CALIFORNIA CENTRAL VALLEY RECOVERY DOMAIN

5-Year Status Review: Summary and Evaluation of *Sacramento River Winter-Run Chinook Salmon ESU*

National Marine Fisheries Service
West Coast Region

December 2016

5-YEAR REVIEW
Central Valley Recovery Domain

Species Reviewed	Evolutionarily Significant Unit (ESU) or Distinct Population Segment
Chinook Salmon *(O. tshawytscha)*	**Sacramento River Winter-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, among others, led to NOAA's 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).

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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 term "threatened species" is defined under the ESA as any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. An "endangered species" under the ESA is any species which is in danger of extinction throughout all or a significant portion of its range.

The most recent listing determinations for west coast salmon and steelhead occurred in 2005 and 2006. NMFS previously completed a 5-year status review in 2011 and concluded that the status of the Sacramento River (SR) winter-run Chinook salmon Evolutionarily Significant Unit (ESU) should remain as endangered. This document summarizes NMFS's current 5-year review of the ESA-listed SR winter-run Chinook salmon 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 NMFS draws on its "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 its listing determinations for Pacific salmon under the ESA, NMFS 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, NMFS 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 (NMFS 2003):

Category 1: The hatchery population was derived from a native, local population; is released within the range of the natural population from which it 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 it 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, NMFS conducted new status reviews and ESA-listing determinations for west coast salmon ESUs and steelhead DPSs using this policy. On June 28, 2005, NMFS issued final listing determinations for 16 ESUs of Pacific salmon (including the SR winter-run Chinook salmon ESU) and on January 5, 2006, NMFS issued final listing determinations for 10 DPSs of steelhead.

On August 15, 2011 we noticed the availability of the 5-year reviews and listing recommendations for 11 ESUs of Pacific salmon and 6 DPSs of steelhead, including SR winter-run Chinook salmon, and determined the status should remain as endangered as was determined in 2005 (76 FR 50447).

1.3 Methodology used to complete the review:

A public notice announcing NMFS's 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 SR winter-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 SR winter-run Chinook salmon. First, the NMFS-Southwest Fisheries Science Center (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 SR winter-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 whether the five ESA listing factors have changed substantially since 2010, several key documents were reviewed such as the Federal Register notices identified in Tables 1 and 2 and other relevant publications including:

(1) 5-year Status Review Report: Summary and Evaluation of Sacramento River Winter-Run Chinook Salmon ESU (NMFS 2011a)
(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) Biological Opinion on the Long-term Operations of the Central Valley Project and State Water Project (NMFS 2009)
(5) Grandtab 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 SR winter-run Chinook salmon should be down listed (*i.e.*, endangered to threatened), delisted from the ESA list, or remain unchanged. CCVO biologists assimilated information from various sources to support this review and the reviews of Central Valley spring-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 FR Notice citation announcing initiation of this review:

80 FR 6695; February 6, 2015

1.4.2 Listing history

The SR winter-run Chinook salmon ESU was first listed as "threatened" in 1989 under an emergency rule (Table 1). In 1994, NMFS reclassified the ESU as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its listing as a threatened species in 1989; (2) the expectation of weak returns in coming years as the result of two small year classes (1991 and 1993); and (3) continuing threats to the species. On June 14, 2004, NMFS proposed to reclassify the ESU as threatened (69 FR 33102; June 14, 2004) primarily because of increasing run sizes and the implementation of numerous conservation efforts in the Central Valley. Following the comment period on the proposed reclassification and additional analysis, NMFS issued a final listing determination on June 28, 2005 (see Table 1) concluding that the ESU was "in danger of extinction" due to risks associated with its reduced diversity and spatial structure, and therefore, warranted continued listing as an endangered species under the ESA (70 FR 37160).

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

Salmonid Species	ESU Name	Original Listing	Revised Listing(s)
Chinook Salmon *(O. tshawytscha)*	Sacramento River Winter-run Chinook salmon	**FR notice:** 54 FR 32085 **Date listed:** 8/4/1989 **Classification**: *Threatened (emergency interim rule)*	
			FR notice: 55 FR 12191 **Date listed:** 4/2/1990 **Classification**: *Threatened (emergency interim rule)*
			FR notice: 55 FR 46515 **Date listed:** 11/5/1990 **Classification**: *Threatened*
			FR notice: 59 FR 440 **Date:** 1/4/1994 **Re-classification**: *Endangered*
			FR notice: 70 FR 37160 **Date listed:** 6/28/2005 **Classification**: *reaffirmed classification* as *Endangered*

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. NMFS designated critical habitat for this ESU in 1993 (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 or injures fish, and may include habitat modification. The ESA automatically prohibits the take of species listed as endangered, In 1990, a 4(d) protective regulation was promulgated for this threatened ESU that applied the section 9 take prohibitions and also created several “limits” or exemptions for specific activities consistent with the conservation and recovery of threatened salmonids. With the 1994 reclassification of the ESU as endangered, the 1990 4(d) rule no longer applied to Sacramento River winter-run Chinook, and ESU was automatically afforded the section 9 take prohibitions.

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

Salmonid Species	ESU Name	4(d) Protective Regulations	Critical Habitat Designations
Chinook Salmon *(O. tshawytscha)*	Sacramento River winter-run Chinook salmon	**FR notice:** 55 FR 46515 **Date:** 11/5/1990*	**FR notice:** 58 FR 33212 **Date:** 6/16/1993

***Note:** The 1990 4(d) rule was later superseded by the 1994 reclassification of this ESU as endangered (see Table 1).

1.4.4 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. Previous scientific assessments for the SR winter-run Chinook salmon ESU.

Salmonid Species	ESU Name	Document Reference
Chinook Salmon *(O. tshawytscha)*	Sacramento River Winter-run Chinook salmon	National Marine Fisheries Service. 1996. Recommendations for the Recovery of the Sacramento river Winter-run Chinook Salmon. Recovery Team. Long Beach. CA. 211 pages.
		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. 1999. Status review update for deferred ESUs of West Coast Chinook salmon (*Oncorhynchus tshawytscha*) from Washington, Oregon, California, and Idaho. Memorandum dated 16 July 1999, to U. Varanasi, Northwest Fisheries Science Center, and M. Tillman, Southwest Fisheries Science Center, from M. Schiewe, Northwest Fisheries Science Center, Montlake, Washington.
		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.
		Good, T.P., R.S. Waples, and P. Adams. 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.
		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.
		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.
		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. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

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, NMFS assesses 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 (NMFS 2015). As a result of the re-evaluation, the recovery potential for SR winter-run Chinook salmon increased, causing the species' recovery priority number to change from 3 to 1. 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 SR winter-run Chinook salmon ESU (Table 4).

Table 4. Recovery Priority Number and Endangered Species Act Recovery Plans for SR winter-run Chinook salmon.

Salmonid Species	ESU Name	Recovery Priority Number	Recovery Plans
Chinook Salmon *(O. tshawytscha)*	Sacramento River Winter-run Chinook Salmon	1	**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/ (West Coast Region salmonid Recovery Plans)

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**
Sacramento River Winter-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**
Sacramento River Winter-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
Sacramento River Winter-run Chinook Salmon	X		1989

** 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 SR winter-run Chinook salmon ESU, NMFS treated the delineated ESU as a DPS, and hence a “species”, under the ESA. Although finalized after the listing of this ESU, 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’s 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 ESUs/DPSs under review

The SR winter-run Chinook salmon ESU is represented by a single naturally-spawning population that has been displaced from nearly all of its historical spawning habitat by the construction of Shasta and Keswick dams. Based on this review, there is no new information indicating that the current freshwater and estuarine geographic boundary of this ESU should be changed or that the population does not constitute an ESU.

USFWS manages a Conservation Hatchery Program for this ESU which is located at the LSNFH. This hatchery program supplements the natural population according to strict guidelines developed in conjunction with NMFS. Based on a review of available genetic and other information, this hatchery stock was considered part of the SR winter-run Chinook ESU and was listed in 2005 (70 FR 37160). Based on that review, there is no new information indicating that this hatchery stock has diverged significantly from the natural spawning population or that there have been substantial changes in the hatchery management since the last status review.

In 2015, the USFWS, NMFS, and CDFW collectively decided to initiate a Captive Broodstock Program using juvenile hatchery fish from the Conservation Hatchery Program. This decision was in response to threats to the ESU caused by the continuation of extreme drought conditions in California’s Central Valley. The goals of a new Captive Broodstock Program, listed in order of priority, will be to provide : 1) a genetic reserve of SR winter-run Chinook salmon in a safe and secure environment to be available for use as hatchery broodstock for the Integrated-Recovery Supplementation Program in the event of a catastrophic decline in the abundance; 2) a future source of winter-run Chinook salmon to contribute to multi-agency efforts to reintroduce winter-run Chinook salmon upstream of Shasta Dam and into restored habitats of Battle Creek; and 3) a future source of winter-run Chinook salmon to fulfill the needs of research projects.

As part of this 5-year review, we reevaluated the relatedness of SR winter-run Chinook ESU hatchery programs. We determined that the fish being reared to maturity at the LSNFH to establish a Captive Broodstock Program are part of the current ESA listing. These captive fish were taken as juveniles directly from the Conservation Hatchery Program and no outside fish were incorporated to establish a new stock. Rather than being released as juveniles, these captive fish from the Conservation Hatchery Program are being reared and maintained at the LSNFH into adulthood. As such, the captive winter-run Chinook at the LSNFH are a component of the Conservation Hatchery Program and should be considered as part of the listing of SR winter-run Chinook, as it is currently defined (79 FR 20802; April 14, 2014).

While the captive fish at the LSNFH are currently a component of the Conservation Hatchery Program and regarded as part of the listed ESU, we recognize that the future intent is to use the progeny of these captive fish in support of different conservation and recovery goals than the Conservation Hatchery Program. Next year, 2017, will be the first year that these fish retained from the Conservation Hatchery Program will be mature and ready to spawn. The progeny from those matings will be retained, establishing the Captive Broodstock Program. This Captive Broodstock Program will represent a new hatchery stock of SR winter-run Chinook being propagated at the LSNFH.

The Captive Broodstock Program, once established in 2017, will be no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the SR winter-run Chinook salmon ESU. As such, consistent with the 2005 Hatchery Listing Policy, we recommend revising the ESU listing to include the Captive Broodstock Program, in addition to the Conservation Hatchery Program, as part of the listed SR winter-run Chinook ESU. While both hatchery programs will both be propagated at the LSNFH, identifying these two hatchery programs as distinct components of the listed ESU will recognize their differing conservation goals, their unique broodstock and rearing practices, and their respective potential for future genetic divergence relative to the local natural population(s).

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
Sacramento River Winter-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 the 2014 recovery plan are based on the Viable Salmon Population (VSP) 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
Sacramento River Winter-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
Sacramento River Winter-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 any final or interim recovery plan, and discuss how each criterion has or has not been met, citing information

The Central Valley Chinook salmon and steelhead recovery plan contains criteria indicating that the SR winter-run Chinook salmon ESU must have three viable populations in the Basalt and Porous Lava Diversity Group in order to support a delisting determination. Criteria for assessing population extinction risk were developed by the Central Valley Technical Recovery Team (TRT) (Lindley *et al*. 2007) and have been incorporated into the recovery plan (Table 5). A population that meets the low extinction risk criteria described in Table 5 is considered to be viable (NMFS 2014). The TRT incorporated the four viable salmonid population parameters from McElhany *et al*. (2000) into assessments of population viability, and two sets of population viability criteria were developed, expressed in terms of extinction risk. The first set of criteria deal with direct estimates of extinction risk from population viability models. If data are available and such analyses exist and are deemed reasonable for individual populations, such assessments may be efficient for assessing extinction risk. In addition, the TRT also provided simpler criteria. The simpler criteria include population size (and effective population size), population decline, catastrophic rate and effect, and hatchery influence. For a population to be considered at low risk of extinction (*i.e*., defined as < 5 percent chance of extinction within 100 years) the population viability assessment must demonstrate that risk level or all of the following criteria must be met:

- Effective population size is > 500 -or- census population size is > 2,500
- No productivity decline is apparent
- No catastrophic events occurring or apparent with the past 10 years
- Hatchery influence is low (as determined by levels corresponding to different amounts, durations and sources of hatchery strays)

Table 5. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids in the Central Valley of California. Overall risk is determined by the highest risk score for any category (Lindley *et. al.* 2007).

	Risk of extinction		
Criterion	High	Moderate	Low
Extinction risk and PVA	> 20% within 20 yrs	> 5% within 100 yrs	< 5% within 100 yrs
	- 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[c]	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 over the past 10 years. 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 Figure 3 for assessing hatchery impacts.

2.3 Updated Information and Current Species Status

2.3.1 Analysis of VSP Criteria

Summary of Previous Biological Review Team (BRT) Conclusions
Good *et al*. (2005) found that viability of the SR winter-run Chinook salmon ESU was consistent with "in danger of extinction." The major concerns of the BRT were that there is only one extant population, and it is outside of its historical spawning distribution in an artificially-maintained habitat that is vulnerable to drought and other catastrophes. In the most recent past assessment, Williams *et al*. (2011) found that the viability of the ESU had changed little since the 2005 review and found that it did not appear that there was a change in extinction risk.

Brief Review of Technical Recovery Team (TRT) Documents and Findings
The TRT delineated four historical independent populations of the SR winter-run Chinook salmon ESU. The spawning areas of three of these historical populations (upper Sacramento, McCloud, and Pit rivers) are above the impassable Keswick and Shasta dams, while Battle Creek (location of the fourth population) is presently unsuitable for winter-run Chinook salmon due to high summer water temperatures. Using data through 2004, Lindley *et al*. (2007) found that the mainstem Sacramento River population was at a low risk of extinction. The ESU as a whole, however, was not considered viable because there is only one naturally-spawning population and it is not within the range of its historical spawning habitat. An emerging concern was the rising levels of LSNFH-origin fish spawning in natural areas (mean=8%, t=10 years), although the duration and extent of this introgression was still consistent with a low extinction risk as of 2010.

New Data and Updated Analyses
Since the 2010 viability assessment, routine escapement data have continued to be collected allowing viability statistics to be updated (Table 6). The Red Bluff Diversion Dam (RBDD) gates were operated in the up/out position during some or all of the winter-run immigration period since 2001 and removed in 2012 to provide unimpaired salmon passage year-round (NMFS 2009). These modifications also changed the ability to count SR winter-run Chinook salmon adults at the RBDD fish ladders (NMFS 2009). Population estimates from 2001 to present are derived exclusively from mark-recapture estimates from the carcass survey (Figure 1).

Table 6 shows the viability metrics for SR winter-run Chinook salmon abundance and trends in the LSNFH and in the Sacramento River. Like many other populations of Chinook salmon in the Central Valley, SR winter-run Chinook salmon have declined in abundance since 2005 with recent decadal lows of 827 spawners in 2011. Escapement in 2011 represents the lowest run since the construction and operation of the LSNFH conservation hatchery in 1997. Both the current total population size (N; LSNFH = 645; Sacramento River = 11,125) and mean population sizes ($\hat{S}$; LSNFH = 215; Sacramento River = 3,708) satisfy the low risk criterion ($N > 2500$).

The point estimate for the 10-year trend in run size is negative (-0.15), suggesting a 15% per year decline in the population (Table 6). The slope is marginally not different than '0', yet it is clear that the population has been steadily declining rather than increasing over the past decade. The maximum year-to-year decline in population size has reached 67%, an increase from 38% in the previous 2010 viability assessment (Williams *et al*. 2011). However, the percent decline does not exceed the catastrophic decline criteria (>90% decline in one generation or annual run size < 500 spawners; Lindley *et al*. 2007).

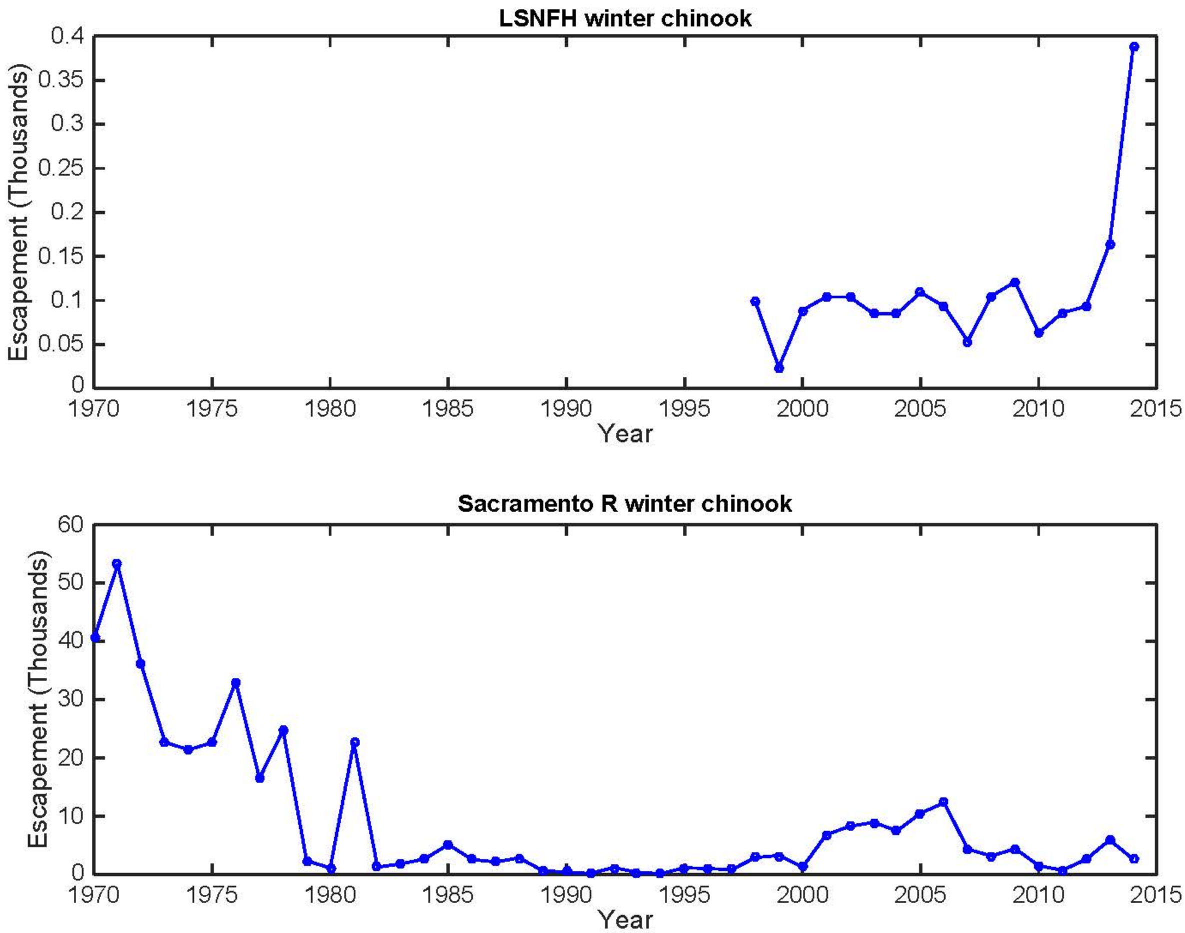

Figure 1: Time series of escapement for SR winter-run Chinook salmon populations (a) used as broodstock at LSNFH and (b) spawning in-river. Estimates for in-river spawners is the average number of adults counted at Red Bluff Diversion Dam and the carcass survey mark-recapture estimates (when available). Note: only mark-recapture estimates used beginning in 2009; Data source: Azat 2014.

Table 6: Viability metrics for SR winter-run Chinook salmon ESU. Total population size (*N*) is estimated as the sum of estimated run sizes over the most recent three years. The mean population size ($\hat{S}$) is the average of the estimated run sizes for the most recent 3 years (2012-2014). Population growth rate (or decline; 10-year trend) is estimated from the slope of log-transformed estimated run sizes. 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 (%)
LSNFH winter chinook	645	215.0	0.102 (-0.019, 0.222)	2.7
SR winter-run chinook	11125	3708.3	-0.155 (-0.345, 0.034)	67.4

The observed levels of hatchery influence exceed the low-extinction risk criteria met in the previous viability assessment and place the genetic integrity of the population at a moderate risk of extinction (Figure 2; Lindley *et al*. 2007). Since the beginning of hatchery production at LSNFH in 1997, the proportion of SR winter-run Chinook salmon spawning in the river that is of hatchery origin has increased (Figure 2). Prior to 2005, the proportion of LSNFH-origin spawners in the river was between 5% to 10%, consistent with guidelines from the Hatchery Scientific Review Group for conservation hatcheries (Figure 2; California HSRG 2012). However, the hatchery proportion has increased since 2005 and reached ~20% in 2005, 2014, and >30% in 2012. The average over the last 12 years (approximately four generations) is 13% (SD= ±8%) with the most recent generation at 20% hatchery influence, placing the population at a moderate risk of extinction (Table 7; Figure 3).

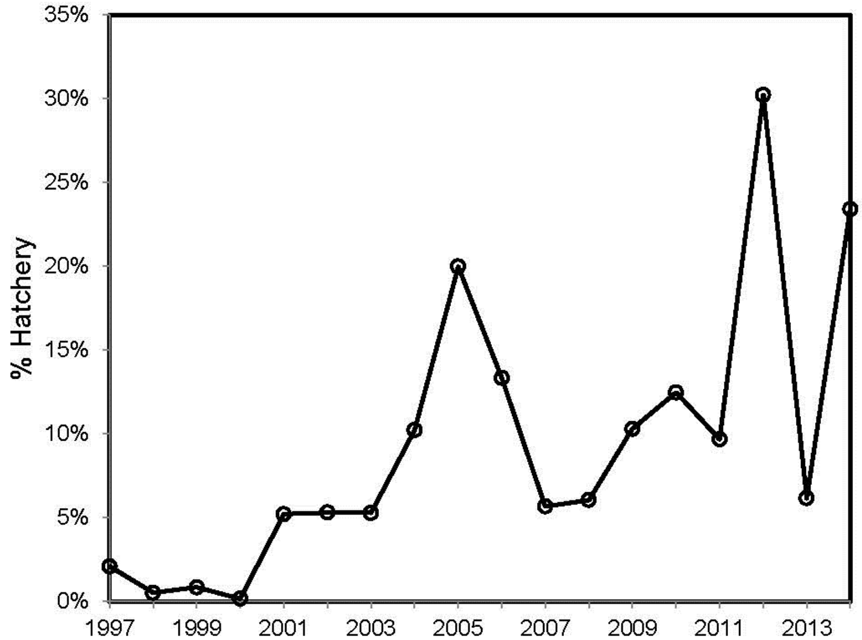

Figure 2: Percentage of SR winter-run Chinook salmon spawning in-river of hatchery origin; Data source: CDFW Doug Killam, unpublished.

Table 7. Average percentage of SR winter-run Chinook salmon river spawners that are hatchery origin over a varying (cumulative) number of years. One generation (g1) consists of the most recent 3 years; two generations (g2) the most recent 6 years; three generations (g3) the most recent 9 years; four generations (g4) the most recent 12 years. Data source: CDFW Doug Killam (unpublished 2014).

	g1	g2	g3	g4
Average hatchery influence	20%	15%	13%	13%

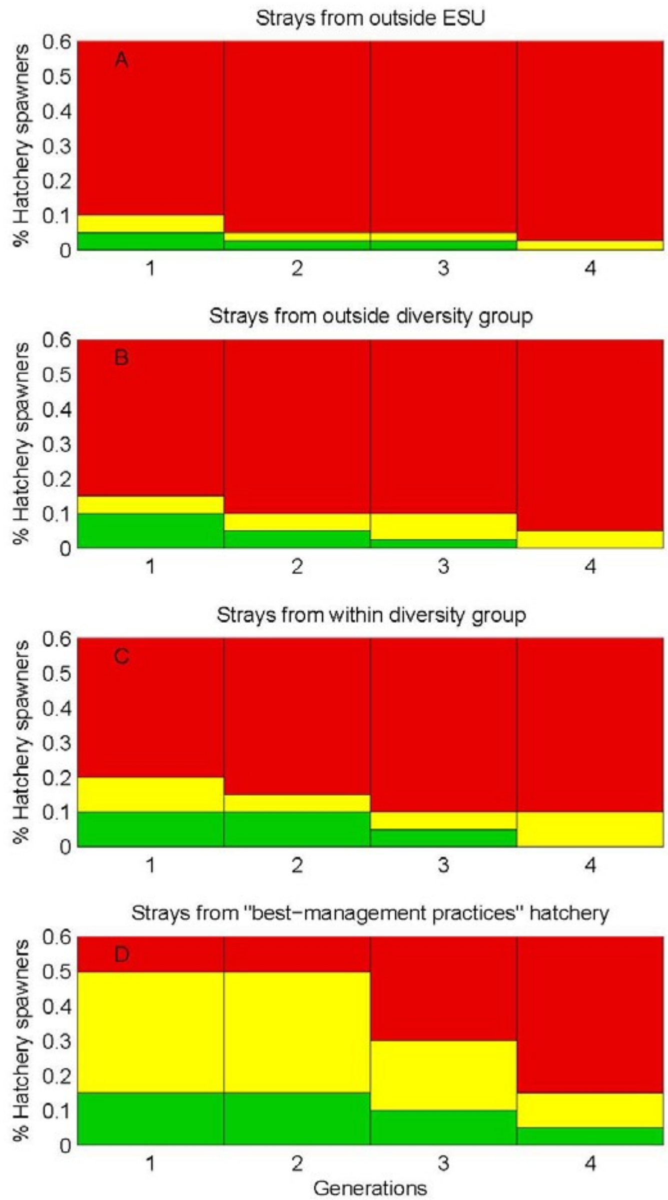

Figure 3. Percentage of hatchery-origin spawners and the resulting risk of extinction due to hatchery introgression from different sources of strays over multiple generations- low (green), moderate (yellow), and high (red). Model using "best-management practices" was used in the SR winter-run Chinook salmon assessment based on the breeding protocols at the LSNFH. Figure reproduced from Lindley *et al*. 2007.

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, the listing status 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 educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence.

Previous reviews of this ESU identified a wide range of factors as being responsible for its decline including: blockage of access to historic habitat, other passage impediments, degradation of remaining available habitat, unscreened water diversions, heavy metal pollution from mine runoff, disposal of contaminated dredge sediments in San Francisco Bay, ocean harvest, predation, drought effects, losses of juveniles at the Central Valley Project (CVP) and State Water Project (SWP) Sacramento-San Joaquin Delta (Delta) pumping facilities, and elevated water temperatures at the spawning grounds. Since 1994, many factors have been addressed, or at least impacts have been reduced, through regulatory and other mechanisms (*e.g.,* reduced harvest impacts, Iron Mountain Mine clean up, Anderson-Colusa Irrigation District fish ladder, screening of water diversions, altered CVP water operations that improve passage and reduce predation, and construction of a temperature control device on Shasta Dam, *etc*.). The last status review described numerous threats to this ESU, but chief among them was that it was comprised of only one population which was very small and wholly dependent on artificially-created spawning and rearing conditions (*i.e.,* cold water releases below Shasta Dam). New information relating to each of these five listing factors is discussed below, including discussion of important conservation efforts being made to protect the species, where appropriate.

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

Blockage of historical habitat by Shasta and Keswick dams

Loss of historic spawning and rearing habitat for this ESU remains a major threat as Shasta and Keswick dams completely displace the naturally-spawning population to the mainstem Sacramento River downstream of the two dams. As required in 2009 NMFS Biological Opinion and Conference Opinion on the Long-term Operation of the CVP and SWP (CVP/SWP biological opinion), the Bureau of Reclamation (Reclamation) along with NMFS, the California Department of Water Resources (DWR), CDFW, and USFWS have taken a number of steps towards reducing this threat and re-introduce SR winter-run Chinook salmon into the McCloud River, including: (1) formation of the Interagency Fish Passage Steering Committee in 2010 to provide technical, management, and policy direction for the fish passage program; and (2) evaluation of salmonid spawning and rearing habitat above Shasta Dam in 2013. Currently Reclamation is leading the development of a fish passage pilot plan which is scheduled to be completed in 2016, with implementation beginning in 2017. NMFS regulatory work, including having an experimental population designation rule in place, is scheduled to be completed by the fall of 2016. Implementation of the 3-year pilot plan is scheduled to be completed in 2019. Reintroduction is expected to be a long-term program with no specific completion date.

Hydroelectric development on Battle Creek

Hydrological development has eliminated approximately 48 miles of potential habitat in Battle Creek. The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) 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 6 miles of tributary habitat will be opened up to anadromous salmonids and will allow for successful reintroduction of the SR winter-run Chinook salmon ESU. The BCSSRP began in 2010 with the removal of Wildcat Diversion Dam and it is nearing its final implementation phase with completion expected by 2020, depending on funding. DWR contributed a total of $12 million of discretionary funds in 2011 and 2012 for restoration Phase 1B and Phase 2 as required in the CVP/SWP biological opinion. A reintroduction plan is currently being written and is scheduled to be completed in August 2016. Implementation of the reintroduction plan will begin soon after, when a lead agency is identified and funding has been secured. Completion for the reintroduction is dependent on the rate of successful colonization.

Warm water releases from Shasta Dam

The SR winter-run Chinook salmon population is artificially maintained through cold water releases in the summer from the reservoir behind Shasta and Keswick dams in order to provide spawning and rearing habitat below the two dams. Reclamation has struggled to maintain an adequate cold water pool in critically dry years and extended drought periods in order to maintain suitable temperatures for winter-run Chinook salmon egg incubation, fry emergence, and juvenile rearing in the Sacramento River. Through the CVP/SWP biological opinion, Reclamation has created and implemented improved Shasta Reservoir storage plans and year-round Keswick Dam release schedules and procedures to provide cold water for spawning and rearing since 2010.

However, the threat of warm water releases from Shasta Dam still remains a significant stressor to winter-run Chinook salmon, especially given the recent extended drought in California from 2012 through 2015. Warm water releases from Shasta Reservoir in 2014 and 2015 contributed to 5.6% and 4.2% egg-to-fry survival rates to RBDD in 2014 and 2015, respectively. Under varying hydrologic conditions from 2002 to 2013, winter-run Chinook salmon egg-to-fry survival ranged from three to nearly 10 times higher than in 2014 and 2015. Measures taken to reduce this threat and improve Shasta Reservoir cold water pool management have been to: (1) relax Wilkins Slough navigational flow requirements; (2) relax D-1641 Delta water quality requirements; (3) delay Sacramento River Settlement Contractor depletions, and transfer a volume of their water in the fall rather than increase depletions throughout the summer; (4) target slightly warmer temperatures during the SR winter-run Chinook salmon holding period (before spawning occurs); (5) replace the Spring Creek temperature control curtain in Whiskeytown Reservoir in 2011 (installation of the Oak Bottom temperature control curtain in Whiskeytown Reservoir is scheduled to be completed in 2016); and (6) install the Shasta Dam temperature control device curtain in 2015. Other efforts to reduce the threat of warm water releases from Shasta Dam include improving reservoir, meteorologic, and hydrologic modeling and monitoring in order to most efficiently manage the reservoir's limited amount of cold water, installation of additional temperature monitoring stations in the upper Sacramento River to better monitor real-time water temperatures, and enhanced redd, egg, and juvenile SR winter-run Chinook salmon monitoring.

Juvenile and adult passage constraints at Red Bluff Diversion Dam (RBDD)
The RBDD on the Sacramento River impeded both upstream migration of adult fish to spawning habitat and downstream migration of juveniles. Since 2012, the gates at RBDD have been open year-round to allow unimpeded upstream and downstream fish passage, as required through the CVP/SWP biological opinion and as part of $113 million American Recovery and Reinvestment Act funded fish passage improvement project by the Tehama Colusa Canal Authority. The completion of this project to allow unimpeded fish passage has eliminated this threat.

Loss of rearing habitat
Urban and agriculture development along with levee construction and channelization for flood control, and water delivery operations have resulted in reduced rearing habitat, migration corridors, and food web production for juvenile winter-run Chinook salmon in the Sacramento River Basin and Delta. To mitigate some of these effects, the CVP/SWP biological opinion contains actions for improving 17,000 to 20,000 acres of floodplain and tidal marsh habitat that is favorable for juvenile salmon rearing in the Lower Sacramento River and Delta. Planning for restoration began in 2011. Lead agencies and partners are undergoing National Environmental Policy Act/California Environmental Quality Act alternative formulation and analysis for environmental planning and permitting. Restoration actions are scheduled to be completed by 2023.

The state and federal public water agencies required to mitigate the ecological impacts of the CVP and SWP in the Delta are largely helping to fund the $300 million California EcoRestore initiative introduced in 2015 to help coordinate and advance at least 30,000 acres of habitat restoration in the Delta in the next 4 years. A broad range of habitat restoration projects will be pursued, including projects to address aquatic, sub-tidal, tidal, riparian, floodplain, and upland ecosystem needs. Twenty four projects have been tracked by California EcoRestore that are in various stages of development from conceptual to complete. Funding for habitat enhancements unassociated with mitigation will come primarily from Propositions 1 and 1E, the AB 32 Greenhouse Gas Reduction Fund, and local, federal, and private investment.

The Central Valley Project Improvement Act (CVPIA) has funded several habitat restoration projects from 2010 to 2015 to benefit SR winter-run Chinook salmon, including a side channel rehabilitation at Painter's Riffle in 2014. Reclamation has also identified six floodplain and side channel enhancement projects that will create approximately 37 acres of new or re-established floodplain and side channel habitat between RM 300.5 (*i.e.,* 1.5 miles downstream of Keswick Dam) and RBDD (RM 242). In addition, gravel augmentation has occurred along the Upper Sacramento River to increase the availability of spawning and rearing habitat.

Private entities have developed a number of conservation banks along the Sacramento River, in the Delta, and Suisun Marsh over the past 5 years. Together they have created over 1,000 acres of riparian, floodplain, and tidal aquatic habitat to benefit juvenile SR winter-run Chinook salmon. In addition, 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.

Water exports in the southern Delta

A significant effect of CVP and SWP water operations is diversion of out-migrating juveniles from the north Delta tributaries into the interior Delta through the open Delta Cross Channel. Instead of migrating directly to the outer estuary and then to sea, these juveniles are caught in the interior Delta and subjected to pollution, predators, and altered food webs that cause either direct mortality or impaired growth. The CVP/SWP biological opinion mandates additional gate closures beyond those in Water Rights Order Decision 1641 to minimize these adverse effects to winter-run. Additionally, since 2010, DWR, Reclamation, USGS, NMFS, and USFWS have been investigating various engineering solutions to prevent emigrating salmonids from entering Georgiana Slough and into the interior Delta. Installation of barriers at Georgiana Slough are expected to be completed by 2022.

In addition, the continued pumping and diversion of water from the CVP and SWP export facilities in the south Delta causes reverse flows, leading to loss of juveniles migrating out from the Sacramento River system in the interior Delta and more juveniles being exposed to the State and Federal pumps, where they are salvaged at the facilities. In order to reduce the number of juveniles exposed to the interior Delta and reduce mortality from entrainment and salvage at the export facilities, the CVP/SWP biological opinion limits Old and Middle River flow levels, curtails exports when protected fish are observed near the export facilities, and improved fish screening and salvage operations. Furthermore, through the CVP/SWP biological opinion there has been enhanced real time fish monitoring, development of an enhanced particle tracking modeling, and formation of the Collaborative Science and Adaptive Management Program to better understand fish presence and distribution in the Delta, Delta hydrologic conditions, and CVP and SWP water operations impacts to ESA species in the Delta.

Also, in 2015 the state of California introduced the California WaterFix (CWF), an initiative to modernize the state's aging water delivery system through a water conveyance system that would include new points of water 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. An analysis of the effects of CWF on winter-run Chinook salmon has not been completed yet. The U.S. Bureau of Reclamation, which is the lead agency for the CWF, is completing a biological assessment on the effects of the CWF on SR winter-run Chinook salmon and other listed species, and NMFS is planning on preparing a biological opinion on those effects once the biological assessment is completed.

Entrainment in a large number of unscreened or poorly screened water diversions
In order to reduce entrainment of juvenile winter-run Chinook salmon from unscreened water diversions, the CVP/SWP biological opinion requires that Reclamation shall screen priority diversions as identified in the CVPIA Anadromous Fish Screen Program (AFSP). Since 2010, the 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 (cfs). The larger diversions over 150 cfs in size on the mainstem Sacramento River have already been screened or are currently proposed for screening. However, there are many small- and moderate-sized unscreened diversions (up to 150 cfs) on the Sacramento River. The AFSP and Ecosystem Restoration Program 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.

Water operations can create false attraction cues that cause adult SR winter-run Chinook salmon to deviate from the mainstem Sacramento River migration corridor and become stranded in agricultural fields behind flood bypass weirs. SR winter-run Chinook salmon have been observed to navigate up the Colusa Basin Drain (CBD) into various agricultural diversions and drainages (USBR and DWR 2012). Once they enter the CBD, there is no upstream route for the fish to return to the Sacramento, so they eventually perish and are lost from production. In 2013, over 600 stranded adult SR winter-run Chinook salmon and Central Valley spring-run Chinook salmon were observed. Seining and trapping efforts transferred 47 of the SR winter-run Chinook salmon to LSNFH for spawning. An estimated 319 SR winter-run Chinook salmon died in the Colusa Basin canals (Killam *et al*. 2014). In 2015, a picket weir was installed at the Knights Landing Outfall Gates to block adult upstream migrating SR winter-run Chinook salmon from potentially straying into the CBD. In 2016, Reclamation District 108 is proposing to construct a new permanent Wallace Weir in the Yolo Bypass to block upstream migrating SR winter-run Chinook salmon from potentially straying into the CBD, and a fish collection facility to return the adult fish back to the Sacramento River.

Water Quality
In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism. Chronic or sublethal effects lessen organism survival over an extended period of time due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. Since the last status review, the overall status trends show improvements to water quality in the Sacramento River and Delta from discharges of agricultural operations, urban, suburban areas, mining, and industrial sites. Emphasis on wastewater treatment plant upgrades,

development and implementation of total maximum daily load programs (TMDLs)[4], and adoption of new water quality standards (i.e., Basin Plans) have all aided in protecting and contributing to a healthy functioning aquatic ecosystem. In the Sacramento River and Delta, TMDL values have been approved for cadmium, copper, zinc, diazinon, and chlorpyrifos, which have been helpful in improving water quality. In addition, TMDLs are in development for organochlorine, mercury, pesticides, and selenium (SWRCB 2015). In recent years, NOAA scientists have investigated and consulted on the direct and indirect effects of pesticides on individual ESA listed species, the foodwebs on which they depend, and at the population level. New testing methods, reasonable and prudent alternatives (*i.e*., buffer requirements and no-spray zones), and programs, such as regulating the discharge from agricultural lands, have been developed to begin minimizing impacts of pesticides.

Despite improvements to water quality in the Sacramento River and Delta, water quality pollution remains a threat for the conservation and recovery of SR winter-run Chinook salmon and their habitat. Many potentially harmful chemicals and contaminants of emerging concern (pharmaceuticals) have yet to be addressed. 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, thereby improving water quality for ESA listed species and the ecosystem on which the species depend.

Conclusion

As discussed above, there are promising habitat restoration, fish passage programs, and other projects being implemented and evaluated that, if successful, would greatly expand SR winter-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 SR winter-run Chinook salmon ESU viability.

While some conservation measures have been successful in improving habitat conditions for the SR winter-run Chinook salmon ESU since it was listed in 1989, 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 SR winter-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 SR winter-run Chinook salmon ESU.

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[4] The maximum amount of pollutants that a body of water can receive while still meeting water quality standards.

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

Ocean Harvest Impacts
SR winter-run Chinook salmon have a more southerly ocean distribution relative to other California Chinook salmon stocks, and are primarily impacted by fisheries south of Point Arena, California. SR winter-run Chinook salmon age-3 ocean fishery impact rate estimates for the region south of Point Arena (an approximation of the exploitation rate) are currently available for 2000–2013, and have remained relatively stable over this time period, averaging 16% (Figure 4). Fisheries in 2008 and 2009 were closed south of Point Arena owing to the collapse of the Sacramento River fall-run Chinook salmon stock and insufficient data (*i.e.*, insufficient coded-wire tag recoveries) exist for estimating a SR winter-run Chinook salmon impact rate in 2010. If years 2008-2010 are omitted, the average age-3 impact rate is 19% (PFMC 2015).

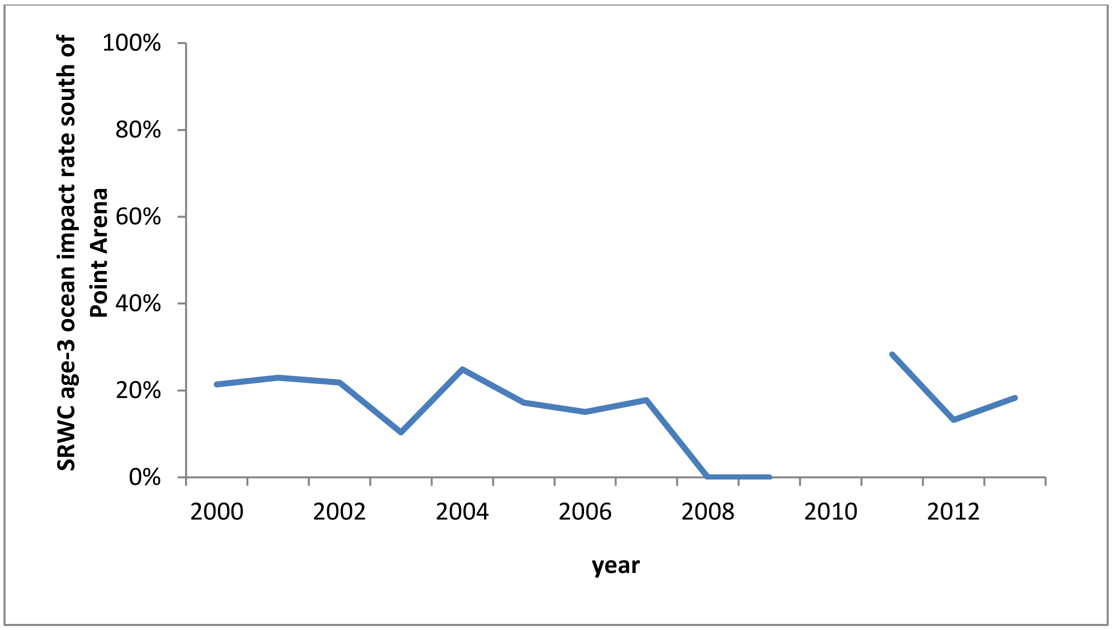

Figure 4. Sacramento River winter-run Chinook salmon age-3 ocean impact rate south of Point Arena for years 2000–2013. Estimates are sourced from PFMC (2015). The impact rate could not be estimated in 2010 due to insufficient coded-wire tag recoveries.

There have been several layers of ocean salmon fishery regulations implemented to protect SR winter-run Chinook salmon beginning in the early 1990s. For example, a substantial portion of the SR winter-run Chinook salmon ocean harvest impacts used to occur in February and March recreational fisheries south of Point Arena, but fisheries at that time of the year have been closed since the early 2000s. O'Farrell and Satterthwaite (2015) hindcasted SR winter-run Chinook salmon age-3 ocean impact rates back to 1978, extending the impact rate time series beyond the range of years where direct estimation is possible (2000-2013). Their results suggest that there were substantial reductions in ocean impact rates prior to 2000 and that the highest impact rates occurred in a period between the mid-1980s and late-1990s.

One component of the Reasonable and Prudent Alternative (RPA) from the 2010 Pacific Salmon Fishery Management Plan Biological Opinion (NMFS 2010) specified that new fishery management objectives must be established. The implementation of the RPA resulted in the development of a harvest control rule which was first used for ocean fishery management in 2012. That harvest control rule specifies the age-3 ocean impact rate limit based on the geometric mean number of spawners from the previous 3 years (Figure 5). The limits to the impact rate imposed by the harvest control rule is an additional control on ocean fisheries which still includes previously existing constraints on fishery opening and closing dates and minimum size limits south of Point Arena. From 2012 to 2015, the SR winter-run Chinook salmon harvest control rule has specified maximum allowable forecast impact rates ranging from 12.9% to 19.0%.

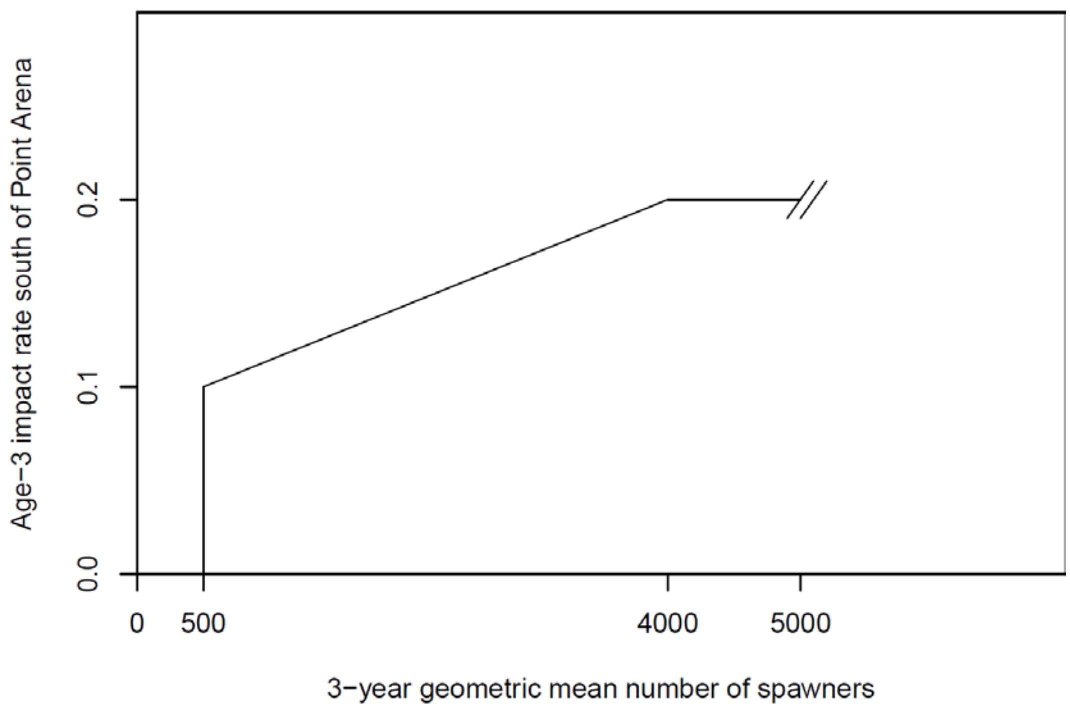

Figure 5. Current SR winter-run Chinook salmon harvest control rule (NMFS 2010). There is no explicit cap on the age-3 impact rate if the three-year geometric mean number of spawners exceeds 5000.

In summary, the available information indicates that, with the exception of 2008-2010 when the ocean salmon fishery was closed or heavily restricted, the level of SR winter-run Chinook salmon fishery impacts has not changed appreciably since the 2010 salmon and steelhead viability assessment (Williams *et al*. 2011), yet there have been additional ocean fishery regulations implemented with the purpose of reducing exploitation of SR winter-run Chinook salmon when average population size is reduced.

Freshwater Angling Impacts

What little SR winter-run Chinook salmon freshwater harvest that existed historically was essentially eliminated beginning in 2002, when Sacramento Basin Chinook salmon fishery season openings were adjusted so that there would be little temporal overlap with the SR winter-run Chinook salmon spawning migration and spawning period. However, early arriving fish may still be harvested prior to January 1. Additionally, higher densities of fish in this portion of the river may lead to higher early harvest rates. Higher densities of fish, particularly below dams, likely create opportunities for both illegal poaching of salmon and the inadvertent or intentional snagging of fish. In addition, the upper Sacramento River supports substantial angling pressure for rainbow trout. Rainbow trout fishers tend to concentrate in locations and at times where winter-run Chinook are actively spawning (and therefore concentrated and more susceptible to impacts). By law, any SR winter-run Chinook salmon inadvertently hooked in this section of river must be released without removing it from the water, however, SR winter-run Chinook salmon are impacted as a result of disturbance and the process of hook-and-release. Also, because the taking of salmon is permitted after August 1, some late spawning winter-run Chinook salmon may be taken.

Scientific Research

For over two decades, research and monitoring activities conducted on SR winter-run Chinook salmon have provided resource managers with a wealth of important and useful information regarding the populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, and coded wire, passive integrated transponder (PIT), and acoustic tagging efforts have increased the knowledge of abundance by providing information on migration timing and survival. By issuing research authorizations, NMFS has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions to sustain populations, mitigate adverse impacts on SR winter-run Chinook salmon, and implement recovery efforts. The resulting information has improved our knowledge of the respective species' life histories, specific biological requirements, genetic make-up, migration timing, responses to human activities (positive and negative), and survival in the rivers and ocean. And that information, as a whole, is critical to the species' recovery.

Over the last five years, the detrimental effects (*i.e.* slight reductions in juvenile and adult abundance and productivity) on SR winter-run Chinook salmon from scientific research has been minimal and have no appreciable effect on the species' diversity or structure. Moreover, the actions have provided lasting benefits for the ESU and all habitat effects have been negligible.

Conclusion

Because regulatory mechanisms designed to minimize the impacts of ocean harvest, freshwater angling, and scientific research on SR winter-run Chinook salmon are in place, it is highly unlikely that overutilization has been a key factor limiting this ESU over the last five years.

2.3.2.3 Disease or predation

Disease

Naturally-occurring pathogens pose a greater threat to this ESU than other Central Valley

Chinook salmon runs since it is comprised of only a single population and its abundance is very low. As the population abundance continues to be low or possibly even decline further the probability increases that disease outbreak could significantly impact the remaining wild population. Artificially-propagated Chinook salmon have been impacted by disease outbreaks at some Central Valley hatcheries and therefore potential disease outbreaks at the LSNFH could pose a risk to wild fish. Infection hematopoietic necrosis virus (IHNV) is commonly detected in 51-81% of SR winter-run Chinook salmon returning to LSNFH and *Renibacterium salmoninarum*, the causative bacterium for bacterial kidney disease (BKD), can be detected in SR winter-run Chinook salmon adults at low levels of infection (*i.e.*, 3-30%) (HSRG 2014).

Despite efforts to increase the number of SR winter-run Chinook salmon used for broodstock during 2015, pathologists from the California-Nevada Health Laboratory noted a dramatic decline in health, and an increase in the prevalence and severity of fish pathogens in the adults collected at Keswick Dam (Voss and True 2015). Poorer water quality, and possibly concentration of fish pathogens in the Sacramento River and Shasta Reservoir contributed to multiple infections in adult SR winter-run Chinook salmon with compromised immune systems and decreased stamina, leading to a higher occurrence of pre-spawn mortality. In 2015, pre-spawn mortality was 27% compared to 16% in 2014 and pre-spawn mortality levels generally below 20% in previous years. No single clear cut infectious process appeared to be causing the overall elevated mortality. Rather, a mix of bacterial pathogens in adults that contributed individually, or in multiple concurrent infections, to mortality despite antibiotic therapies that should have reduced the growth of these bacterial pathogens.

A pilot sentinel trial was conducted by the USFWS California-Nevada Fish Health Center in late September 2015 to assess potential disease risk to wild SR winter-run Chinook salmon fry (Foott 2016). Sentinel late-fall Chinook salmon, exposed to the Sacramento River for 5 days in late September at Balls Ferry and Red Bluff, were highly infectious with *Ceratonova shasta*. The level of infectivity was sufficient to cause disease and mortality. Eighty juvenile SR winter-run Chinook salmon were collected at the RBDD rotary screw trap between October 15 – November 19, 2015, and sampled for histological examination. *C. shasta* were observed in 15% of the sample set. These infections were largely at an early stage, indicating a recent exposure to the parasite. Fry had reared for weeks in locations with little to no *C.shasta* infectivity. These observations do not support a significant role for *C.shasta* infection in the low egg to fry estimates generated from the RBDD trap data in 2015. However, the disease could have impaired survival of out-migrant SR winter-run Chinook salmon fry in 2015 as *C.shasta* is a progressive disease and the early stage infections could go to a disease state over time. Future disease surveys for the upper Sacramento River and their impact on SR winter-run Chinook salmon are being proposed for 2016.

<u>*Predation*</u>
Predation is an ongoing threat to this ESU throughout the Sacramento River and Delta where there are high densities of non-native (*i.e.*, striped bass, small-mouth bass, and largemouth bass) and native species (*e.g.*, pikeminnow, rainbow trout) that prey on juvenile salmon. In the ocean, and even the Delta environment, salmon are common prey for harbor seals and sea lions,

although the impacts on SR winter-run Chinook salmon are unknown. The presence of man-made structures, including water diversions, in the Sacramento River and Delta contribute to increased predation levels by altering the predator-prey dynamics that favor predatory species (Michel personal communication 2015). In addition, the altered hydrology of the Delta due to CVP and SWP water project operations has created favorable conditions for non-native predators (*e.g.*, decreased salinity, decreased turbidity, increased water clarity, *etc*.). While the available data analyses have generated valuable information regarding aspects of the predation process in the Delta, they do not provide unambiguous and comprehensive estimates of fish predation rates on juvenile salmon nor on population-level effects for SR winter-run Chinook salmon in the Delta (Grossman *et al*. 2013).

Since 2010, steps have been taken to reduce juvenile SR winter-run Chinook salmon predation in the CVP and SWP fish collection facilities in the southern Delta, including studies on the use of electric barriers, carbon dioxide, netting, aquatic weed control, electrofishing, a fishing incentive program, construction of a fishing pier, refurbishment of the fish salvage release site, and the expected completion of two additional release sites in 2017. In 2011, CDFW proposed to modify striped bass sport fishing regulations to allow additional harvest in an effort to reduce striped bass predation on the listed species in the Delta, however the California Fish and Game rejected the proposed changes. In the Sacramento River, removing the gates at the RBDD year-round since 2012 has minimized the impacts of predation at the dam. In addition, numerous studies have been conducted and are currently being in the Central Valley to understand the effects of predation on salmonid populations, including SR winter-run Chinook salmon. Based on preliminary results of acoustic telemetry studies of LSNFH SR winter-run Chinook salmon from 2013 to 2015, survival rates to the ocean varied from 5% to 12% with lowest survival occurring in the middle Sacramento River every year (Ammann personal communication 2015). It is assumed that much of this mortality experienced by these fish is likely due to an increase in predators, exposure time, or the metabolic rate for predators (*i.e.*, due to warmer water temperatures).

Conclusion

Disease and predation are persistent problems that can adversely affect SR winter-run Chinook salmon. New information from the USFWS and the LSNFH indicates that the threat of disease may have increased in severity since the last status review due to the low flows and high temperature in Sacramento River from drought conditions. And although there have been actions to understand and reduce predation, it is unclear whether these action have substantially decreased the overall level of predation throughout the Sacramento River and Delta.

2.3.2.4 Inadequacy of existing regulatory mechanisms

Laws relevant to the protection and restoration of SR winter-run Chinook salmon include the ESA, the Magnuson-Stevens Fishery Conservation and Management Act, the CVPIA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Clean Water Act, the National Environmental Policy Act, and numerous State laws administered by CDFW, DWR, or the SWRCB. These laws and associated regulations generally provide adequate mechanisms for recovering winter-run Chinook salmon (52 FR 6041, 6046; February 27, 1987); however some of the goals of these existing mechanisms have not yet been achieved.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Artificial Propagation Programs

Captive broodstock and conservation hatchery programs were established for the SR winter-run Chinook salmon ESU in the early 1990s. These programs were established to augment the naturally-spawning population in the Sacramento River as well as to provide a captive broodstock in case the natural population was unexpectedly decimated. The captive broodstock program was discontinued in 2007 based on the increased and sustained abundance of the natural spawning population.

Strict guidelines have been in place for the number of hatchery fish that can be spawned together with naturally-spawning fish at LSNFH; however, the genetic integrity of the natural population is still threatened from having passed through several population bottlenecks in the 1990s when the population numbered less than 200 individuals. Unlike typical production-oriented hatchery programs, the SR winter-run Chinook salmon conservation program at LSNFH does not have a fixed annual target for juvenile production. Rather, production levels are dictated by the number of broodstock that are collected and spawned annually, which is dependent upon the estimated upriver escapement of SR winter-run Chinook salmon. The broodstock collection limit is 15% of the estimated upriver escapement, with an upper limit of 120 broodstock per brood year (*i.e.*, when run sizes >800). To maintain genetic diversity in the event of very low abundance, no less than 20 SR winter-run Chinook salmon adults are collected for broodstock regardless of run size. The typical annual production level anticipated when broodstock collections are maximized is approximately 250,000 smolts. Along with adhering to these strict guidelines, several innovative propagation techniques and genetic markers have been developed to guide what is considered a very successful conservation program.

However, since 2012, California has been in the midst of one of the most severe droughts on record and SR winter-run Chinook salmon are experiencing the consequences of low water storage and a limited volume of cold water in Shasta Reservoir. In response to the drought impacts, USFWS, NMFS, and CDFW decided in 2015 to reinitiate a SR winter-run Chinook salmon Captive Broodstock Program. Together with the Conservation Hatchery Program, the SR winter-run Chinook salmon Captive Broodstock Program is expected to increase the security of the SR winter-run Chinook salmon ESU by rearing a captive population in a safe and secure environment, to be available for use as hatchery broodstock in the event of a catastrophic decline in the abundance of winter-run Chinook salmon spawners in the Sacramento River. Furthermore, the Captive Broodstock Program will potentially be used to re-establish SR winter-run Chinook salmon to native habitats upstream of Shasta Dam and to Battle Creek and potentially for research purposes.

Another recent change in operations at LSNFH is the expansion of normal winter-run Chinook salmon propagation activities for the conservation program, an emergency action that was initially implemented in 2014 to partially mitigate for the continuing drought and its effects on naturally spawning SR winter-run Chinook salmon in the Sacramento River. This multi-agency decision was based on forecasts of precipitation and reservoir storage levels that provided a clearer picture of environmental conditions that would be present in the Sacramento River during SR winter-run Chinook salmon spawning, egg incubation and juvenile rearing. Elevated water temperatures in the upper Sacramento River during the summer and fall of 2014 resulted in extremely low survival of naturally-produced SR winter-run Chinook salmon eggs and fry. Increased broodstock collection during 2014 allowed for the release of approximately 612,000 juvenile SR winter-run Chinook salmon, almost three times the normal production, in order to make up for the anticipated substantial losses in natural production. A similar approach was attempted for 2015, however LSNFH staff have clearly noted a decline in health, and increase in prevalence and severity of fish pathogens in the adults collected at LSNFH during the past 2 years of the most extreme drought conditions. This occurrence has significantly increased the level of pre-spawn mortality at LSNFH, reducing the potential for increased production.

This effort to increase hatchery production during 2014 and 2015 was in response to prolonged drought conditions, and should be discontinued with improving environmental conditions and increased in-river survival. Although this provides a near-term benefit through an overall increase in abundance, broodstock management will be extremely important in subsequent years to ensure that the large proportion of returning adult hatchery-origin winter-run Chinook salmon do not negatively affect the genetic integrity (through domestication selection, *etc.*) of the natural population.

Species Identification for Regulatory Purposes

Determining survival through the Delta, entrainment losses at the Delta export pumps, the proportion of fish that enter the interior Delta, and eventual survival to the ocean, all depend on accurate means of identification and the ability to discriminate SR winter-run Chinook salmon from other Central Valley Chinook salmon races. Currently, monitoring and identification of juvenile SR winter-run Chinook salmon is based on a modified length-at-date growth curve developed was developed for the Delta, however, the growth curves are not adjusted annually for differences in emergence timing or poor rearing conditions. As a result, there is overlap between the individual salmon races.

Since 2010, a couple of studies have found the use of genetic identification as a more accurate and improved way of identifying Central Valley Chinook salmon race and estimation of population size. Harvey and Stroble (2013) compared genetic identification versus length-at-date race assignments of juvenile Chinook salmon salvaged from the CVP and SWP pumping operations in the south Delta. Pyper *et al*. (2013) estimated juvenile Chinook salmon abundance by run assignment using genetic markers for catch in midwater trawling at the confluence of the Sacramento and San Joaquin rivers near Chipps Island. Both studies found SR winter-run Chinook salmon DNA assignments had the closest fit to their expected length-at-date range, with only a few fish overlapping the adjacent late-fall run and spring-run Chinook salmon ranges. However, relatively large numbers of fall, late-fall, and spring-run Chinook salmon overlapped with the SR winter-run Chinook salmon length criteria. Consequently, use of DNA assignments provided much more accurate, and reduced, annual estimates of run composition for SR winter-run Chinook salmon, which were one half to one sixth of the run compositions based on length-at-date criteria across years at the both the salvage facilities and at Chipps Island. These studies show that genetic tools have the potential to improve estimation of population sizes and corresponding take of SR winter-run Chinook salmon.

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, in turn, to 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. 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 air temperature rises. However, the magnitude and timing of these and other changes, and specific effects on individual salmon and steelhead ESUs/DPSs, remain unclear.

Drought Conditions

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 drought conditions experienced over the last 4 years were the most extreme in the past 500 or perhaps more than 1,000 years. Anomalously-high surface temperatures have made this a “hot drought,” in which high surface air temperatures substantially amplified annual water deficits during the period of below average precipitation.

The SR winter-run Chinook salmon ESU is highly vulnerable to drought conditions. The combination of low precipitation and high temperatures results in less cold water available in the Shasta reservoir to control instream water temperatures downstream in the Sacramento River. The resulting increased in-river water temperature resulting from such drought conditions reduces the availability of suitable holding, spawning, and rearing conditions in the Sacramento River. 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 56°F daily average temperature limit in SR winter-run Chinook salmon spawning areas contributed to 5.6% and 4.2% egg-to-fry survival rates to RBDD in 2014 and 2015, respectively.

Ocean Conditions

Much of the northeast Pacific Ocean, including parts typically used by SR winter-run Chinook salmon, experienced exceptionally high upper ocean temperatures beginning early in 2014 and areas of extremely high ocean temperatures continue to cover most of the northeast Pacific Ocean. 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 ocean temperatures became anomalously warm in spring 2014, and this warming spread to the Central California coast in July 2014. In fall 2014, a shift in wind and ocean current patterns caused the entire northeast Pacific domain to experience unusually warm upper ocean temperatures from the West Coast offshore for several hundred kilometers. In spring 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 ocean temperatures, while the exceptionally high temperature waters remained offshore and in coastal regions to the south and north.

Adult SR winter-run Chinook salmon returns for WY 2016 and for the next 2 to 3 years (depending on ocean residence times, maturing in 2015, 2016, 2017 and 2018) have likely been negatively impacted by poor stream and ocean conditions. The 2015/16 tropical El Niño favored a more coastally-oriented warming of the Northeast Pacific Ocean over the fall and winter that persisted into spring 2016. Ocean migrants from brood year 2015 will likely encounter an ocean strongly influenced by (if not dominated by) a subtropical food-web that favors poor early marine survival for SR winter-run Chinook salmon (O'Farrell and Mantua, unpublished analysis in prep).

Multiple dry years in a row could potentially devastate this ESU. While SR winter-run Chinook salmon have historically been able to withstand droughts, the currently diminished habitat, 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 SR winter-run Chinook salmon are likely much more vulnerable to drought today than they were historically. Prolonged drought andshifts in the timing and/or amount of snowmelt runoff could easily render most existing SR winter-run Chinook salmon habitat unsuitable due to elevated water temperatures.

2.4 Synthesis

The SR winter-run Chinook salmon ESU was first listed as threatened in 1989 and then reclassified as endangered in 1994. The ESU consists of only one naturally-spawning population that spawns in the upper Sacramento River. Critical habitat includes the entire mainstem Sacramento River (including riparian habitat along the bank) from Keswick Dam downstream to and including the Delta. There is no new information indicating the ESU boundary should be changed; however, if a new population is established in Battle Creek or if the ESU is reintroduced above Shasta Dam, the existing ESU boundary will need to be reexamined.

The Central Valley Technical Recovery Team delineated four historical independent populations of this ESU. The spawning areas for three of these historical populations are above the impassable Keswick and Shasta dams, while the fourth population (Battle Creek) is presently unsuitable for SR winter-run Chinook salmon due to high summer water temperatures. Lindley *et al*. (2007) developed viability criteria for Central Valley salmonids and, using data through 2004, found that the mainstem Sacramento River population was at low risk of extinction (see Table 5), but that the ESU as a whole remained at a high risk of extinction because there is only one naturally-spawning population, and it is not within its historical range.

The 2010 status review concluded that the SR winter-run Chinook salmon ESU's poor status had not changed from previous assessments. The ESU's status has declined since the 2010 status review, with the single spawning population on the mainstem Sacramento River no longer at a low risk of extinction (Table 9). New information indicates an increased extinction risk to SR winter-run Chinook salmon. The larger influence of the hatchery broodstock in addition to the rate of decline in abundance over the past decade has placed the population at a moderate risk of extinction.

Table 9. Extinction risk summary for the Sacramento River winter-run Chinook salmon population by criteria described in Lindley *et al*. (2007) for the 2010 and 2015 review periods. Overall risk to the population is determined by the highest risk score for any criterion.

	2010 Status Review	2015 Status Review
Population Size	Low risk	Low risk
Population Decline	Low risk	Moderate risk
Catastrophe, rate and effect	Low risk	Low risk
Hatchery Influence	Low risk	Moderate risk

Many of the factors originally identified as being responsible for the decline of this ESU are still present, though in some cases they have been reduced by regulatory actions (*e.g*., NMFS CVP/SWP biological opinion in 2009, an ocean harvest biological opinion in 2010, and actions implemented under the CVPIA). Despite efforts to reduce these and other threats (*e.g*., controlling water temperatures with cold water releases, annual spawning gravel augmentation, stabilizing mainstem flows, unimpeded fish passage at RBDD, harvest restrictions, and reduction in Delta export pumping), the ESU has continued to decline in abundance. Harvest-related impacts have generally remained the same as they were prior to the ocean fishery closures in 2008 and 2009 and a significantly limited fishery in 2010. Similarly, impacts from predation have generally remained unchanged since the last status review. In contrast, impacts from factors such as drought, diseases, and poor survival conditions have increased since the last status review and most likely have contributed substantially to the declining abundance of the ESU.

SR winter-run Chinook salmon abundance has declined during recent periods of unfavorable ocean conditions (2005-06), and droughts (2007-09) and are expected to continue to be low due to drought conditions in 2012-15. The low adult returns in 2011 created a potential increase in vulnerability to a year class, yet the progeny from this cohort had relatively high survival resulting in positive cohort replacement rate (3.5) from this numerically weak brood (Azat 2014).

Poor early life stage survival during the consecutive drought conditions (2012-2015) coupled with potential poor ocean conditions and hatchery production practices may further impact SR winter-run Chinook salmon survival-to-adulthood and risk of extinction. Temperature conditions during egg development and fry emergence were suboptimal over the duration of SR winter-run Chinook salmon rearing in 2014 and 2015 due to reduced cold water in Shasta Reservoir for these life stages. The egg-to-fry survival estimate at RBDD for brood years 2014 and 2015 were 5.6% and 4.2%, respectively, which are significantly lower than the average of 26.4% (coefficient of variation = 37.9%) for brood years 2002-2012 measured at RBDD (Poytress *et al*. 2014). Potential impacts to these cohorts would be observed in viability criteria once adults return in 2015 and onward.

The SR winter-run Chinook salmon ESU is likely at a lower extinction risk with a sustainable LSNFH population and naturally-spawning population than it would be with just a single naturally-spawning population, at least in the near term. Yet, reliance on production from LSNFH and potential introgression between natural-origin SR winter-run Chinook salmon is increasing (Figure 2). In an attempt to prevent the loss of SR winter-run Chinook salmon cohorts during the 2013-2015 droughts, a greater number of spawners were brought into the LSNFH as broodstock (Figure 1). The LSNFH also produced and released three times as many juveniles in 2014. Thus, it reasons that in years where mortality of natural-origin fish may be particularly high and LSNFH production is significantly increased, the contribution of LSNFH-origin fish to the returning adult spawners may elevate the overall risk of extinction of SR winter-run Chinook salmon due to genetic impacts from LSNFH. Potential impacts would manifest in viability criteria evaluations in escapement years 2016 and onward, unless hatchery introgression is minimized through active adult management on the spawning grounds.

In summary, the most recent biological information suggests that the extinction risk of this ESU has increased since the last status review largely due to extreme drought and poor ocean conditions. The best available information on the biological status of the ESU and new threats to the ESU indicate that its ESA classification as an endangered species is appropriate and should be maintained. Long-term recovery of this ESU will require improved freshwater habitat conditions, abatement of a wide range of threats, and the establishment of additional spawning areas in Battle Creek and the McCloud River.

3.0 RESULTS

3.1 Classification Recommendation

Based on a review of the best available information, NMFS recommends that the SR winter-run Chinook salmon ESU remain listed as an endangered species.

3.2 ESU Boundary and Hatchery Stocks

Available genetic and other information supports the current boundary of this ESU and, therefore, NMFS recommends no changes in the ESU boundary. As described in Section 2.1.4, we recommend revising the ESU listing to include the Captive Broodstock Program once it is established in 2017, in addition to the Conservation Hatchery Program, as part of the listed SR winter-run Chinook ESU.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Re-establish SR winter run Chinook salmon in Battle Creek and the McCloud River to their historical spawning and rearing habitats to reduce the risk of extinction of species from lost resiliency and increased vulnerability to catastrophic events.

- Improve management of Shasta Reservoir coldwater storage in order to provide suitable habitat temperatures for SR winter-run Chinook salmon spawning, egg incubation, fry emergence and juvenile rearing in the Sacramento River.

- Restore floodplain habitat in the Yolo Bypass for SR winter-run Chinook salmon to improve juvenile rearing and provide fish passage in the Yolo Bypass to reduce migratory delays and loss from straying into agricultural diversions.

- Continue partnership and support of the Collaborative Adaptive Management Team (CAMT) and the Salmon Scoping Team (SST); installation of barriers at Georgiana Slough and other key junctions; improve enhanced particle tracking modeling; and real-time salmon monitoring and water export management in the Delta.

- Alter project operations to return the Sacramento River and Delta to more ecologically functional flow regimes and restore habitat to create an ecosystem more conducive for native fish populations and reduce the presence of exotic species.

- Enhance SR winter-run Chinook salmon monitoring in order to reduce uncertainty in life-stage impacts and assist in management. Specific recommendations include incorporating genetic run identification for species identification, bolstering estimates of juvenile abundance and cohort strength across their life history, integrating fish survival and behavioral data with water quality monitoring, and developing and collecting data for life history diversity, fish condition, and vital rates at multiple locations.

- Develop and implement quantitative modeling tools that link water project operations, temperature management, and habitat restoration actions to SR winter-run Chinook salmon population dynamics to improve our ability to make science-informed management decisions.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW
CALIFORNIA CENTRAL VALLEY DOMAIN
Sacramento River Winter-run Chinook Salmon ESU

Current Classification: Endangered

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

REGIONAL OFFICE APPROVAL:

Approve: Maria Rea Date: 12-12-16

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