CENTRAL VALLEY RECOVERY DOMAIN

5-Year Review:
Summary and Evaluation of

Central Valley Spring-run Chinook Salmon ESU

National Marine Fisheries Service
Southwest Region
Long Beach, CA

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 ESU**

1.0 GENERAL INFORMATION

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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 the National Marine Fisheries Service (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 listing determinations for west coast salmon and steelhead occurred 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 substantially reproductively isolated from other con-specific populations and 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."

In 2006, we announced that NMFS would apply the joint U.S. Fish and Wildlife Service-National Marine Fisheries Service DPS policy (61 FR 4722) rather than our agency's ESU policy to populations of West Coast steelhead (*O. mykiss*). Under this policy, a DPS of steelhead must be discrete from other con-specific populations, and it must be significant to its taxon. A group of organisms is discrete if it is ''markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors" (61 FR 4722). According to the DPS policy, if a population group is determined to be discrete, we must then consider whether it is significant to the taxon to which it belongs. Considerations in evaluating the significance of a discrete population include: (1) persistence of the discrete population in an unusual or unique ecological setting for the taxon; (2) evidence that the loss of the discrete population segment would cause a significant gap in the taxon's range; (3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere outside its historical geographic range; or (4) evidence that the discrete population has marked genetic differences from other populations of the 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 (SHAGG 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 (including the CV spring-run Chinook salmon ESU) and on January 5, 2006 we issued final listing determinations for 10 DPSs of steelhead.

1.3 Methodology used to complete the review

A public notice announcing NMFS' intent to conduct 5-year status reviews for the 26 ESUs/DPSs of west coast anadromous salmonids was published in the Federal Register on March 18, 2010 (75 FR 13082). 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 Southwest Region (SWR) of NMFS coordinated informally by letter with State and tribal co-managers to ensure those co-managers were informed about 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 Southwest Fisheries Science Center (SWFSC) reviewed any new and substantial scientific information that had become available since the 2005 status review (Good et al. 2005) and produced an updated biological status summary report (herein cited as Williams et al. 2011 and referred to as the "viability report"). The viability report was intended to determine whether or not the biological status of spring-run Chinook salmon has changed since the 2005 status review was conducted. Next, the Central Valley Office (CVO) of the Protected Resources Division (PRD) reviewed the viability report and assessed whether the five ESA listing factors (threats) changed substantially since the 2005 listing determination. To assess whether the five ESA listing factors have changed substantially since 2005, several key documents were reviewed such as the Federal Register notices identified in Tables 1 and 2 and other relevant publications including:

(1) Central Valley Salmon and Steelhead Public Draft Recovery Plan (NMFS 2009a)
(2) Biological Opinion on the Long-term Operations of the Central Valley Project and State Water Project (NMFS 2009b)
(3) Listen to the River: An Independent Review of the CVPIA Fisheries Program (Cummins et al. 2008)
(4) Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin (Lindley et al. 2007)
(5) What caused the Sacramento River fall Chinook stock collapse? (Lindley et al. 2009)
(6) Migration and survival of juvenile salmonids in California's Central Valley and San Francisco estuary, 2007 and 2008 data (MacFarlane et al. 2008)

Finally, the CVO PRD staff considered the viability report, the current threats to the species, and relevant conservation measures before making a determination whether the listing status of the species should be uplisted (i.e., threatened to endangered), downlisted (i.e., endangered to threatened), or remain unchanged. In the CVO a team of three 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 Central Valley steelhead.

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

1.3.1 FR Notice citation announcing initiation of this review

75 FR 13082; March 18, 2010

1.3.2 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, including hatchery populations that were considered part of the ESU, and issued a final listing determination on June 28, 2005, that the ESU continued to warrant listing as a threatened species and that the Feather River hatchery stock of spring-run Chinook was 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 reaffirmed the threatened status of ESU (70 FR 37160).

1.3.3 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, if they contain physical or biological features essential to conservation, and those features 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. 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 to conserve species listed as threatened. This applies particularly to "take," which can include any act that kills or injures fish, and may include habitat modification. The ESA prohibits any take of species listed as endangered, but some take of threatened species that does not interfere with salmon survival and recovery can be allowed. In 2002, we promulgated a 4(d) protective regulation for this ESU that applied the section 9 take prohibitions and also created several take limits for addressing take. 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).

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for Central Valley 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

1.3.4 Review History

Numerous scientific assessments have been conducted to assess the biological status of this ESU. A list of those assessments is provided in Table 3.

Table 3. Summary 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. Status review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.
		National Marine Fisheries Service. 2003. Draft Report of Updated Status of Listed ESUs of Salmon and Steelhead. NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington. (http://www.nwfsc.noaa.gov/trt/brt/brtrpt.html)
		Lindley, S.T., R. 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 ESU in California's Central Valley basin. NMFS Southwest Science Center NOAA-TM-NMFS-SWFSC-360. Santa Cruz, CA. http://swfsc.noaa.gov/textblock.aspx?Division=FED&ParentMenuId=54&id=2260
		Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.
		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. July. Prepared by the NOAA Fisheries, Protected Resources Division, Long Beach, California. Available at: http://swr.nmfs.noaa.gov/chd/CHART%20Final%20Assessment/Final_CHART_Report-July_05.pdf.
		Lindley, S.T., R. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. 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), Article 4: 26 pages. Available at: http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art4. http://swfsc.noaa.gov/textblock.aspx?Division=FED&ParentMenuId=54&id=2260
		National Marine Fisheries Service. 2011. T. H. Williams, D. A. Boughton, S. T. Lindley, and B. C. Spence. Draft status review update for Pacific salmon and steelhead under the Endangered Species Act. Southwest Fisheries Science Center, Santa Cruz, CA. 109 pages.

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

NOAA Fisheries issued guidelines in 1990 (55 FR 24296) for assigning listing and recovery priorities. Three criteria are assessed to determine a species' priority for recovery plan development, implementation, and resource allocation: 1) magnitude of threat; 2) recovery potential; and 3) existing conflict with activities such as construction and development. The recovery priority number for CV spring-run Chinook salmon, as reported in the 2006-2008 Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species (http://www.nmfs.noaa.gov/pr/pdfs/laws/esabiennial2008.pdf), is 7 as shown in Table 4, below.

1.3.5 Recovery Plan or Outline

In 2009, NMFS released a draft multi-species recovery plan that addresses all three listed salmonids in the Central Valley, including the CV spring-run Chinook salmon ESU (Table 4). This draft plan was released for public comment and is undergoing final revisions prior to publication as a final, approved recovery plan. NMFS anticipates the final recovery plan will be released in late 2011.

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	7	**Name of Plan:** Public Draft 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 Central Valley Steelhead (October 2009) **Plan Status:** Draft http://swr.nmfs.noaa.gov/recovery/centralvalleyplan.htm

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 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 evolutionarily significant unit (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 spring-run Chinook salmon in the Sacramento River and its tributaries, including the Feather River, as well as the Feather River Hatchery spring-run Chinook salmon program. Based on this review, there is no new information indicating that the boundary of this ESU should change or that its status as an ESU should change. However, there may be a need to modify the ESU boundary in the future if spring-run Chinook salmon are successfully reintroduced into the San Joaquin River Basin[1] and/or into Central Valley habitats upstream of currently impassable barriers.

In conjunction with the most recent status review for the CV spring-run Chinook ESU (Good et al. 2005), NMFS reviewed available information on hatchery stocks and programs within the range of the ESU (Salmon and Steelhead Assessment Group 2003). This review and analysis concluded that the Feather River hatchery stock of spring run chinook was substantially divergent from other natural stocks in the Central Valley (Butte, Deer and Mill creeks) as a result of introgression with fall-run Chinook salmon at the hatchery. Nevertheless, NMFS ultimately concluded this hatchery stock should be included in the ESU because it still exhibited a spring-run migration timing and was the best opportunity for restoring a more natural spring-run population in the Feather River. Based on this assessment and a subsequent review of the ESU, including the hatchery stock, consistent with NMFS' hatchery listing policy, we ultimately included this stock in the listed ESU in 2005 (70 FR 37160). As part of this 5-year review, we have re-evaluated the status of this hatchery stock and concluded that it still should be considered part of the CV spring-run Chinook ESU.

2.2 Recovery Criteria

[1] Under the San Joaquin River Restoration Program, spring-run Chinook salmon will be reintroduced into the San Joaquin River as an experimental population, which is considered separate from the listed ESU. If the reintroduction is successful and at some future time the experimental population designation is removed, then the ESU boundary would need to be modified to include the San Joaquin River.

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 has not yet issued a final approved recovery plan for this ESU. A draft multi-species recovery plan for Central Valley salmon and steelhead has been published which contains proposed recovery criteria that are objective and measureable. The proposed criteria 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 proposed biological recovery criteria in the draft 2009 recovery plan are based on the Viable Salmon Population (VSP) criteria developed by McElhany et al. (2000).

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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 public draft recovery plan are based on the best available information. The biological recovery criteria in the final recovery plan will also be 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 public draft multi-species recovery plan contains threat abatement recovery criteria that address each of the five listing factors. The final recovery plan will also contain 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 public draft recovery plan for the Central Valley contains the following proposed, draft ESU-level and population-level recovery criteria for CV spring-run Chinook.

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 Flow Diversity Group at low risk of extinction
- Three populations in the Northern Sierra Diversity Group (because of their geographic proximity, Mill and Deer Creek are considered part of the same meta population at low risk of extinction)
- Two populations in the Southern Sierra Diversity Group at low risk of extinction
- Maintain Core 2 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. Those recovery criteria are presently far from being met. Based on the viability report developed by the SWFSC for this review, there is currently only one population (Butte Creek) at a low extinction risk and that population has declined in recent years, most likely because of drought and poor ocean conditions.

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 up to the three most recent generations, if that much data are available. 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.

Core 1 Populations must meet 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

Core 2 Populations must meet 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

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.

Criterion	Risk of Extinction		
	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 (VSP) Criteria

Summary of Previous Biological Review Team (BRT) Conclusions

At the last status review, 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 (CVTRT) delineated 18 or 19 historic independent populations of spring-run Chinook salmon, and a number of smaller dependent populations, that are distributed among 4 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 Creek) 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.

New Data and Updated Analyses

Figure 1 shows the escapement of CV spring-run Chinook salmon to various areas in the Central Valley, and Table 7 shows abundance and trend statistics for this ESU related to the viability criteria. With a few exceptions, escapements have declined over the past 10 years, in particular since 2006. The recent declines in abundance place the Mill and Deer Creek populations in the high extinction risk category due to their rate of decline, and in the case of Deer Creek, also the level of escapement. Butte Creek continues to satisfy the criteria for low extinction risk, although the rate of decline is close to triggering the population decline criterion for high risk. Overall, the recent declines have been significant but not severe enough to qualify as a catastrophe under the criteria of Lindley et al. (2007). On the positive side, spring-run Chinook salmon appear to be repopulating 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 spring-run Chinook salmon population in Clear Creek has been increasing, although Lindley et al. (2004) classified this population as a dependent population, and thus it is not expected to exceed the low-risk population size threshold of 2500 fish (i.e., annual spawning run size of about 833 fish).

There is also a spring-run Chinook salmon population in the Yuba River, which is a tributary to the Feather River. The annual spawning run size of spring-run Chinook salmon on the Yuba River generally ranges from a few hundred to a few thousand fish with the annual trend closely following the annual abundance trend of the Feather River Hatchery spring-run Chinook salmon population. The Yuba River spring-run Chinook salmon population satisfies the moderate extinction risk criteria for abundance, but likely falls into the high risk category for hatchery influence.

Discussion

The status of CV spring-run Chinook salmon ESU has probably deteriorated on balance since the 2005 status review and Lindley et al.'s (2007) assessment, with two of the three extant independent populations of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Butte Creek remains at low risk, although it is on the verge of moving towards high risk. In contrast, spring-run Chinook salmon in Battle and Clear creeks have increased in abundance over the last decade, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have increased at least in part due to extensive habitat restoration, although in the case of Clear Creek, it is not yet clear the degree to which strays, as opposed to local production, have driven this dramatic increase. With

the recent implementation of mass marking of Feather River Hatchery spring-run Chinook salmon, this question may be answered.

The time since 2005 has been a period of widespread declines in the abundance of Chinook salmon in the Central Valley, including spring-run Chinook salmon. In an analysis focused on Sacramento River fall Chinook, Lindley et al. (2009) found that unusual ocean conditions in the spring of 2005 and 2006 led to poor growth and survival of juvenile salmon entering the ocean in those years. From 2007-2009, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon. There is a possibility that with the recent cessation of the drought and a return to more typical patterns of upwelling and sea-surface temperatures that declining trends in abundance may reverse in the near future. At the ESU level, the reintroduction of spring-run Chinook salmon into Battle Creek and the increasing abundance of spring-run Chinook salmon in Clear Creek is improving the status of CV spring-run Chinook salmon. Further efforts, such as those underway to establish spring-run Chinook salmon production in the San Joaquin River below Friant Dam and to facilitate passage of fish above Englebright Dam on the Yuba River, will be needed to make the ESU viable.

In summary, the status of the CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review. Improvements, evident in the improved status of two populations, are not sufficient to warrant a downgrading of the ESU extinction risk. The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern. New information available since Good et al. (2005) indicates an increased extinction risk.

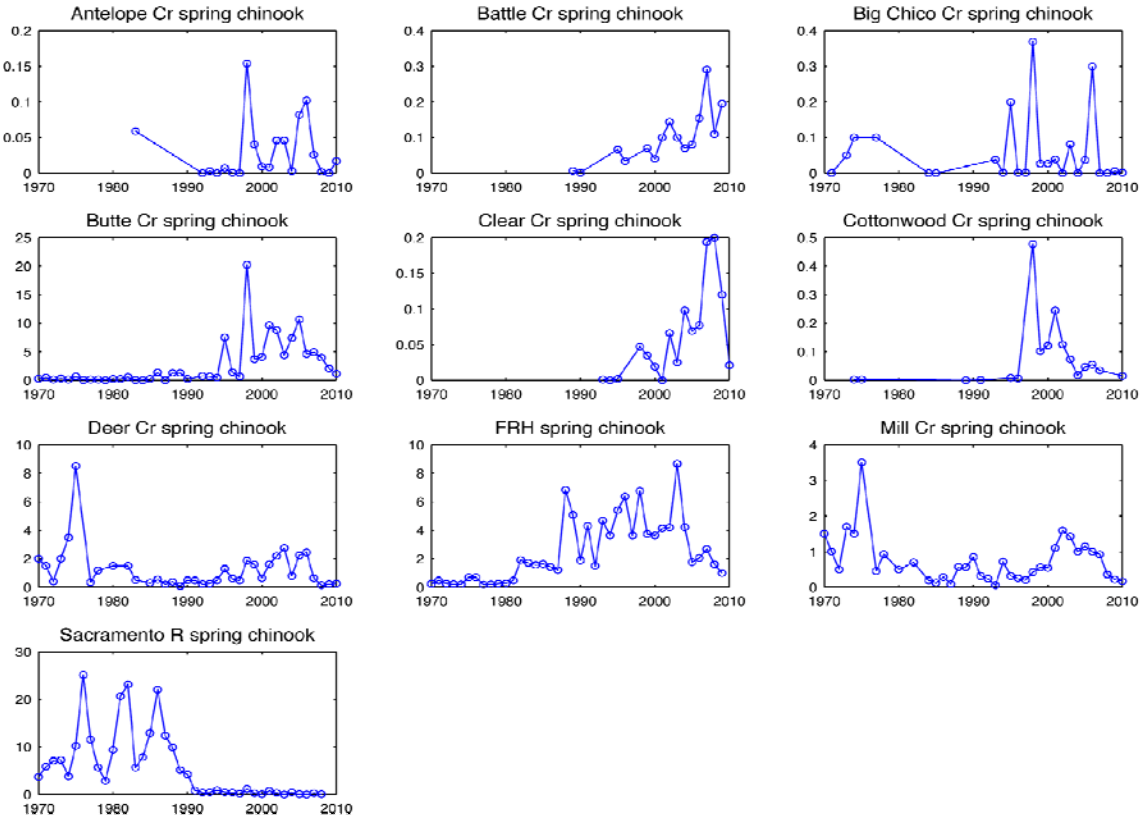

Figure 1. Time series of escapement for CV spring-run Chinook salmon populations. Y axis is in thousands of fish.

Table 7: Viability metrics for CV spring-run Chinook salmon populations. Populations in **bold** are historically independent populations. Data are from the 2010 CDFG Grand Tab database, which generally includes data through 2009.

Population	$\hat{S}$	N	10-year trend (95% CI)	Recent Decline (%)
Antelope Creek	9.3	28.0	-0.156 (-0.554, 0.242)	44.2
Battle Creek	198	595	0.119 (0.006, 0.232)	NA
Big Chico Creek	2.0	6.0	-0.186 (-0.749, 0.376)	26.9
Butte Creek	3,650	10,900	-0.090 (-0.205, 0.025)	42.5
Clear Creek	171	514	0.373 (0.083, 0.664)	NA
Cottonwood Creek	45.3	136	-0.248 (-0.406, -0.090)	66.7
Deer Creek	332	997	-0.196 (-0.430, 0.037)	58.4
Feather River Hatchery	1,760	5,290	-0.156 (-0.266, -0.046)	56.8
Mill Creek	501	1,500	-0.119 (-0.259, 0.022)	45.3
Sacramento River	100	300	-0.238 (-0.845, 0.369)	60.7
Yuba River	665[1]	1,994[1]	NA	NA

[1] Metrics based on data from 2006-2008. Massa et al. (2010) identified two temporal modes of adult salmon migrating upstream passed Daguerre Point Dam (DPD), with the first mode occurring from March through August. For this analysis, it is assumed that upstream migration passed DPD from March through August approximates the annual run size of spring-run Chinook salmon in the Yuba River.

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

Section 4(a)(1) of the ESA and the listing regulations (50 CFR Part 424) set forth procedures for listing species. NMFS must determine, through the regulatory process, if a species is endangered or threatened based upon any one or a combination of the following factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or education purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or human-made factors affecting its continued existence.

In the last status review Good et al. (2005) described the threats to the CV spring-run Chinook salmon ESU as falling into three broad categories: loss of historical spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring-run Chinook salmon program[2]. The first two categories are discussed in this section and genetic threats resulting from the hatchery program are discussed below in section 2.3.2.5. This section concludes with a summary discussion of whether the threats associated with this listing factor have substantially changed in magnitude since the 2005 status review.

[2] 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.

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 the CV spring-run Chinook salmon ESU was originally listed as threatened in 1999, spawning habitat for this species has been expanded very little compared to the hundreds of miles of habitat that continues to be blocked by dams. The removal of Seltzer Dam on Clear Creek in 2000 opened up 10 miles of habitat. A partial low flow barrier on Cottonwood Creek was fixed in 2010 that improved access to 30 miles of habitat. Additionally, the removal of Wildcat Dam in 2010 along with the completion fish ladders at Eagle Canyon Dam and North Battle Feeder Dam opened up about 10 miles of habitat on Battle Creek.

The Battle Creek Salmon and Steelhead Restoration Project will eventually 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 program is completed, a total of 42 miles of mainstem habitat and six miles of tributary habitat will be opened up to anadromous salmonids, including CV spring run Chinook salmon. Phases lA (North Fork Battle Creek actions) and 1B (a tailrace connector project) have been funded. Phase 2 of the restoration project (South Fork Battle Creek actions) has not been completely funded and the schedule for when phase 2 is expected to be completed has not yet been determined.

Efforts to reintroduce CV spring-run Chinook salmon to historic habitat are being planned in the San Joaquin River and are being evaluated for areas upstream of both Shasta Dam on the Sacramento River and Englebright Dam on the Yuba River. The San Joaquin River Restoration Program (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 spring-run Chinook salmon as an ESA 10(j) experimental population. The first flow releases from Friant Dam in support of the SJRRP occurred in October 2009. Key SJRRP milestones include: (1) reintroducing spring-run Chinook salmon by December 2012; (2) completing all high priority channel and structural construction activities by December 2013; and (3) releasing the full restoration flows in 2014.

The 2009 CVP-SWP biological opinion includes a phased fish passage program that is intended to expand habitat for spring-run Chinook salmon to areas upstream Shasta Dam on the Sacramento River. Phases of the fish passage program include habitat evaluations through January 2012, pilot reintroductions from January 2012 through January 2015, and implementation of the long-term program by January 31, 2020.

In the Yuba River watershed, there are multi-party discussions among operators of water and hydropower facilities, resource management agencies, and non-governmental organizations regarding watershed-wide options for addressing the reintroduction of spring-run Chinook salmon upstream of Englebright Dam and related issues through Federal Energy Regulatory Commission (FERC) relicensings on the North, Middle, and South Yuba rivers. Through these

discussions and FERC relicensings, there is potential for expanding spring-run Chinook salmon habitat in the Yuba River at some point in the future.

These efforts on Battle Creek and in the San Joaquin, Sacramento, and Yuba rivers are major conservation efforts that will hopefully provide opportunities for habitat and population expansion of this ESU in the future. At this time, however, they are not providing CV spring-run Chinook salmon access to historic habitat, and therefore, loss of historic spawning habitat remains a major threat to the ESU.

Degradation of Remaining Habitat

Previous status reviews for CV spring-run Chinook salmon (Myers et al. 1998, Good et al. 2005) and listing determinations (see Table 1) have indicated that the remaining spawning and rearing habitat for this species is severely degraded. Threats to spring-run Chinook salmon habitat include, but are not limited to: (1) operation of antiquated fish screens, fish ladders, and diversion dams on streams throughout the Sacramento River Basin including on Deer, Mill, Butte, 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, the main-stem Sacramento River (Central Valley Project), and the Feather River (State Water Project).

Cummins et al. (2008) attributed the much reduced biological status of Central Valley anadromous salmonid stocks, including Central Valley spring-run Chinook salmon, to habitat effects related to the construction and operation of the Central Valley Project (CVP) and State Water Project (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 spring-run Chinook salmon to respond to additional stressors, such as unproductive ocean conditions and drought, both of which have occurred since the last status review. Over the last five years, there has been a period of widespread decline in all Central

Valley Chinook salmon stocks. An analysis by Lindley et al. (2009) examining fall-run Chinook found that unusual oceanic conditions led to poor growth and survival for juvenile salmon entering the ocean from the Central Valley during the spring of 2005 and 2006. These unusual ocean conditions likely affected spring-run Chinook salmon as well. Additionally, the Central Valley experienced drought-like conditions during 2007 through 2009 which likely led to reduced juvenile survival and lower overall salmon abundance.

One conservation measure with the potential to greatly improve habitat and increase the ability Central Valley 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 2009b). The CVP-SWP biological opinion contains mandatory actions that are intended to ensure that long term operation of the projects does not jeopardize the continued existence of listed salmonids, including spring-run Chinook salmon, or destroy or adversely modify their critical habitat. Specific actions in the CVP/SWP BO that are intended to improve 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;
- modifying gate operations at Red Bluff Diversion Dam so that the gates are out from September 1 through June 14 to improve upstream migration for adults as well as downstream survival of juveniles; by May 2012 the dam must be operated with the gates out year-round;
- providing funding to help complete the Battle Creek Restoration Project (project is briefly describe above);
- providing funding to support the CVPIA Anadromous Fish Screen Program;
- providing significantly increased acreage of seasonally inundated floodplain habitat to improve juvenile rearing in the lower Sacramento River basin; and
- implementing multiple actions to improve flow and habitat conditions in the Delta.

Other recent programs and projects that have contributed to increasing 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.

Anadromous Fish Restoration Program. The Central Valley Improvement Act (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 the Bureau of Reclamation and USFWS. Approximately $15 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 Central Valley Project.

In November 2007, AFRP funds were used to place 500 short tons of gravel in the Yuba River immediately downstream of Englebright Dam as a pilot test for a larger spawning gravel augmentation program required of the Army Corps of Engineers. Chinook salmon were

subsequently observed spawning on patches of this pilot test gravel. While a small amount of spawning habitat was created with the 2007 gravel injection, much larger amounts of gravel additions are needed to substantially increase the availability of spawning habitat in the stream reach just downstream of the dam.

Other AFRP funded projects benefiting spring-run Chinook salmon include: (1) the elimination of a partial low flow barrier on Cottonwood Creek, which improves access to 30 miles of habitat; (2) mainstem Sacramento River and Clear Creek gravel augmentation; and (3) the installation of fish screens on several mainstem Sacramento River diversions, including the City of Sacramento diversion, which was completed in 2005.

Ecosystem Restoration Program (ERP). 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 (ROD) in 2000, the California Department of Fish and Game (DFG) 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 DFG fish passage goals.

Since 2000, the ERP has protected or restored more than 38,900 acres of habitat, most of which directly or indirectly benefits spring-run Chinook salmon, including:

- Contribution to the restoration and protection of 8,000 acres of wetlands in San Pablo Bay and Suisun Marsh;
- Protection of more than 11,000 acres and 18 river miles for riparian and shaded-riverine-aquatic habitat restoration;
- Enhancement or restoration of more than 3,900 acres and 59 miles of riparian and riverine aquatic habitat;
- Installation or restoration of 70 fish screens (11 that draw >250 cfs)
- Restoration of stream habitats and removed impediments to salmonid passage in critical areas including Clear Creek, Battle Creek, and Cottonwood Creek; and
- Protection of 16,000 acres of agricultural land largely through conservation easements with private landowners.

Bay-Delta Conservation Plan. The purpose of the Bay Delta Conservation Plan (BDCP) is to help recover endangered and sensitive species and their habitats in the Delta in a way that also will provide for a reliable water supply. A proposed BDCP 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, habitat restoration, and measures to reduce other stressors to the Delta ecosystem and covered species. BDCP is in a developmental stage, its implementation is uncertain, and any new benefits or threats to spring-run Chinook salmon resulting from the plan would not occur for many years.

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 FERC Project No. 803 have been implemented in recent years to reduce the water temperature-related effects of the project on spring-run Chinook salmon adults during the summer.

Feather River – Oroville Dam FERC License Settlement. Through the Oroville FERC License Settlement, DWR has committed to constructing a weir to segregate the spawning of 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 spring-run Chinook salmon habitat in the Feather River in recent years.

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 improved fish passage at Daguerre Point Dam, a long-term program to add woody material to the river in an effort to increase habitat complexity, and a riparian enhancement project intended to improve rearing habitat in the short- and long-term.

Summary

As discussed above, there are promising fish passage programs and other projects being implemented (e.g., San Joaquin River Restoration Program and Battle Creek Salmon and Steelhead Restoration Project) and evaluated (e.g., CVP-SWP biological opinion and Yuba River) that, if successful, would greatly expand spring-run Chinook salmon spawning habitat in the Central Valley. Likewise, there is potential for substantial habitat improvements to occur through the ERP, the AFRP, FERC relicensing processes, and through implementation of the actions required by NMFS' CVP-SWP biological opinion. Some of those habitat improvements are already occurring, such as better passage conditions at Red Bluff Diversion Dam and other operational changes at water management facilities. However, key habitat improvement actions included in the CVP-SWP biological opinion, such as substantially increasing the availability of floodplain habitat along the Sacramento River, have yet to be implemented. Implementation of those types of large scale habitat restoration actions are needed along the Sacramento River and Bay-Delta in order to reverse the dramatic loss of juvenile rearing habitat that occurred with the construction of major levee systems and the widespread development of tidal marshes.

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 and Cummins et al. 2008). Accordingly, the habitat supporting this ESU remains in a highly degraded state and it is uncertain whether habitat quality has substantially changed since 1999 or the last status review in 2005 (Good et al. 2005). Overall, major habitat expansion and restoration for 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 fishery impacts on the CV spring-run Chinook salmon ESU have not changed appreciably since the 2005 status review (Good et al. 2005), except that impacts were extremely low to non-existent in 2008 and 2009. 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 salmon ocean harvest rate are thought to provide a reasonable proxy for trends in the CV spring-run Chinook salmon ocean harvest rate. The fall Chinook salmon ocean harvest rate index peaked in the late 1980's at 84% and then steadily declined over the 1990's to an average level of 51% from 2000–2007 (Figure 2). Due to extremely low fall Chinook salmon abundance in 2008 and 2009, the ocean fisheries south of Cape Falcon were closed and the ocean harvest rate index dropped precipitously to 6% and 0%, respectively. Ocean fisheries resumed in 2010, but commercial fishing opportunity was severely constrained, particularly off California, resulting in a forecasted harvest index of 22% for 2010. 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 since the last status review because ocean harvest impacts were significantly reduced from 2008 through 2010 and in-river fishery impacts were limited because of the stock's migration timing.

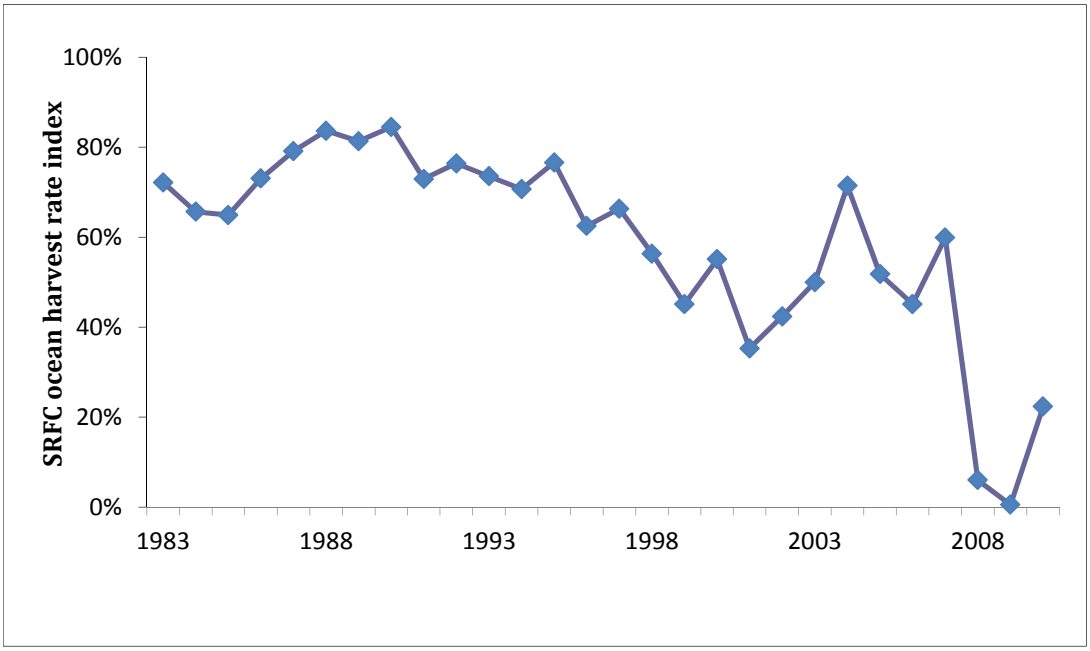

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Figure 2. Sacramento River fall Chinook (SRFC) ocean harvest rate index for years 1983–2010 (PFMC 2010a, PFMC 2010b). The 2010 index value is a forecast.

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 spring-run Chinook salmon are susceptible to disease outbreaks such as the Infectious Hematopoietic Necrosis Virus (IHNV) and Bacterial Kidney Disease. No disease outbreaks at the Feather River Fish Hatchery affecting spring-run Chinook salmon have occurred in the last five years.

Predation is a threat to the CV spring-run Chinook salmon ESU, especially in the lower Feather River, the Sacramento River, and in the Delta where there are high densities of non-native (e.g., striped bass, small-mouth bass and large-mouth bass) and native fish species (e.g., pikeminnow) that prey on outmigrating salmon. The presence of man-made structures in the environment that alter natural habitat conditions also likely contributes to increased predation by altering the predator-prey dynamics such that predatory species are often favored. In the Sacramento River, removing the gates at the Red Bluff Diversion Dam (RBDD) 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 salmon 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 status review. Predation at RBDD should decrease starting in 2010 as the dam gates are in for a shorter period and be further reduced in 2012 when the dam gates will be out year-round. Although reducing predation at RBDD will benefit 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.

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 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 spring-run Chinook salmon for fall-run Chinook salmon may lead to less timely Delta regulatory actions necessary to protect the listed species. Likewise misidentification of spring-run Chinook salmon for fall-run Chinook salmon in other areas will continue to delay and or hamper real-time efforts to protect the listed species.

2.3.2.5 Other natural or manmade factors affecting its continued existence

Feather River Hatchery Spring-run Chinook Salmon Program

The most recent genetic analysis on this stock (Garza and Pearse 2008) found subtle, but significant, differentiation between the Feather River Hatchery spring- and fall-run 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 that has been heavily introgressed with fall-run Chinook. A lack of close clustering relationships was also found between hatchery and naturally spawned population samples for the Feather Rivers, although they were all still relatively closely related. However, the Feather River Hatchery fall-run and "spring-run" stocks did cluster together with relatively high bootstrap support, reflecting historic gene flow between them.

In our 2005 listing determination (70 FR 37160), we included the Feather River spring-run Chinook hatchery stock in the listed CV spring-run Chinook ESU because it contained the remaining genetic legacy of the historic spring-run population in the Feather River and also continued to exhibit a spring-run migration timing. Since 2002, DFG, DWR and NMFS have worked to reinforce the expression of a spring run life history at the Feather River hatchery by adopting new broodstock protocols designed to reduce or minimize the introgression of spring run and fall run chinook at the hatchery. A draft hatchery genetics management plan has been developed that describes the new management protocols for the spring run 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. Overall, the negative impacts of this program on naturally produced spring-run Chinook salmon are not likely to have changed substantially since the 2005 review, but the new management efforts should reduce impacts in the future

Climate Change

Lindley et al. (2007) summarized several studies (Hayhoe et al. 2004, Dettinger et al. 2004, Dettinger 2005, VanRheenen et al. 2004, Knowles and Cayan 2002) on how anthropogenic climate change is expected to alter the Central Valley, and based on these studies, described the possible effects to anadromous salmonids. Climate models for the Central Valley are broadly

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

Precipitation and Drought

The CV spring-run Chinook salmon ESU is highly vulnerable to drought conditions. During dry years, less cold water is available in storage reservoirs such as Whiskeytown, Shasta, Oroville, and New Bullards Bar to control instream water temperatures downstream. The increased in-river water temperature resulting from 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 spring-run Chinook salmon river systems without major storage reservoirs (e.g., Mill, Deer, and Butte creek) is also likely to 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 over time with climate change suggest that spring-run Chinook salmon are 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 spring-run Chinook salmon habitat unusable, either through temperature increases or lack of adequate flows. The most recent drought, which occurred from 2007-2009, was likely a factor in the recent widespread decline of all Chinook salmon runs (including spring-run Chinook) in the Central Valley (Williams et al. 2011). The period of consecutive dry years ended with a relatively wet winter during water year 2010 (October 2009-September 2010). Water year 2011 also appears to be relatively wet as the Sierra Nevada Mountain snowpack as of March 2011 is at above average levels.

Ocean Conditions

Ocean conditions, such as sea-surface temperatures and upwelling are major factors influencing west coast salmon populations (Wells et al. 2008), including those from the Central Valley (Lindley et al. 2009). As previously discussed, Lindley et al. (2009) found that poor ocean

conditions in the spring of 2005 and 2006 led to poor growth and survival of Central Valley juvenile salmon entering the ocean in those years. Upwelling off the California coast was stronger than average in the spring of 2007 and 2008 indicating good ocean conditions for Central Valley spring-run Chinook salmon smolts entering the ocean during those years (Lindley et al. 2009). Since the unusual ocean conditions in 2006, more typical patterns of upwelling and sea-surface temperatures have returned (Williams et al. 2011). The poor ocean conditions in recent years clearly had adverse impacts on the CV spring-run Chinook ESU as discussed previously.

2.4 Synthesis

Lindley et al. (2004) examined the population structure of the CV spring-run Chinook salmon ESU and delineated 18 or 19 independent populations and a smaller number of dependent populations in four population diversity groups. Of these 18 or 19 independent 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 spring-run Chinook, but those populations all have low abundance and/or are heavily influenced by hatchery origin spring-run fish from the Feather River hatchery.

With a few exceptions, CV spring-run Chinook salmon populations have declined over the past 10 years particularly since 2006. The recent declines in abundance place the Mill and Deer Creek populations in the high extinction risk category due to their rate of decline, and in the case of Deer Creek also the level of escapement. Butte Creek continues to satisfy the criteria for low extinction risk, although the rate of decline is close to triggering the population decline criterion for high risk. The only spring-run Chinook salmon populations that seemed to have improved in status over the past 10 years are in Battle Creek and Clear Creek. Overall, the SWFSC concluded in their viability report that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams et al. 2011).

Since 2005 there have been widespread declines in the abundance of all Chinook salmon in the Central Valley, including CV spring-run Chinook. In an analysis focused on Sacramento River fall-run Chinook salmon, Lindley et al. (2009) found that unusual ocean conditions in the spring of 2005 and 2006 led to poor growth and survival of juvenile salmon entering the ocean in those years. Although Lindley et al. (2009) identified unusual ocean conditions as the proximate cause of the fall-run Chinook salmon collapse they also stated that the poor ocean conditions were acting together with a long-term, steady degradation of freshwater and estuarine habitat conditions. The notion that habitat for Chinook salmon and steelhead in the Central Valley continues to be in a highly degraded condition is consistent with the conclusions of other recent assessments (e.g., NMFS 2009b, Cummins et al. 2008). The degraded and simplified habitat of the Central Valley makes it difficult for spring-run Chinook salmon to withstand environmental stressors such as the poor ocean conditions in 2005 and 2006 and the period of drought that occurred in 2007 and 2008. The poor ocean conditions and the drought are likely important factors causing most Central Valley spring-run Chinook salmon populations to decline in recent years.

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 San Joaquin River Restoration Program. Other key actions for spring-run Chinook salmon are being formally discussed (e.g., Upper Yuba River reintroduction) or planned (e.g., Bay Delta Conservation Plan). Some conservation measures are helping CV spring-run Chinook now, such as the removal of Wildcat Diversion Dam on Battle Creek, the modified 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 benefit CV spring-run Chinook salmon and its habitat are uncertain.

A summary of how the five ESA listing factors have changed since the 2005 status review are presented in Table 8. The only major change is related to harvest impacts which have decreased and natural factors such as drought and poor ocean conditions which have increased in severity as stressors to CV spring-run Chinook salmon.

Table 8. Summary of how each ESA listing factor for Central Valley spring-run Chinook salmon has changed since the 2005 status review. See section 2.3.2 for more detail.

LISTING FACTOR	CHANGE SINCE 2005
Present or threatened destruction, modification, or curtailment of habitat or range	Limited habitat expansion. Some habitat restoration through CVP/SWP biological opinion, AFRP, and ERP. Overall, no major change in this listing factor since 2005.
Overutilization for commercial, recreational, scientific, or education purposes	Ocean harvest has not appreciably changed since 2005, except for extreme reductions from 2008 through 2010, as indicated by SRFC harvest rate index. The ocean salmon fisheries were closed in 2008 and 2009, and heavily restricted in 2010.
Disease of predation	No evidence suggests that this listing factor has substantially changed since 2005.
Inadequacy of exiting regulatory mechanisms	No evidence suggests that the impact of this listing factor on spring-run Chinook salmon has substantially changed since 2005.
Other natural or manmade factors	Impacts of the Feather River Hatchery likely did not substantially change since 2005. Unusual ocean conditions in 2005 and 2006, likely reduced the abundance of spring-run Chinook salmon returning to spawn in 2007 and 2008 (Lindley et al. 2009). Off the California coast, the ocean has returned to more normal conditions since 2006. From 2007 through mid-2009 ocean conditions off the Oregon coast were good for salmon. From mid-2009 through April 2010, ocean conditions were poor, but improved dramatically after April (http://www.nwfsc.noaa.gov/research/divisions/fed/estuarine.cfm). Drought conditions in 2007 and 2008, likely reduced the abundance of those two brood years, which would impact the abundance of returning adults in 2010 and 2011. The Central Valley has had wetter conditions since late 2009.

3.0 RESULTS

3.1 Recommended Classification

Based on a review of the best the available information, we recommend that the CV spring-run Chinook salmon ESU remain classified as a threatened species. However, this review indicates that the biological status of this ESU has worsened since the last status review, and therefore, we recommend that its status be reassessed in 2-3 years if it does not respond positively to improvements in environmental conditions and management actions. Specifically, we recommend that:

- The SWR and SWFSC monitor the status of this ESU and its response to changes in environmental conditions and management actions;
- The SWR and SWFSC conduct an updated status review of this ESU by 2013 if it does not respond positively to changes in environmental conditions and management actions;
- The SWR (including the CVO) and SWFSC work to collaboratively to develop ESU/DPS-specific biological guidelines and criteria for distinguishing between threatened and endangered species; 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 has declined in the last five years and this new information on its status may trigger reinitiation[3] of the ocean fishery consultation.

3.2 Recovery Priority Number

No change is recommended from the current recovery priority number of 7.

3.3 ESU Boundary and Hatchery Stocks

No change is recommended in the ESU boundary or hatchery membership status.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Priority Recovery Actions Needed

- Conduct a Central Valley-wide assessment of keystone dams and passage opportunities and implement programs to restore access to high elevation habitat that spring-run Chinook salmon historically depended on for their persistence
    - Priority areas for reintroductions include the McCloud River, Battle Creek, the Yuba River upstream of Englebright Dam, and the San Joaquin River;

[3] 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.

- 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;
- Modify diversion structures and utilize ground water in Antelope, Butte, Deer, and Mill Creeks to allow unimpeded upstream and downstream fish passage and to provide increased instream flows;
- Continue implementation of the Battle Creek Salmon and Steelhead Restoration Project;
- Continue implementation of the San Joaquin River Restoration Program;
- Reduce state-wide urban water use by 20 percent per capita by 2020, to help provide ecologically based flows in the Sacramento River and Bay-Delta;
- 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;
- Reduce the amount of spring-run Chinook salmon harvested in the commercial and recreational ocean salmon fishery;
- Finalize and implement the genetics management plan for the Feather River Hatchery; and implement the Feather River Oroville Hydroelectric Facility's Fish Habitat Management Plan to reduce the interaction between hatchery and wild fish and between spring-run Chinook salmon and fall-run Chinook salmon in the Feather River.

5.0 REFERENCES

Baker, P.F. and J.E. Morhardt. 2001. Survival of Chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. *In* R.L. Brown, editor, Contributions to the Biology of Central Valley Salmonids, Volume 2, pages 163-182. California Department of Fish and Game, Fish Bulletin 179.

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. Prepared under contract with Circlepoint for the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service. December. 51 pages plus 4 appendices.

Dettinger, M.D., D.R. Cayan, M.K. Meyer, and A.E. Jeton. 2004. Simulated hydrological responses to climate variations and changes in the Merced, Carson, and American River basins, Sierra Nevada, California, 1900-2099. Climatic Change 62:283-317.

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 (14 pages) Available at: http://repositories.cdlib.org/jmie/sfews/vol3/art4.

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 Contract # PO485303.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-66, 598 p.

Grover, A.M., 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 Progress Report to the Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Hayhoe, K.D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America. 101(34)12422-12427.

Kjelson, M.A. and P.L. Brandes. 1989. The use of smolt estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin Rivers, California. Pages 100-115 *in* C.D. Levings, L.B. Holtby, and M.A. Henderson (editors), Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105.

Knowles N. and D. Cayan. 2002. Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophysical Research Letters 29(18), 1891, doi:10.1029/2001GL014339.

Lindley, S.T., R. 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 ESU in California's Central Valley basin. NMFS Southwest Science Center NOAA-TM-NMFS-SWFSC-360. Santa Cruz, CA.

Lindley, S.T., R. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. 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), Article 4: 26 pages. Available at: http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art4.

Lindley, S.T., C.B. Grimes, M.S. Mohr, 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, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. March 18. 57 pages plus a 61-page appendix.

MacFarlane, R.B., A.P. Klimley, S.L. Lindley, A.A. Ammann, P.T. Sandstrom, C.J. Michel, and E.D. Chapman. 2008. Migration and survival of juvenile salmonids in California's Central Valley and San Francisco estuary, 2007 and 2008 data. Presentation given to Southwest Region Protected Resources Division, National Marine Fisheries Service, Lake Tahoe, California. August 20, 2008.

Massa, D., J. Bergman, and R. Greathouse. 2010. Lower Yuba River Accord monitoring and evaluation plan – annual vaki riverwatcher report, March 1, 2007 – February 29, 2008. Prepared for the Yuba River Accord Planning Team. Available at: http://www.yubaaccordrmt.com

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. Technical Memorandum NMFS-NWFSC-35. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 443 pages.

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. 443 pages.

National Marine Fisheries Service. 2003. Draft Report of Updated Status of Listed ESUs of Salmon and Steelhead. NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington. (http://www.nwfsc.noaa.gov/trt/brt/brtrpt.html)

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. July. Prepared by the NOAA Fisheries, Protected Resources Division, Long Beach, California. Available at:http://swr.nmfs.noaa.gov/chd/CHART%20Final%20Assessment/Final_CHART_Report-July_05.pdf.

National Marine Fisheries Service (NMFS). 2009a. Public Draft 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 Central Valley Steelhead. Sacramento Protected Resources Division. October 2009.

National Marine Fisheries Service (NMFS). 2009b. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. National Marine Fisheries Service, Southwest Region. June 4, 2009. http://www.swr.noaa.gov/ocap.htm

Newman, K.B. and J. Rice. 2002. Modeling the survival of Chinook salmon smolts outmigrating through the lower Sacramento River system. Journal of the American Statistical Association 97(460):983-993.

Pacific Fishery Management Council (PFMC). 2010a. Preseason report I: stock abundance analysis for 2010 ocean salmon fisheries. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Pacific Fishery Management Council (PFMC). 2010b. Preseason report III: analysis of council adopted management measures for 2010 ocean salmon fisheries. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Peterson, J.H. and J.F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: Bioenergetic implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences. 58:1831-1841.

VanRheenen, N.T., A.W. Wood, R.N. Palmer, D.P. Lettenmaier. 2004. Potential implications of PCM climate change scenarios for Sacramento-San Joaquin river basin hydrology and water resources. Climate Change 62:257-281.

Vigg, S. and C.C. Burley. 1991. Temperature-Dependent Maximum Daily Consumption of Juvenile Salmonids by Northern Squawfish (*Ptychocheilus-Oregonensis*) from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48: 2491-2498.

Wells, B.K., C.B. Grimes, J.G. Sneva, S. McPherson, and J.B. Waldvogel. 2008. Relationships between oceanic conditions and growth of Chinook salmon (*Oncorhynchus tshawytscha*) from California, Washington, and Alaska, USA. Fisheries Oceanography 17: 101-125.

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: Southwest. 17 May 2011 – Update to 5 January 2011 report. National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, CA.

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
Central Valley Recovery Domain
Central Valley Spring-run Chinook Salmon

Current Classification: Threatened

Recommendation resulting from the 5-Year Review: Retain current ESA classification as threatened and current ESU boundary. Continue to include Feather River spring-run hatchery stock in the ESU.

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve: _____ Date: _____

Cooperating Regional Administrator, NOAA Fisheries

_____Concur _____ Do Not Concur

Signature_____ Date_____

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

_____Concur _____ Do Not Concur

Signature_____ Date_____