 2009-September 2010), and 2011, with the Sierra Nevada Mountain snowpack at above average levels.

California has experienced well below average precipitation in each of the past 4 water years (2012, 2013, 2014 and 2015), record high surface air temperatures the past 2 water years (2014 and 2015), and record low snowpack in 2015. Some paleoclimate reconstructions suggest that the current 4-year drought is the most extreme in the past 500 or perhaps more than 1000 years. Anomalously high surface temperatures have made this a “hot drought”, in which high surface temperatures substantially amplified annual water deficits during the period of below average precipitation.

California's 2014 Water Year, which ended September 30, 2014, was the third driest in 119 years of record. It also was the warmest year on record. On April 1, 2015, CDWR measured the statewide water content of Sierra snowpack at five percent of average for April 1st. These levels are lower than any year in records going back to 1950. Annual runoff, which is calculated from streamflow data, supplies many of our needs for water. Recent runoff estimates for California show measurements on par with 1930's and late 1970's droughts. Additionally, excessive groundwater pumping and aquifer depletion has resulted in land subsidence (sinking), which can cause permanent loss of groundwater storage in the aquifer system and infrastructure damage.

Finally, dry, hot and windy weather, combined with dry vegetation and a spark - either through human intent, accident or lightning - can start a wildfire. Drier-than-normal conditions can increase the intensity and severity of wildfires. According to CalFire (www.calfire.ca.gov), in 2014, fire crews responded to 4,266 fires which burned over 191,000 acres (which was similar to the year-to-date average of 4,508 wildfires on 109,888 acres burned), and in 2015, there have been 6,284 fires and over 307,595 acres burned. Wildfires often lead to high sedimentation and landslides into salmon bearing streams, and may burn riparian vegetation that would shade and cool the waterway.

The combination of low precipitation and high temperatures favored elevated stream temperatures, and these have been documented to be extreme in some watersheds. The lack of cold water stored behind Shasta Dam, in combination with water release decisions, led to a loss of stream temperature control below Shasta Dam in September 2014. Stream temperatures that exceeded the 13°C (56°F) target in Sacramento River Chinook salmon spawning areas are thought to have contributed to 95 percent mortality rates for eggs and fry produced by spawning winter-run and fall-run Chinook salmon in 2014. Concerns over a high potential for fish kills prompted emergency reservoir releases that were aimed at lowering downstream temperatures to alleviate those risks.

Ocean Conditions

Much of the northeast Pacific Ocean, including parts typically used by California salmon and steelhead, experienced exceptionally high upper surface ocean temperatures beginning early in 2014 and areas of extremely high ocean temperatures continue to cover most of the northeast Pacific Ocean. Additionally, a "warm blob" formed offshore of the Pacific Northwest region in fall 2013 (Bond et al. 2015). Off the coast of Southern and Baja California, upper surface ocean temperatures became unusually warm in the spring of 2014, and this warming spread to the Central California coast in July 2014. In the fall of 2014, a shift in wind and ocean current patterns caused the entire northeast Pacific domain to experience unusually warm upper surface ocean temperatures from the West Coast offshore for several hundred kilometers (km). In the spring of 2015, nearshore waters from Vancouver Island south to San Francisco mostly experienced strong and at times above average coastal upwelling that created a relatively narrow band (~50 to 100 km wide) of near normal upper surface ocean temperatures, while the exceptionally high temperature waters remained offshore and in coastal regions to the south and north.

Adult Chinook salmon maturing in 2015, 2016, 2017, and 2018 will likely be negatively impacted by poor stream and ocean conditions. The expected effects of the 2015/2016 tropical El Niño are likely to favor a more coastally-oriented warming of the Northeast Pacific this fall and winter that will persist into spring 2016. These ocean migrants will likely encounter an ocean strongly influenced by (if not dominated by) a subtropical food-web that favors poor early marine survival for Chinook salmon (Williams et al. 2016).

NOAA's Climate Prediction Center forecasts a 95 percent likelihood that the tropical El Niño event will persist through the winter of 2016, and they also predict a high likelihood for this event to alter North Pacific and Western US climate for the next few seasons. Because El Niño events favor fall/winter periods with an especially strong Aleutian Low pressure anomaly centered in the Gulf of Alaska, the "warm blob" of exceptionally warm upper ocean temperatures off the Pacific Northwest coast is expected to weaken considerably. In contrast exceptionally warm ocean temperatures between Central, Southern, and Baja California and Hawaii are expected to remain elevated for the next few seasons. El Niño-related changes in wind and related ocean current patterns are expected to cause a coast-wide warming of upper ocean temperatures from Alaska south to Mexico, but confined to a relatively narrow band within 100 miles off the coast.

The strong El Niño event is predicted to substantially reduce the odds for a repeat of the extreme warmth of the past two winters, extreme precipitation deficit experienced in California the past four winters, and the extreme warmth of the offshore waters of the Northeast Pacific Ocean that have persisted for most of the past two years. The past two years have also seen persistence in the warm phase PDO pattern of North Pacific Ocean temperatures, and the warm phase of the PDO is likely to continue for another year because of it strong tendency for persistence and the expected El Niño influences on the Aleutian Low and related ocean currents in the coming months.

2.4 Synthesis

The Central Valley technical recovery team delineated 18 or 19 independent populations of CV spring-run Chinook salmon that occurred historically, along with a number of smaller dependent populations, within four diversity groups (Lindley et al. 2004). Of these 18 or 19 populations, only three are extant (Mill, Deer, and Butte creeks) and they occur only in the Northern Sierra Nevada diversity group. In addition to these three extant populations, there are other tributaries with phenotypic CV spring-run Chinook salmon in them, but those populations all have fluctuating abundance reaching very low numbers, and/or are heavily influenced by hatchery origin spring-run Chinook salmon from the FRFH. Additionally there are current efforts underway to reintroduce CV spring-run Chinook salmon back into the San Joaquin River, as well as discussions for reintroduction into other Central Valley watersheds.

With a few exceptions, CV spring-run Chinook salmon populations have increased through 2014 returns since the last status review (2010/2011), which has moved the Mill and Deer creek populations from the high extinction risk category, to moderate, and Butte Creek has remained in the low risk of extinction category. Additionally, the Battle Creek and Clear Creek populations have continued to show stable or increasing numbers the last five years, putting them at moderate risk of extinction based on abundance. Overall, the SWFSC concluded in their viability report that the status of CV spring-run Chinook salmon (through 2014) has probably improved since the 2010/2011 status review and that the ESU's extinction risk may have decreased, however the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years as the full effects of the recent drought are realized (Williams et al. 2016).

As discussed previously, there are potentially significant conservation measures to restore or expand habitat that are in early stages of implementation, such as the Battle Creek Salmon and Steelhead Restoration Project, actions required by NMFS' CVP/SWP biological opinion, and the SJRRP. Other key actions for CV spring-run Chinook salmon are being formally discussed (e.g., Upper Yuba River reintroduction) or planned (e.g., EcoRestore). Some conservation measures are helping now, such as the removal of Wildcat Diversion Dam on Battle Creek, the removal of gate operations at Red Bluff Diversion Dam, and flow/export related actions in the Delta. However, some of the potential benefits from the aforementioned actions will not be realized for several years or more and the degree to which they will help benefit CV spring-run Chinook salmon and their habitat are uncertain.

The 2015 adult CV spring-run Chinook salmon returns were very low. Those that did return experienced high pre-spawn mortality. Juvenile survival during the 2012 to 2015 drought has likely been impacted, and will be fully realized over the next several years.

Summary descriptions of how the five ESA listing factors have changed since the 2010 status review are presented in Table 8 below. The only changes are related to improvements due to restoration activities, and impacts due to severe drought.

Table 8. Summary of whether and how each ESA listing factor for CV spring-run Chinook salmon has changed since the 2010/2011 status review. See section 2.3.2 for more detail.

LISTING FACTOR	CHANGE SINCE 2010/2011
Present or threatened destruction, modification, or curtailment of habitat or range	Limited habitat expansion. Some habitat restoration through CVP/SWP biological opinion, AFRP, B13, and ERP. Implementation of the San Joaquin spring-run Chinook salmon Reintroduction Plan has begun. Overall, no major change in this listing factor since 2010.
Overutilization for commercial, recreational, scientific, or educational purposes	Ocean harvest has not appreciably changed since 2010, as indicated by the Sacramento River fall Chinook harvest rate index. Restrictions in place in 2010 have continued the past 5 years.
Disease or predation	No evidence suggests that this listing factor has substantially changed since 2010.
Inadequacy of exiting regulatory mechanisms	No evidence suggests that the impact of this listing factor on CV spring-run Chinook salmon has substantially changed since 2010.
Other natural or manmade factors	Impacts of the Feather River Fish Hatchery likely did not substantially change since 2010. Drought conditions in 2012 to 2015 will likely reduce the abundance of those brood years, which would impact the abundance of returning adults in 2015 through 2018. Observations of this occurring has already begun, with very low returns in 2015.

3.0 RESULTS

3.1 Recommended Classification

Based on a review of the best available information, we recommend that the CV spring-run Chinook salmon ESU remain classified as a threatened species. It is important to note that the full effect of the ongoing severe drought on the ESU will be observed and measured over at least the next few years. In addition to the low adult returns observed in 2015, juveniles hatched in the drought years of 2013 through 2015 are expected to produce low adult returns in 2016 through 2018. Based on the severity of the drought and the low escapements as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, there is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria. Monitoring environmental and biological conditions and management actions for these drought impacted year classes will be extremely important.

3.2 ESU Boundary and Hatchery Stocks

No change is recommended in the ESU boundary or hatchery membership status. NMFS will continue to monitor the spring-running Chinook salmon in the San Joaquin River tributaries and will assess whether a change to the ESU boundary is warranted in subsequent status reviews.

3.3 Experimental populations

When designating the San Joaquin River CV spring-run Chinook salmon experimental population, NMFS needed to determine whether the experimental population was essential to the continued existence of the species in the wild. The nonessential designation was based on the existence in the Sacramento River basin of four independent populations, one of which is supplemented by a hatchery, and several dependent or establishing populations that would be expected to persist should the San Joaquin River population not persist. The reintroduction is in its early phases, and the current condition of the Sacramento River populations are sufficient to support the survival of the species in the wild, thus there is no indication that a change from nonessential to essential would be warranted at this time.

We will continue to consider if a change to essential may be warranted in subsequent 5-year Status Reviews for this ESU as described in the 10(j) rule (78FR79622): "*We will assess the contribution of the NEP to the status of the species during the required 5 year status review of the CV spring-run Chinook salmon ESU. This information will be used by NMFS to determine if changes to the NEP designation may be warranted*."

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Priority near-term drought actions:

- The CCVO, SWFSC, CDFW and other partners should closely monitor the status of this ESU and its response to the drought;
- The CCVO, SWFSC, CDFW and other partners should monitor environmental conditions and take protective measures to minimize the drought's impacts on CV spring-run Chinook salmon;
- NMFS should continue to work with partners to improve instream flows in Antelope, Deer, and Mill creeks; and
- NMFS should analyze whether the ESA consultation for the ocean salmon fishery with respect to its impacts on the CV spring-run Chinook salmon ESU should be reinitiated.

The status of this ESU may be severely impacted due to the extended drought, which may trigger reinitiation[2] of the ocean fishery consultation.

Priority actions for CV spring-run Chinook salmon recovery:

- Continue efforts to restore access to high elevation habitat in the Yuba River upstream of New Bullards Bar Dam and in the Sacramento River upstream of Shasta Dam;
- Battle Creek actions: Continue implementation of the Salmon and Steelhead Restoration Project; improve fish passage over natural barriers;
- Continue implementation of the San Joaquin River Restoration Program;
- Modernize fish passage facilities on Mill, Deer and Antelope creeks; increase spring, early summer, and fall instream flows for adult and juvenile fish passage through water acquisition, conjunctive use wells and storage, and water use efficiency plans and improvements;
- Develop and implement alternative water operations and conveyance systems, and restore Bay-Delta habitat and ecological flow characteristics to provide multiple and suitable salmonid rearing and migratory habitats for all Central Valley salmonids;
- Restore the ecological health of the Sacramento–San Joaquin River Delta and lower Sacramento River through significant changes in water, levee, and floodplain management, and reducing the abundance of non-native predatory fish;
- Implement ecologically based flows in the Sacramento River;
- Reduce the amount of CV spring-run Chinook salmon harvested in the commercial and recreational ocean salmon fishery;
- Butte Creek actions: Expand CV spring-run Chinook salmon monitoring program in to evaluate juvenile production and survival; implement temperature reduction at the DeSabla Forebay; modernize the fish passage facilities at Weir 1 in the Sutter Bypass;
- San Joaquin tributary actions: Continue the Scientific Evaluation Process to guide restoration of the Stanislaus, Tuolumne, and Merced rivers, and the San Joaquin basin as a whole to benefit CV spring-run Chinook salmon; continue to monitor spring-running Chinook salmon; and
- Feather River actions: Finalize and implement the HGMP for the FRFH; implement the Feather River Oroville Hydroelectric Facility's Fish Habitat Management Plan to reduce the interaction between hatchery and wild fish and between CV spring-run Chinook salmon and fall-run Chinook salmon in the Feather River; provide passage at Sunset Pumps weir.

[2] Section 7(a)(2) of the ESA and its implementing regulations (50 CFR 402.16) require Federal agencies to reinitiate consultation on previously reviewed actions if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered.

5.0 REFERENCES

Baldwin, D. H., J. A. Spromberg, T. K. Collier, and N. L. Scholz. 2009a. A Fish of Many Scales: Extrapolating Sublethal Pesticide Exposures to the Productivity of Wild Salmon Populations. Ecological Applications 19:2004-2015.

Baldwin, D. H., J. A. Spromberg, T. K. Collier, and N. L. Scholz. 2009b. A Fish of Many Scales: Extrapolating Sublethal Pesticide Exposures to the Productivity of Wild Salmon Populations. Ecological Applications 19(8):2004-2015.

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and Impacts of the 2014 Warm Anomaly in the Ne Pacific. Geophysical Research Letters 42(9):3414-3420.

Califonia Department of Fish and Wildlife. 2015. Grandtab.

California Department of Fish and Wildlife. 2015. Aerial Salmon Redd Survey Excel Tables, Unpublished Data.

California Hatchery Scientific Review Group (California HSRG). 2012. California Hatchery Review Report. U.S. Fish and Wildlife Service and Pacific States Marine Fisheries Commission, 100 pp.

Cohen, S. J., K. A. Miller, A. F. Hamlet, and W. Avis. 2000. Climate Change and Resource Management in the Columbia River Basin. Water International 25(2):253-272.

Cummins, K., C. Furey, A. Giorgi, S. Lindley, J. Nestler, and J. Shurts. 2008. Listen to the River: An Independent Review of the Cvpia Fisheries Program.

Dettinger, M. D. 2005. From Climate Change Spaghetti to Climate-Change Distributions for 21st Century California. San Francisco Estuary and Watershed Science 3(1):article 4.

Dettinger, M. D. and D. R. Cayan. 1995. Large-Scale Atmospheric Forcing of Recent Trends toward Early Snowmelt Runoff in California. Journal of Climate 8(3):606-623.

Dettinger, M. D., Daniel R. Cayan, Mary K. Meyer, Anne E. Jeton. 2004. Simulated Hydrologic Responses to Climate Variations and Changes in the Merced, Carson and American River Basins, Sierra Nevada, California, 1900-2099. Climatic Change 62(62):283-317.

Feist, B. E., E. R. Buhle, P. Arnold, J. W. Davis, and N. L. Scholz. 2011. Landscape Ecotoxicology of Coho Salmon Spawner Mortality in Urban Streams. PLoS ONE 6(8):e23424.

FISHBIO. 2015. Adult Chinook Salmon Adults Observed in the Video Weir and Provided in Excel Tables During the Spring on the Stanislaus River, Unpublished Data.

Fisher, F. W. 1994. Past and Present Status of Central Valley Chinook Salmon. Conservation Biology 8(3):870-873.

Franks, S. 2014. Possibility of Natural Producing Spring-Run Chinook Salmon in the Stanislaus and Tuolumne Rivers, Unpublished Work. National Oceanic Atmospheric Administration.

Fry, D. H., Jr. 1961. King Salmon Spawning Stocks of the California Central Valley, 1940–1959 California Fish and Game 47(1):55-71.

Garman, C. 2015. Butte Creek Spring-Run Chinook Salmon, Oncoryhnchus Tshawytscha Pre-Spawn Mortality Evaluation, 2014.

Garza, J. C. and D. E. Pearse. 2008. Population Genetic Structure of Oncorhynchus Mykiss in the California Central Valley: Final Report for California Department of Fish and Game. University of California, Santa Cruz, and National Marine Fisheries Service, Santa Cruz, California.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed Esus of West Coast Salmon and Steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66, 637 pp.

Grover, A., A. Grover, A. Low, P. Ward, J. Smith, M. Mohr, D. Viele, and C. Tracy. 2004. Recommendations for Developing Fishery Management Plan Conservation Objectives for Sacramento River Winter Chinook and Sacramento River Spring Chinook. Interagency Workgroup.

Kormos, B., M. Palmer-Zwahlen, and A. Low. 2012. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010. Fisheries Branch Administrative Report 2012-02, California Department of Fish and Game.

Laetz, C. A., D.H. Baldwin, T.K. Collier, V. Hebert, J.D. Stark, and N. L. Scholz. 2009. The Synergistics Toxicity of Pesticides Mixtures: Implications for Risk Assessment and the Conservation of Endangered Pacific Salmon. Environmental Health Perspectives 117(3):348-353.

Lindley, S. T., M. S. M. C. B. Grimes, W. Peterson, J. Stein, J. T. Anderson, L. W. Botsford, , D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, , and F. B. S. M. Palmer-Zwahlen, J. Smith, C. Tracy, R. Webb, B. K. Wells, T. H. Williams. 2009. What Caused the Sacramento River Fall Chinook Stock Collapse?

Lindley, S. T., R. S. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon Esus in California's Central Valley Basin. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-360.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Macneale, K. H., P.M. Kiffney, and N.L. Scholz. 2010. Pesticides, Aquatic Food Webs, and the Conservation of Pacific Salmon. . Frontiers in Ecology and the Environment 8:475-482.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42, 174 pp.

McIntyre, J. K., J. W. Davis, C. Hinman, K. H. Macneale, B. F. Anulacion, N. L. Scholz, and J. D. Stark. 2015. Soil Bioretention Protects Juvenile Salmon and Their Prey from the Toxic Impacts of Urban Stormwater Runoff. Chemosphere 132:213-219.

McIntyre, J. K., J. W. Davis, J. P. Incardona, J. D. Stark, B. F. Anulacion, and N. L. Scholz. 2014. Zebrafish and Clean Water Technology: Assessing Soil Bioretention as a Protective Treatment for Toxic Urban Runoff. Science of the Total Environment 500-501:173-180.

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, and R. B. MacFarlane. 2015. Chinook Salmon Outmigration Survival in Wet and Dry Years in California's Sacramento River. Canadian Journal of Fisheries and Aquatic Sciences 72(11):1749-1759.

Mosser, C. M., L. C. Thompson, and J. S. Strange. 2013. Survival of Captured and Relocated Adult Spring-Run Chinook Salmon Oncorhynchus Tshawytscha in a Sacramento River Tributary after Cessation of Migration. Environmental Biology of Fishes 96(2-3):405-417.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California., Report No. NMFSNWFSC-35. NOAA Tech. Memo. U.S. Department of Commerce.

National Marine Fisheries Service. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35.

National Marine Fisheries Service. 2005. Final Assessment of the National Marine Fisheries Service's Critical Habitat Analytical Review Teams (Charts) for Seven Salmon and Steelhead Evolutionarily Significant Units (Esus) in California.

National Marine Fisheries Service. 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. U.S. Department of Commerce.

National Marine Fisheries Service. 2011. 5-Year Review: Summary and Evaluation of Central Valley Spring-Run Chinook Salmon. U.S. Department of Commerce, 34 pp.

National Marine Fisheries Service. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office.

National Marine Fisheries Service. 2015. Recovering Threatened and Endangered Species Fy 2013-2014 Report to Congress.

Pacific Fishery Management Council. 2016. Review of 2015 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan.

Palmer-Zwahlen, M. and B. Kormos. 2013. Recovery of Coded-Wire Tags from Chinook Salmon in California’s Central Valley Escapement and Ocean Harvest in 2011.

Roos, M. 1991. A Trend of Decreasing Snowmelt Runoff in Northern California. Page 36 Western Snow Conference, April 1991, Washington to Alaska.

Rueth, J. 2015. pers. comm. with Naseem Alston and R. Johnson.

Salmon and Steelhead Hatchery Assessment Group. 2003. Hatchery Broodstock Summaries and Assessments for Chum, Coho, and Chinook Salmon and Steelhead Stocks within Evolutionarily Significant Units Listed under the Endangered Species Act.

San Joaquin River Restoration Program. 2015. Revised Framework for Implementation

Scholz, N. L., E. Fleishman, I. W. L. Brown, M.L. Johnson, M.L. Brooks, C. L. Mitchelmore, and a. D. Schlenk. 2012. A Perspective on Modern Pesticides, Pelagic Fish Declinces, and Unknown Ecological Resilience in Highly Managed Ecosystems. Biosciences 62(4):428-434.

Spromberg, J. A., D. H. Baldwin, S. E. Damm, J. K. McIntyre, M. Huff, C. A. Sloan, B. F. Anulacion, J. W. Davis, and N. L. Scholz. 2016. Coho Salmon Spawner Mortality in Western Us Urban Watersheds: Bioinfiltration Prevents Lethal Storm Water Impacts. Journal of Applied Ecology 53(2):398-407.

Spromberg, J. A. and N. L. Scholz. 2011. Estimating the Future Decline of Wild Coho Salmon Populations Resulting from Early Spawner Die-Offs in Urbanizing Watersheds of the Pacific Northwest, USA. Integrated Environmental Assessment and Management 7(4):648-656.

The San Francisco Estuary Partnership. 2015. State of the Estuary Report: Status Trends and Update of 33 Indicators of Ecosystem Health, San Francisco Bay and Sacramento-San Joaquin River Delta.

Thompson, L. C., M. I. Escobar, C. M. Mosser, D. R. Purkey, D. Yates, and P. B. Moyle. 2011. Water Management Adaptations to Prevent Loss of Spring-Run Chinook Salmon in California under Climate Change. Journal of Water Resources Planning and Management 138(5):465-478.

United States Fish and Wildlife Service. 2014. pers. comm. with N. Alston.

VanRheenen, N. T., Andrew W. Wood, Richard N. Palmer, Dennis P. Lettenmaier. 2004. Potential Implications of Pcm Climate Change Scenarios for Sacramento-San Joaquin River Basin Hydrology and Water Resources. Climatic Change 62(62):257-281.

West Coast Salmon Biological Review Team. 2003. Updated Status of Federally Listed Esus of West Coast Salmon and Steelhead. National Marine Fisheries Service, 25 pp.

Williams, J. G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3):416.

Williams, T. H., B. C. Spence, D. A. Boughton, R. C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S. T. Lindley. 2016. Viability Assessment for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest, Memorandum from Steve Lindley to Will Stelle.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Update to January 5, 2011 Report., National Marine Fisheries Service, Southwest Fisheries Science Center. Santa Cruz, CA.

Workman, M. L. 2003. Lower Mokelumne River Upstream Fish Migration Monitoring Conducted at Woodbridge Irrigation District Dam August 2002 through July 2003.

NATIONAL MARINE FISHERIES SERVICE
5-YEAR STATUS REVIEW
CALIFORNIA CENTRAL VALLEY DOMAIN
Central Valley Spring-run Chinook Salmon ESU

Current Classification: Threatened

Recommendation resulting from the 5-Year Status Review: Retain current ESA classification as threatened and current ESU boundary.

REGIONAL OFFICE APPROVAL:

Approve: Maria Rea Date: 4-13-16

Maria Rea
Assistant Regional Administrator
California Central Valley Office
West Coast Region