UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
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Endangered Species Act Section 7(a)(2) Biological Opinion for the Issuance of an ESA Section 10(a)(1)(A) Enhancement Permit to the United States Fish and Wildlife Service for Implementation of two Hatchery and Genetic Management Plans at Livingston Stone National Fish Hatchery

National Marine Fisheries Service Consultation Number: WCR-2016-4012

Action Agencies: National Marine Fisheries Service

Affected Species and Determinations:

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

*Please refer to Section 2.11 for the analysis of species or critical habitat that are not likely to be adversely affected.

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

Issued By: Maria Rea for Barry A. Thom
Regional Administrator

Date: 9-27-2017

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1. INTRODUCTION

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

The Proposed Action is funded by the United States Bureau of Reclamation (BOR) and is carried out by the United States Fish and Wildlife Service (USFWS). The USFWS proposes to operate two hatchery programs at the Livingston Stone National Fish Hatchery (LSNFH) which release Sacramento River (SR) winter-run Chinook salmon into the Sacramento River basin and may eventually result in the release of fish into Battle Creek for reintroduction purposes (Table 1).

The Winter Chinook Integrated-Recovery Supplementation Program (IRSP), as described in Section 1.6 of the Hatchery Genetic Management Plan (HGMP) (USFWS 2016b), propagates winter-run Chinook salmon that are managed to be integrated with the natural population in the Upper Sacramento River and are intended to provide a demographic enhancement to aid in the resilience, rebuilding and recovery of that population.

The Winter Chinook Captive Broodstock Program (CBP) is conducted by withholding from release a portion of the juveniles produced annually in the IRSP and rearing them to maturity at LSNFH. Thus, winter-run Chinook salmon captive broodstock are sourced from a program that is operated with an integrated-recovery strategy.

Table 1. The Proposed Action, including program operator and funding agency.

Hatchery and Genetics Management Plan	Program Operator	Funding Agency
Sacramento River winter-run Chinook salmon Integrated-Recovery Supplementation Program (USFWS 2016b)	USFWS	BOR and USFWS
Sacramento River winter-run Chinook salmon Captive Broodstock Program (USFWS 2016a)	USFWS	BOR and USFWS

*The U.S. Bureau of Reclamation (BOR) is the primary funding agency. The LSNFH is part of the Coleman Complex and was built to partially mitigate for the construction and operation of Shasta Dam.

1.1. Background

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

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

The opinion, incidental take statement, and EFH consultation are in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review. The project files for both consultations are held at the California Central Valley Office (CCVO) of NMFS in Sacramento, California.

In 1990, SR winter-run Chinook salmon in California were listed as threatened under the ESA by NMFS (55 FR 46515). This listing was re-classified in 1994, when the status of SR winter-run Chinook salmon was changed to endangered (59 FR 440). In 1988, prior to the listing, NMFS and USFWS agreed to develop a winter-run Chinook salmon hatchery propagation program at the Coleman National Fish Hatchery (CNFH) as part of a ten-point cooperative agreement to restore winter-run Chinook salmon in the Upper Sacramento River.

On June 29, 1990, USFWS submitted an ESA Section 10(a)(1)(A) Permit application to NMFS requesting take of ESA-listed SR winter-run Chinook salmon for various research activities. Among the research activities proposed in the application was a captive propagation program for SR winter-run Chinook salmon at the CNFH. On August 18, 1991, NMFS issued Permit 747 to USFWS for authorization to take ESA-listed SR winter-run Chinook salmon for the CNFH captive propagation program through December 31, 1995. Permit 747 allowed USFWS a direct take of a limited number of adult, ESA-listed, SR winter-run Chinook salmon broodstock each year at the Keswick Dam Fish Trap (KDFT) and the Red Bluff Diversion Dam (RBDD) fish trap.

On February 14, 1994, NMFS issued a non-jeopardy ESA Section 7 opinion (NMFS 1994) for: 1) Modification of Permit 747 authorizing take of adult and juvenile, ESA-listed, SR winter-run Chinook salmon associated with the artificial propagation and captive broodstock programs at CNFH from January 1, 1994 through December 31, 1995; and 2) non-winter-run Chinook salmon artificial propagation programs at CNFH from January 1, 1994, through December 31, 1995. Permit 747 was subsequently amended three times to extend the expiration date of the permit to January 31, 1997.

In 1996, USFWS instituted a voluntary moratorium on the collection of ESA- listed adult SR winter-run Chinook salmon because detailed genetic analyses conducted by Dr. Dennis Hedgecock of the University of California, Davis (UCD) indicated that some hybridization with spring-run Chinook salmon may have occurred during 1993-1995 due to misidentification of broodstock based on phenotypic characteristics. Another reason for the voluntary moratorium was that returning adult winter-run Chinook salmon produced by the program were returning to Battle Creek, the tributary to the Sacramento River where CNFH is sited, rather than to the spawning grounds in the mainstem Sacramento River. This indicated that juvenile winter-run Chinook salmon reared in raceways at CNFH were imprinting on Battle Creek rather than the mainstem Sacramento River.

On January 31, 1997, NMFS issued Section 10(a)(1)(A) Permit 1027 to the USFWS for the Sacramento River winter-run Chinook salmon artificial propagation and captive broodstock programs. However, due to the suspected hybridization and imprinting issues at CNFH, the collection of ESA-listed adults for use as broodstock was not authorized under Permit 1027.

According to Permit 1027, when a USFWS proposed genetic testing protocol has been reviewed and approved by NMFS and a mainstem Sacramento River hatchery facility has been acquired, tested with non-winter-run Chinook salmon, and approved by NMFS, the collection of ESA-listed adult fish for broodstock may be authorized by an amendment to Permit 1027.

The IRSP and CBP are closely allied; genetic material for the CBP is obtained from fish used in the supplemental propagation program to prevent severe in-breeding. For this reason, the CBP could not exist without the supplemental propagation program as a source of gametes. As a result of the close linkage of the two programs and the self-imposed moratorium on the capture of wild winter-run Chinook salmon due to the imprinting issues and the questions concerning the genetic integrity of the adults used in the program, the CBP was placed in jeopardy. Immediate action was required to prevent collapse of both programs and the potential loss or degradation of this species genetic integrity.

On November 21, 1997, USFWS and BOR issued a Final Environmental Assessment (EA) titled, *Establishment of a winter-run Chinook Salmon Supplemental Spawning and Rearing Facility using Sacramento River Water*. The EA addressed options for implementation of a supplemental spawning and rearing facility and identified potential locations for the proposed facility on the mainstem Sacramento River. A facility on the right bank of the Sacramento River at the base of Shasta Dam was chosen as the preferred alternative. After receiving the appropriate authorizations, a new mainstem incubation and rearing facility, later named LSNFH, was constructed at the base of Shasta Dam (dedicated on February 5, 1998) to rectify the imprinting problem.

On February 20, 1998, USFWS requested that trapping of adult winter-run Chinook salmon from the mainstem Sacramento River be reauthorized under Section 10(a)(1)(A) Permit 1027. This request was contingent on improvements to both imprinting and genetics. The request was supplemented with supporting information that provided documentation of the significant progress made in addressing these concerns and further justification for allowing reauthorization of broodstock collection. Construction of the new mainstem spawning and rearing facility (LSNFH) and evaluation of a genetic analysis technique demonstrating the tool's ability to accurately identify winter-run Chinook salmon, thus reducing the potential risks to the genetic integrity of the population, contributed to the eventual reauthorization of this program. On March 13, 1998, NMFS completed an opinion for the issuance of Amendment 1 to Permit 1027, which approved both the new genetic testing measures and the new mainstem rearing facility, authorizing the resumption of ESA-listed adult winter-run Chinook salmon broodstock collection. Permit 1027 expired on July 31, 2001.

Prior to the expiration of Permit 1027, on June 13, 2001, NMFS received a biological assessment (BA) submitted by the USFWS for incidental take of ESA-listed species during artificial propagation programs at CNFH and LSNFH. The document was intended to provide a single, comprehensive source of information to describe and assess incidental impacts of current or proposed operations of CNFH and LSNFH on ESA-listed Central Valley populations of anadromous salmonids, the southern distinct population segment (SDPS) of North American green sturgeon and Southern Resident Killer Whales.

Given that hatchery propagation activities at LSNFH involve the direct take of ESA-listed species, on March 5, 2003, USFWS submitted a request to renew Section 10(a)(1)(A) Permit 1027 for take of SR winter-run Chinook salmon. The permit application consisted of the USFWS 2001 BA for Artificial Propagation at CNFH and LSNFH, including updated and supplemental information. The supplemental information incorporated changes to the winter-run Chinook salmon IRSP that had occurred since submittal of the 2001 BA, a description of the release group study conducted to evaluate the efficacy of the Winter Chinook Captive Broodstock Program, and the Fish Health Management Protocol for LSNFH.

Although Section 10(a)(1)(A) Permit 1027 expired on July 31, 2001, USFWS continued hatchery propagation activities at LSNFH under interim coverage as provided by Regulation Number 50 CFR 222.304, which allows for the continuation of activities as authorized by the expired permit until the renewal application is acted upon. Due to the important and necessary role played by LSNFH in enhancing and recovering the endangered population of SR winter-run Chinook salmon, hatchery operations were allowed to continue, contingent upon adherence to the Terms and Conditions required by Permit 1027. USFWS was required to notify NMFS of any potential deviations from the requirements mandated by Permit 1027.

Captive Broodstock Program

In 1991, after the winter-run Chinook salmon adult run size had fallen to a record low of 191 fish, an ad hoc Captive Broodstock Committee was formed by volunteers from commercial and sport-fishing organizations, representatives from the University of California and Steinhart Aquarium, and representatives from USFWS, NMFS, and the California Department of Fish and Game (CDFG), to discuss options for developing a captive broodstock program that would help prevent the extinction of the species. Following approval from NMFS, up to 1,000 juvenile winter-run Chinook salmon produced as part of the artificial propagation program at CNFH were transferred annually to the Bodega Bay Marine Laboratory for extended rearing to adulthood from 1991 through 1995. A portion of the fish held at Bodega Bay Marine Laboratory were subsequently transferred to Steinhart Aquarium.

The CBP for SR winter-run Chinook salmon was previously conducted from 1991 to 2007. That program was discontinued in 2007, based on the increased and sustained abundance of the natural spawning population. The Winter Chinook CBP was reinitiated in 2015, as a result of a mutual decision by USFWS, NMFS, and the California Department of Fish and Wildlife (CDFW). The decision to reinitiate the program was made, in part, to respond to threats to the winter-run Chinook salmon population caused by the continuation of extreme drought. Additionally, the program is anticipated to play a role as a potential source of winter-run Chinook salmon to be used for planned range expansion projects. Together with the IRSP, the Winter Chinook CBP 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 multiple potential uses, as mentioned above. Operated to achieve these purposes, the CBP may be used to achieve two Priority 1 Recovery Actions, as identified in the Final Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014):

1) “Develop and implement a program to reintroduce winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to historic habitats upstream of Shasta Dam. The program should include feasibility studies, habitat evaluations, fish passage design studies, and pilot reintroduction phase prior to implementation of the long-term reintroduction program.”

2) “Develop and implement a winter-run Chinook salmon reintroduction plan to re-colonize historic habitats made accessible by the Battle Creek Salmon and Steelhead Restoration Project.”

With the potential to benefit multiple projects, it will be necessary to determine how winter-run Chinook salmon captive broodstock and their progeny will be allocated amongst projects. Decisions regarding the apportioning of captive broodstock and their progeny towards each of these efforts has not yet been determined, but will be determined jointly by the USFWS, NMFS, and CDFW based on the merit of each competing need. This opinion and the associated Section 10(a)(1)(A) Permit will only authorize the propagation of winter-run Chinook salmon for the CBP and maintenance of those fish at LSNFH, including the possible release of excess Captive Broodstock adults and/or their progeny in order to “jumpstart” reintroduction efforts in North Fork Battle Creek. Release of excess Captive Broodstock or their resulting progeny is the preferred strategy over allowing these fish to intentionally senesce (*i.e*., die naturally without spawning) in the hatchery, given the presence of only a single population and extinction risk of the ESU.

Release of fish originating from the CBP specifically associated with implementation of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan (ICF International 2016) or the Shasta Dam Fish Passage Evaluation (BOR 2016) project, or for purposes not discussed here, will be permitted separately and the effects associated with those releases will be analyzed in separate opinions. These projects are still under development and the specific actions, numbers of fish needed, and potential impacts have all yet to be determined.

1.2. Consultation History

From 2001-2013, the USFWS continued hatchery operations at LSNFH following to the terms and conditions outlined in expired Permit 1027. On July 10, 2013, USFWS provided their initial submission of an HGMP and associated Section 10(a)(1)(A) Permit application (*i.e.* request for renewal of Permit 1027) for hatchery activities at LSNFH.

On March 5, 2014, USFWS requested a modification to the Annual Adult Winter Chinook Broodstock Trapping Plan in response to ongoing drought conditions in California’s Central Valley and the anticipation of water temperatures becoming unfavorable for successful natural spawning of winter-run Chinook salmon in the Sacramento River below Keswick Dam. Specifically, the principal difference in planned propagation activities reflected the desire to substantially increase the number of winter-run Chinook salmon broodstock that would be collected and spawned at LSNFH for the 2014 spawning season. The planned expansion of winter-run Chinook salmon propagation activities was intended to partially mitigate for the ongoing drought, and was based on the anticipation of poor condition (high water temperatures, low flows) for naturally spawning winter-run Chinook salmon in the Sacramento River. Given the urgency of the proposed modifications, NMFS committed to address the actions taken by the USFWS after-the-fact in a Section 7 Consultation associated with the renewal of Permit 1027.

On August 18, 2014, NMFS suggested additional language to be incorporated into the HGMP and Section 10(a)(1)(A) Permit application previously submitted by USFWS. Specifically, information was lacking regarding potential winter-run Chinook salmon reintroduction efforts and the role that LSNFH would play during these efforts. In order to ensure that the HGMP laid out both the current and future uses of winter-run Chinook salmon propagated at LSNFH, some general language regarding potential reintroduction efforts should be included. On August 27, 2014, USFWS approved the suggested language and incorporated it into both the HGMP and Section 10(a)(1)(A) Permit application.

On February 5, 2015, USFWS provided their proposed plan for collecting winter-run Chinook salmon broodstock in 2015. The proposed strategy for collecting winter-run Chinook salmon broodstock in 2015 differed from standard protocols at LSNFH. The principal difference in broodstock collection activities planned for 2015 reflected the desire to begin collecting winter-run Chinook salmon broodstock according to established protocols, but to maintain the flexibility to substantially increase collection targets, if warranted, based on continuance of severe drought conditions. Expansion of winter-run Chinook salmon propagation activities in 2015, would re-initiate an emergency action implemented in 2014 to partially mitigate for the continuing severe drought and its effects on natural spawning winter-run Chinook salmon in the Sacramento River.

On February 26, 2015, NMFS completed its review of the HGMP for hatchery activities at LSNFH submitted by USFWS on July 10, 2013, and provided comments to be addressed by USFWS.

On October 7, 2015, USFWS submitted two signed HGMPS, pursuant to the issuance of a Section 10(a)(1)(A) Permit authorizing hatchery activities at LSNFH. The HGMPs describe the operation of the Winter Chinook IRSP and the recently reinstated Winter Chinook CBP. After preliminary review, NMFS notified USFWS that the HGMPs and Section 10(a)(1)(A) Permit application should be formally submitted.

On January 20, 2016, USFWS formally submitted a cover letter and two HGMPs associated with the conservation hatchery programs at LSNFH. These documents, together with the online permit application (File #16477), constitute an application for a Section 10(a)(1)(A) permit authorizing direct take associated with the hatchery programs at LSNFH.

On February 25, 2016, NMFS provided a letter advising the USFWS that the submitted HGMPs were determined to be sufficient for consideration under Section 10(a)(1)(A) of the ESA. HGMPs submitted for NMFS review are "sufficient" when: (1) the purpose of the hatchery program is described in meaningful and measurable terms, (2) available scientific information is included, (3) the proposed action (*i.e.*, hatchery program) is clearly described, (4) effects on ESA-listed species are analyzed, and (5) preliminary review suggests that the HGMP has addressed ESA criteria such that public review will be meaningful.

On August 22, 2016, NMFS published a Notice of Receipt in the *Federal Register* asking for public comment on the Section 10(a)(1)(A) Permit Application and the associated HGMPs (81 FR 56603). The public was given 30 days to comment on the permit application and associated HGMPs. The public comment period ended on September 21, 2016, and no comments were received.

This opinion is based on a series of documents submitted to NMFS by the USFWS. A complete record of this consultation is on file with the Central Valley Office in Sacramento, California. On January 20, 2016, the USFWS submitted two HGMPs and requested initiation of formal consultation under Section 7 of the ESA to "authorize direct take of listed species" through the issuance of a Section 10(a)(1)(A) Enhancement Permit (USFWS 2016a, 2016b). The HGMPs described the Proposed Action and the potential effects of the action on SR winter-run Chinook salmon, Central Valley (CV) spring-run Chinook salmon, and California Central Valley (CCV) steelhead.

NMFS completed its review of the HGMP and determined it sufficient for formal consultation on February 24, 2016 (NMFS 2016c). Subsequently, and during formal ESA consultation, NMFS received additional information and analysis, comments and proposals from the USFWS.

The USFWS requested that the consultation be effective for up to ten years so that research, monitoring, and evaluation (RM&E) included in the HGMP can provide meaningful results and inform future management decisions. The temporal scope of NMFS's effects analysis must be long enough to make a meaningful determination of effects, and thus the analysis in this opinion is not limited to a ten-year period. However, given the USFWS request, in addition to the standard regulatory reinitiation triggers, reinitiation will be required if implementation of the Proposed Action is to continue beyond December 31, 2027.

1.3. Proposed Action

"Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg *et al.* 2004). In this specific case, the Proposed Action is described in the January 20, 2016, HGMPs (USFWS 2016a, 2016b) determined sufficient for formal consultation.

The Proposed Action involves the operation of two hatchery programs that produce ESA-listed SR winter-run Chinook salmon. Broodstock is sourced from naturally produced SR winter-run Chinook salmon. Duration of the Proposed Action is approximately ten years. LSNFH was constructed by BOR in 1997 for the explicit purpose of propagating ESA-listed SR winter-run

Chinook salmon. Hatchery propagated winter-run Chinook salmon are managed to be integrated with the natural population in the Upper Sacramento River and are intended to provide a demographic enhancement to aid in the resilience, rebuilding and recovery of that population.

The overarching goal of the hatchery programs at LSNFH is Preservation/Conservation of the SR winter-run Chinook ESU. Winter-run Chinook salmon are propagated at LSNFH to conserve the genetic resources of a single fish population at low abundance and endangered of extinction. A potential complementary goal of the winter Chinook salmon program is restoration. When the need arises, this goal will be achieved by providing a source of winter-run Chinook salmon to re-establish naturally spawning populations in historical habitats. Reintroductions contribute to preservation and conservation by improving spatial structure, productivity, diversity, and abundance of the SR winter-run Chinook salmon ESU, thereby reducing the likelihood of extinction.

1.3.1. Describing the Proposed Action

Proposed hatchery broodstock collection:

<u>Broodstock origin and number</u>: The Proposed Action is derived from SR winter-run Chinook salmon collected at the KDFT or the Anderson Cottonwood Irrigation District (ACID) Dam (Figure 1). Unlike typical production-oriented hatchery programs, the IRSP does not have a fixed annual target for juvenile production. Prior to 2014, the broodstock collection target was limited to a maximum of 15 percent of the estimated upriver escapement, with an upper limit of 120 broodstock (60 pairs) per brood year (*i.e.*, when run sizes >800).

In emergency situations, such as the extreme drought that was experienced during the summer of 2014 and 2015, production of winter-run Chinook salmon may be increased above the standard production levels indicated above to partially mitigate for extremely poor conditions faced by naturally spawning winter-run Chinook salmon in the Sacramento River. The temporary expansion of winter-run Chinook salmon propagation activities during the 2014-2015 season was intended to partially mitigate for the effects of drought, and was based on the anticipation of temperatures unfavorable for successful natural spawning in the Sacramento River. Should similar situations arise in the future, potential expansion of program goals will be determined collaboratively by USFWS, NMFS, and CDFW and will be based on factors such as expected adult escapement, expected environmental conditions, expected juvenile survival, and the number of tagged juveniles available for fishery assessments.

Annual production may also be increased when contributing to reintroduction efforts, such as those that will soon be underway in Battle Creek. Again, in these situations, potential expansion of program goals will be determined collaboratively by USFWS, NMFS, and CDFW as described in the final Battle Creek Winter-Run Chinook Salmon Reintroduction Plan (ICF International 2016) and consulted upon separately.

As a result of increased hatchery production and poor in-river spawning success during 2014 and 2015, the USFWS expects that the spawning escapement for 2017 and 2018 will be comprised of a majority of hatchery-origin fish. In order to account for the increased proportion of hatchery-origin adults expected to return to LSNFH, the principal differences in broodstock collection activities planned for 2017 and 2018 include the following three changes: (1) USFWS proposes to temporarily abandon the guidelines that dictate variable program size and instead target 60 female broodstock to produce a hatchery release of approximately 200,000 pre-smolts; (2) increase the number of male broodstock to 120 to increase the effective size of the hatchery component of the winter-run Chinook salmon population, and; (3) use hatchery-origin fish, to the extent necessary, to achieve the broodstock collection targets. Through implementation of these temporary changes, USFWS intends to bolster abundance and maintain diversity within the depleted winter-run Chinook salmon population. Further, these changes allow the hatchery programs at LSNFH to respond and adapt to the effects that extreme drought has had on the winter-run Chinook salmon population during recent years.

The Winter Chinook CBP is conducted by withholding from release a portion (up to 1,035 individuals) of the juveniles produced annually in the IRSP and rearing them to maturity at the LSNFH. During years when Captive Broodstock are in excess of the hatchery program needs, adult Captive Broodstock (or their resulting progeny) may be released into North Fork Battle Creek in an effort to "jumpstart" the reintroduction of winter-run Chinook salmon. Release of excess Captive Broodstock or their resulting progeny is the preferred strategy over allowing these fish to intentionally senesce (*i.e*., die naturally without spawning) in the hatchery, given the presence of only a single population and extinction risk of the ESU.

Proportion of natural-origin fish in the broodstock (pNOB): Since the inception of the IRSP in the early-1990s, most broodstock have been natural-origin. Prior to 2010, broodstock collection targets allowed up to 10 percent of the broodstock to be of hatchery-origin. Beginning in 2011, a decision was made to use only naturally produced winter-run Chinook salmon as broodstock to reduce the potential for harmful genetic effects due to domestication. From 2011 to 2013 only natural-origin fish were used as broodstock, and this will be standard protocol at the LSNFH under normal operating conditions.

This practice was temporarily modified in 2014 and 2015, when the IRSP was substantially increased in size (*i.e.*, release of approximately 610,000 juveniles) to mitigate for continued extreme drought in California. In order to obtain sufficient broodstock to increase the size of the program, it was necessary to spawn hatchery-origin winter-run Chinook salmon as broodstock. In the future, when the program is operated at standard production levels, USFWS will again strive to exclude hatchery-origin fish from being used as broodstock, however; it is anticipated that there may be a need to consider exceptions to this strategy during some years. For example, it is expected that the spawning escapement during 2017 and 2018 will be comprised of a majority of hatchery-origin fish as a result of increased hatchery production and poor in-river spawning success in 2014 and 2015.

Because fish in the CBP are sourced from juveniles produced in the IRSP, the proportion of natural-origin fish used as broodstock will be zero. However, a large proportion of the parents that produce the fish in the CBP are of natural-origin. Captive broodstock fish will only be used to supplement the natural population of winter-run Chinook salmon in emergency situations and will otherwise be used for experimental purposes, such as reintroduction efforts.

Broodstock selection: Selection of winter-run Chinook salmon broodstock is accomplished by screening collected adults using several diagnostic criteria developed to reliably discriminate SR winter-run Chinook salmon from non-target stocks. To be selected as hatchery broodstock, an adult salmon must have an intact adipose fin (indicating it is of natural origin), satisfy phenotypic criteria (run and spawn timing, location of capture, physical appearance indicators), and meet stringent genetic criteria (based on 96 single nucleotide polymorphism (SNP) markers that provide a high-level of discrimination from other stocks). In combination, the phenotypic and genetic criteria used to select winter-run Chinook salmon broodstock provide an accurate and precise discriminatory tool. Jacks are incorporated as hatchery broodstock at their rate of collection.

Production levels for the Winter Chinook CBP are dictated by the number of juveniles that are retained from releases from the IRSP. Beginning in 2015 (brood year 2014), 1,035 winter-run Chinook salmon juveniles were withheld from the IRSP release group. These fish will be reared to maturity at the LSNFH as Captive Broodstock. Currently, USFWS expects that approximately 1,000 fish will be withheld from future brood years; however, the number of juveniles entered into the CBP will be re-considered on an annual basis by the USFWS, NMFS, and CDFW. Considerations in determining the actual number of juveniles to enter into the CBP annually are the ability to achieve the multiple program objectives while balancing the negative effects that result from removing winter-run Chinook salmon from the IRSP release groups. Based on previous performance of the Winter Chinook CBP, USFWS anticipates at least 50 percent of the fishes retained as Captive Broodstock survive to sexual maturity, thereby producing approximately 500 mature winter-run Chinook salmon adults per brood year.

Method and location for collecting broodstock: Adult winter-run Chinook salmon broodstock are collected from the Sacramento River at a fish trap constructed onto the face of the Keswick Dam and a supplemental collection facility at the ACID Dam.

The KDFT and associated structures are located in the center of the dam between the powerhouse and the spillway. Broodstock collection facilities consist of a twelve-step fish ladder, a brail-lift, and a 1,000-gallon fish-tank elevator. The top of the ladder leads to a fyke weir. After passing through the fyke weir, adult fish are contained in a large fiberglass brail enclosure. When the brail is raised, fish are directed into a 1,000-gallon elevator which transports them up the face of the dam to a fish distribution vehicle. Fish are then trucked a short distance to LSNFH, where they will be screened (phenotypic and genotypic) for use as broodstock.

Operation of the KDFT varies seasonally and between years, depending on broodstock needs and the numbers of fish volunteering into the trap. The trap entrance is opened to collect fish during the day and closed at night. This diurnal operation strategy was developed to exclude predacious river otters from entering the trap at night. When the number of fish entering the trap is high, trapping may be further restricted during daylight hours to preclude the over-collection of broodstock. The KDFT is generally emptied twice per week during the period of winter Chinook broodstock collection. Emptying of the trap typically occurs on Tuesdays and Fridays. Therefore, the maximum duration any fish could be confined within the trap is four days. For example, if the trap is emptied on a Friday then it would generally be emptied again the following Tuesday, for a maximum duration of four days. Incidental impacts to non-target stocks of Chinook salmon are reduced by installing a fish counter at the entrance of the KDFT. The fish counter automatically closes the trap door at a pre-determined count; thereby limiting the numbers of fish allowed to enter the trap and prevents overcrowding.

USFWS desires that broodstock retained for the IRSP be representative of the SR winter-run Chinook salmon population, with a preference towards naturally produced winter-run Chinook salmon to reduce the effects of domestication selection. However, due to the KDFT being located at the terminus of winter-run Chinook salmon spawning habitat, a large component of the population may not reach the trapping location, and therefore, would not have the opportunity to be selected for broodstock. To lessen this concern, USFWS has partnered with CDFW and ACID to develop an additional broodstock collection facility at the ACID Dam in Redding. The ACID Trap will serve as a secondary trapping facility for collecting winter-run Chinook salmon broodstock. The location of this facility benefits from being centrally located to the natural spawning population in the Upper Sacramento River. Additionally, the ACID Trap benefits in that it has been designed to be staffed continuously during operation, which will potentially reduce effects of confinement and handling compared to the KDFT. Collection of broodstock at the ACID Dam began during 2015.

The ACID fish trap is located in the pool at the upstream section of the north bank fish ladder; a location that had been previously used for video monitoring associated the fish ladder when it was completed in 2001. The fish trap will be staffed continuously by a trained operator while it is being fished. Additional staffing will be available, as necessary, to assist with transporting salmon to LSNFH. To initiate trapping, the operator will close the fyke panels on the upstream side of the fish trap and adjust the downstream fyke panels into a ‘V-shaped’ configuration; the wide opening of the ‘V’ faces the downstream direction and serves to guide fish into the trap whereas the narrow opening of the ‘V’ extends into the trap and prevents fish trapped from exiting. The fyke panels at the upstream end of the trap are closed to block the upstream movement of fish and confine them within the trap. An operator will be present at the trapping site at all times during its operation to prevent overcrowding.

To inspect the trap’s contents or when a fish is observed in the trap, the operator will close and secure the downstream fyke panels. While observing the trap from above, the operator will begin to slowly raise the fish basket slightly from the bottom position by depressing a button on the winch control. If no fishes are observed in the trap, the trap will be lowered to the bottom and the downstream fyke panels will again be opened to resume fishing. If a salmon is observed to be within the trap, the operator will lower a floating mesh lid onto the water’s surface above the fish basket. Then floating mesh lid prevents fish from jumping from the trap. With the lid covering the top of the basket, the operator will continue to raise the basket to the surface of the water. When the rim of the fish basket is above the water’s surface, to a level sufficient to prevent additional inflow of fresh water, the operator will open the valve on the carbon dioxide (CO_2) tank to begin to anaesthetize the fish in the elevated basket. When the fish has calmed to the point where it can be safely handled, the operator will raise the trap to the highest elevation, remove the mesh lid, and inspect the salmon for characteristics of targeted broodstock (*i.e.*, displays phenotypic characteristics of winter Chinook, good physical condition of fish, satisfies targeted sex). If the salmon will be retained for use as hatchery broodstock, the fish will be netted from the elevated basket and transferred to a stock tank, located nearby. Data collection, tagging, and collection of a sample of fin tissue (identical sampling as conducted at the KDFT) may occur either while fish are in the stock tank or later, when fish arrive at the LSNFH. Transfer from the stock tank to the transport truck will occur in a vinyl bag containing an amount of water sufficient to cover the gills.

Fish that are not retained as hatchery broodstock will be dart tagged and returned to the fish basket, and lowered to an elevation such that fresh water is allowed to flow through the basket. When they have the ability to maintain their position in the current and appear to have fully recovered from the effects of anesthesia the upstream fyke panels will be fully opened, thereby allowing the fish to volitionally swim out of the trap in the upstream direction. When the trap is not in operation, the adjustable fyke panels upstream and downstream of the fish basket will be locked in the open position, thereby affording unimpeded passage to fishes through the fish ladder.

Duration of collection: Winter-run Chinook salmon broodstock are collected throughout the period of adult migration into spawning areas in the Upper Sacramento River. Trapping for winter-run Chinook salmon broodstock occurs from approximately mid-February through July. Monthly broodstock collection targets are established to ensure appropriate representation of the complete run timing of SR winter-run Chinook salmon. A schedule of proposed monthly collection targets for broodstock is forecasted prior to the beginning of winter-run Chinook salmon broodstock collection (Table 2). The pre-season collection schedule is determined by allocating the total annual collection goal throughout the total duration of winter-run Chinook salmon migration timing.

Table 2. Example schedule of monthly winter-run Chinook salmon broodstock collection targets.

Month	Percent Distribution	Monthly Target[1]	Cumulative Target
February	16.5	20	20
March	36.0	43	63
April	28.5	34	97
May	8.8	11	108
June	6.8	8	116
July	3.4	4	120
Total	100		120

[1] Monthly target number assumes the standard seasonal collection goal of 120 winter-run Chinook salmon. These targets will be adjusted when targeting up to 60 females and 120 males.

Encounters, sorting and handling, with ESA listed fish, adults and juveniles: The disposition of fishes that are not retained as hatchery broodstock varies. Some fish are transported to the Sacramento River and released on the same day as they are collected from the KDFT. Included in this group are hatchery-origin winter-run Chinook salmon and natural-origin winter-run Chinook salmon not needed to meet monthly collection targets, fish not meeting the hatchery's gender needs, and those with severe injuries that are not likely to contribute to successful spawning in the hatchery. Hatchery-origin non-winter-run Chinook salmon, which generally consist of either late-fall Chinook salmon from the CNFH or spring-run Chinook salmon from the Feather River Hatchery (FRH), are sacrificed for recovery and analysis of the coded-wire tag (CWT). Natural-origin Chinook salmon identified as non-winter Chinook (using genetic analysis), as well as steelhead, are relocated to the Sacramento River. Releases into the Sacramento River occur at one of two sites in Redding, California. The release location used depends on water levels; the boat ramp at the Posse Grounds is used when the ACID Dam is not installed and the boat ramp at Caldwell Park is used when the ACID Dam is installed. Length of time in transit from the LSNFH to the boat ramp in Redding is about an hour.

Since fish in the CBP are sourced from juveniles produced in the IRSP (*i.e*., hatchery-origin winter-run Chinook salmon juveniles produced at LSNFH), there are no encounters with ESA-listed fish associated with this program.

Proposed mating protocols:

Pairing of broodstock for mating is accomplished without consideration of phenotypic characteristics other than synchronous timing of maturation. Broodstock at the LSNFH are examined twice weekly to assess their state of sexual maturity. To accomplish this, fish are crowded into a wedge-shaped containment area using a hinged crowder constructed of vinyl screens. Tricane methanesulfonate (MS-222) is added to anaesthetize the fish so they can be easily handled while being examined for maturity and overall fish health. Sexually mature female salmon are euthanized at the time of spawning. Male salmon may be returned to the tank for extended holding and use in subsequent spawning events.

The selection of mating pairs is informed by a genetic analysis that assesses kinship amongst individuals that are ready for spawning on the same date. Based on the results of the kinship analysis, most-distantly related parent pairs are preferentially mated together, to the extent feasible. This strategy is intended to reduce the potential for mating siblings and closely related fish.

Luteinizing Hormone-Releasing Hormone analogue (LH-RHa) implants are administered, as necessary to synchronize maturation of broodstock. Implants are injected into the dorsal muscle lateral and anterior to the dorsal fin. The LH-RHa implants release 30 percent of their content in the first three days after injection and the remaining hormone over a 20-day period to sustain an effective concentration within the fish.

Sexually mature salmon are removed from the tank, euthanized, and rinsed in fresh water to remove MS-222. Each female is assigned a number and each male is assigned a letter. The caudal artery of ripe females is severed so that blood does not mix into the eggs during spawning. Eggs are removed from the body cavity by making an incision from the vent to the pectoral fin. Expelled eggs are separated into two approximately equal groups; each group is fertilized with semen from a different male forming two half-sibling family groups. For example, when female 1 is spawned with males A and B, "family groups" 1A and 1B are created. After mixing semen and eggs, a tri-glycine buffer is added to extend sperm life and motility. Spawned males are either returned to the holding tank for additional spawning or euthanized, depending on their condition, how many times they've been spawned, and the abundance of alternate males. Males are preferred to be spawned twice (*i.e.*, to fertilize the number of eggs equivalent to a single female); however, males may be spawned a maximum of four times if needed to fertilize available females.

Cryopreserved sperm may be used to fertilize eggs of winter Chinook, if necessary. Excess semen is collected and cryopreserved during years when a sufficient number of males have been collected to meet the hatchery's spawning targets. In the event that male broodstock are in short abundance, cryopreserved semen may be used as a secondary source to semen collected from live males, as necessary, to prevent winter-run Chinook salmon eggs from remaining unfertilized. Spawning with cryopreserved semen is accomplished similarly as to using fresh males. That is, eggs from each female are split into two lots and each egg lot is fertilized using the sperm of a different male. Cryopreserved semen is selected randomly, and no male is used more than 4 times. Viability of cryopreserved semen is highly variable and generally lower than that of fresh semen, with survival from green egg to eye-up ranging from less than one percent to nearly 78 percent. Milt from live males is used preferentially to cryopreserved semen because fertilization success is substantially higher using live males.

Proposed protocols for each release group (annually):

Life stage: Juveniles from the IRSP are reared at the hatchery to the sub-yearling, pre-smolt size. The intent of pre-smolt releases is to balance the objectives of achieving acceptable rates of post-release survival with the desire to expose hatchery-origin fish to some of the same forces of natural selection that are faced by naturally produced winter-run Chinook salmon.

This opinion and the associated Section 10(a)(1)(A) Permit will only authorize the propagation of winter-run Chinook salmon for the CBP and maintenance of those fish at LSNFH, including the possible release of excess Captive Broodstock adults and/or their progeny in order to "jumpstart" reintroduction efforts in North Fork Battle Creek. Release of excess Captive Broodstock or their resulting progeny is the preferred strategy over allowing these fish to intentionally senesce (*i.e*., die naturally without spawning) in the hatchery, given the presence of only a single population and extinction risk of the ESU.

Because the CBP is likely to serve multiple purposes, carried out by various entities, USFWS by way of this Proposed Action, is only requesting authorization for maintenance, operation, and release of excess adults (or resulting juveniles) associated with the CBP at LSNFH. Release of fish originating from the CBP specifically associated with implementation of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan (ICF International 2016) or the Shasta Dam Fish Passage Evaluation (BOR 2016) project will be permitted separately and the effects associated with those releases will be analyzed in separate opinions. These projects are still under development and the specific actions, numbers of fish needed, and potential impacts have all yet to be determined.

Acclimation (Y/N) and duration of acclimation: Winter-run Chinook salmon from the supplementation program are not acclimated prior to their release. Because hatchery produced winter-run Chinook salmon are released near their rearing location (*i.e.*, minimal travel time) and were reared in water that has essentially identical physical (*e.g.*, temperature, turbidity) and chemical (*e.g.*, acidity, dissolved gas concentrations, alkalinity and hardness) characteristics, there is no need to hold them in acclimation pens prior to release.

Volitional release (Y/N): Juvenile winter-run Chinook salmon are transported approximately 11 miles to the release site in two groups using aerated and insulated fish distribution trucks. Transportation to the release site in two groups is done to avoid the catastrophic loss of an entire brood of hatchery fish that could be caused by potential difficulties experienced during transport to the release site (*e.g.*, traffic accident). Transportation to the release site requires less than one hour.

External mark(s): All juvenile winter-run Chinook salmon propagated at the LSNFH are marked prior to release by removing (clipping) the adipose fin.

Internal marks/tags: All juvenile winter-run Chinook salmon produced at LSNFH receive a CWT that is inserted into their snout. Additionally, a portion of the juvenile winter-run Chinook salmon may receive an acoustic tag, which provides real-time information on survival and timing of emigration.

Maximum number released: The typical annual production level anticipated when operating under normal broodstock collection limits is approximately 200,000 pre-smolts. During years when the program is expanded to mitigate for poor in-river conditions or to contribute to reintroduction efforts, hatchery production may increase, perhaps substantially up to 750,000. For example, during the drought-related expansion of 2014 total hatchery releases exceeded 600,000 juvenile winter-run Chinook salmon. The need for program expansion will be determined collaboratively by USFWS, NMFS, and CDFW and will be based on factors such as expected adult escapement, expected environmental conditions, expected juvenile survival, and the number of tagged juveniles available for fishery assessments.

Release location(s): All IRSP fish will be released from LSNFH in the Upper Sacramento River at Caldwell Park (river-mile [RM] 299). If production is increased for contribution to reintroduction efforts or fish are in excess of hatchery program needs, IRSP juveniles or excess CBP adults (or resulting progeny) may also be released into North Fork Battle Creek. The level of increased production will be determined by NMFS, USFWS, and CDFW based on factors including estimates of adult escapement and the number of juveniles likely to be produced given environmental conditions.

Time of release: Releases occur generally in late-January or early February; however, actual release timing may occur outside of this target window in order to time the release to coincide with a flow and turbidity event, which are believed to decrease predation during the period of acclimation and to stimulate emigration from the upper river. Releases of hatchery-origin juveniles are conducted at dusk to reduce the risk of predation while juveniles acclimate to the river.

Fish health certification: The California-Nevada Fish Health Center (CA-NV FHC) conducts fish health inspections to observe for indication that disease is present. A pre-release examination is conducted 30 days prior to the scheduled release. Tissue samples are screened for viral, bacterial, and parasitic fish pathogens. The pre-release examination is conducted using methods described in the American Fisheries Society (AFS) Blue Book and the USFWS Aquatic Animal Health Handbook. The hatchery receives an inspection report that lists the pathogens present, if any.

Proposed adult management:

Anticipated number or range in hatchery fish returns originating from this program: The Winter Chinook IRSP is designed to reduce the potential for genetic divergence of the hatchery- and natural-origin fish and to manage the natural spawning aggregate in the Sacramento River downstream of Keswick Dam as a single integrated population.

Table 3. Estimated number and proportion of juvenile winter-run Chinook salmon produced at LSNFH from 2000 through 2011 contributing to fisheries and returning to spawning areas of the Upper Sacramento River. Data are complete only through 2014.

Brood Year	Release No.	Return No.[1]	% Return
2000	166,206	558	0.336
2001	190,732	390	0.204
2002	164,806	3,326	2.018
2003	152,011	2,226	1.465
2004	148,385	126	0.085
2005	160,273	166	0.104
2006	161,212	481	0.299
2007	71,883	196	0.272
2008	146,211	34	0.023
2009	198,582	1,116	0.562
2010	123,859	411	0.332
2011	194,264	738	0.380

[1]Return data for hatchery-origin winter-run Chinook salmon from the USFWS Hatchery Evaluation Program, Red Bluff, California and the RMPC database (http://www.rmpc.org).

Removal of hatchery-origin fish and the anticipated number of natural-origin fish encountered: Trapping efforts for winter-run Chinook salmon broodstock are frequently adjusted to stay within monthly collection targets. For example, trapping may occur anywhere from seven days a week to only a few hours a week, depending on broodstock needs and the number of fish observed entering the trap. Winter-run Chinook salmon collected in excess of year-to-date collection targets are released back into the Sacramento River in Redding, California, near natural spawning areas.

Appropriate uses for hatchery fish that are removed: Carcasses of winter-run Chinook salmon that are used as broodstock are disposed in a landfill. They cannot be rendered or donated for consumption since they are treated with chemicals.

Are hatchery fish intended to spawn naturally? (Y/N): Fish produced are intended to spawn in the wild and be genetically integrated with the targeted natural population while reducing the potential for negative effects resulting from the propagation program.

Performance standard for pHOS (proportion of naturally spawning fish that are of hatchery-origin): USFWS does not propose a pHOS standard for this program. However, pHOS levels over the last 10 years have consistently been below 30 percent with most years falling under 15 percent (Killam *et al.* 2016). Winter-run Chinook salmon produced at LSNFH are intended to integrate with the natural population.

Performance standard for stray rates into natural spawning areas: There is no stray rate standard proposed for this program. Hatchery produced winter-run Chinook salmon are released in the Upper Sacramento River, which limits straying and increases the likelihood that adults return to spawning grounds in the Upper Sacramento River. Additionally, adults return to the Sacramento River from February through June. Water temperatures suitable for holding and spawning during this time of year are typically only present this time of year in the Upper Sacramento River Basin, which also limits straying. As restoration efforts continue in Battle Creek, some natural straying into this system may occur. Reintroduction of winter-run Chinook salmon into Battle Creek is currently planned (ICF International 2016), therefore any natural straying that occurs would be encouraged.

Proposed research, monitoring, and evaluation:

Adult sampling, purpose, methodology, location, and the number of ESA-listed fish handled:

Winter Chinook Carcass Survey: The two primary purposes of the Winter Chinook Carcass Survey project are to estimate the abundance of winter Chinook salmon spawners and to gather information to assist in the evaluation of the winter-run Chinook salmon propagation program at LSNFH. The estimate of winter-run Chinook salmon abundance is used by the NMFS to develop a Juvenile Production Estimate (JPE), which is used to determine allowable take limits of juvenile winter Chinook salmon at the state and federal pumping facilities in the Sacramento-San Joaquin Delta. Estimates of winter-run Chinook salmon abundance resulting from this project will also be used by the fishery agencies to assess progress towards ESA delisting.

A second objective the Winter Chinook Carcass Survey is to gather information to evaluate the Winter Chinook IRSP at the LSNFH. This project is the primary source of information to assess the propagation program and to recommend refinements to increase benefits leading to restoration of a self-sustaining natural population.

Another benefit of this project is that coded-wire tags recovered on this project are used by a multi-agency team to conduct a cohort reconstruction analysis of SR winter-run Chinook salmon.

This cohort analysis provides the basis for evaluating the effects of ocean harvest upon this endangered species.

The Winter Chinook Carcass Survey is conducted in the Upper Sacramento River from May through August, encompassing the duration of the winter Chinook salmon spawning period. The survey area of this project includes the Upper Sacramento River in Shasta County, extending from Keswick Dam at RM 301 downstream to near Cottonwood Creek (RM 273). The survey is divided into sections, which are chosen as convenient areas for crews to start or stop the daily surveys. In past years, three to four survey sections have been used to cover the entire survey area. Survey sections will be covered on a rotating basis throughout the survey season.

Field sampling procedures and techniques for the Winter Chinook Carcass Survey are described below and further explained in USFWS Annual Reports for this project (see Red Bluff Fish and Wildlife Office web site at http://www.fws.gov/redbluff/default.html). Most of the survey effort is conducted by boat, utilizing from two to five boats per day, each boat having a driver and an observer. Beginning at the downstream boundary of the reach being surveyed, survey teams slowly maneuver the boats upstream while observing for salmon carcasses. Observers from each boat are responsible for surveying along one shoreline out to the middle of the river. Several short stretches of river may be surveyed on foot, as a result of low-water conditions that could be hazardous to boat navigation. Survey effort is intended to sample all areas where salmon carcasses could be located; however, sampling efforts tend to concentrate in areas where carcasses have been shown to collect through previous surveys. Observed carcasses are collected using a gaff or gig. No live fish are collected during this survey. Most collected carcasses are tagged, except those found in an advanced state of decomposition. Fresh carcasses (those with firm flesh and at least one clear eye) are tagged by attaching a small colored plastic ribbon to the upper jaw with a hog ring. The tag color is used to identify the survey period that the carcass was tagged. Similarly colored tags are applied to the lower jaw of slightly decayed, or non-fresh, carcasses. Carcass condition (fresh or non-fresh) is noted during tagging to accommodate the various population estimators. Carcasses found to be severely decayed are enumerated, cut in half, or “chopped”, and disregarded in subsequent surveys. Data and biological samples are collected from non-chopped carcasses, as described below. Following sampling, collected carcasses are returned to a flowing section of the river, near to the location where the carcass was located.

USFWS estimates that take resulting from this project, in the form of minimal disturbances to winter-run Chinook salmon spawners, will potentially affect nearly all of the winter-run Chinook spawners annually. Effects of this disturbance are expected to be negligible, similar to that experienced when a fishing boat passes through a section of river. Disturbances to actively spawning winter-run Chinook salmon are reduced by avoiding areas where active winter-run Chinook spawning is occurring. Additional take in the form of handling dead carcasses of winter-run Chinook salmon spawners will occur to approximately half the spawners. This estimate is based on an average handling rate of approximately 50 percent of the total estimated abundance on the carcass survey. USFWS does not anticipate take of other listed species to result from project activities because they are either not expected to be spawning at that time of this survey and/or they are not known to occur in shallow water habitats of the Upper Sacramento River during the time this survey occurs.

Acoustic tracking of winter Chinook adults collected at the KDFT: This study was developed to help reconcile discordant information resulting from broodstock collections at the KDFT and the Winter Chinook Carcass Survey. The original purpose of this study was to track the movements of winter-run Chinook salmon following their capture at the KDFT and subsequent release into the Sacramento River to elucidate how and when they use various habitat types during pre-spawn staging, spawning, and post-spawn senescence. An additional purpose of this project is to examine incidental impacts associated with trapping winter-run Chinook salmon broodstock at the KDFT. Information resulting from this project will be used to assess possible biases associated with the carcass survey methodology and possible incidental impacts associated with trapping broodstock at the KDFT.

Utilizing the KDFT to collect fish for this study concurrent with collections of winter-run Chinook salmon broodstock requires minimal additional handling and does not necessitate additional anesthetization. Trapped fish are transported to LSNFH in a 3,785 liter fish transport truck for sorting, which occurs in the tank of the transport truck. Fish are anesthetized with CO_2 to subdue their activity. All captured Chinook salmon received one or two dart-type anchor tags, which are placed into their dorsal musculature. Radio/acoustic tags are inserted into the gastric cavity (gastric tagging) of winter-run Chinook salmon. Gastric tagging is used to reduce the stress, physical trauma, and tag loss associated with surgical implantation and external attachment. Two bands of surgical tubing (13 mm) encircle each cylindrical tag, separated by a spacing of approximately 25 millimeters (mm). The surgical tubing provides a non-uniform surface to aid in the prevention of tag regurgitation (Keefer *et al.* 2004). Alternative tags such as JSAT tags may be used instead if deemed necessary.

USFWS anticipates take of up to 50 winter-run Chinook salmon spawners annually. Take will be in the form of handling, necessary to insert tags, and behavioral modifications resulting from the gastric insertion of acoustic tags.

<u>Juvenile sampling, purpose, methodology, location, and the number of ESA-listed fish handled</u>:

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH: The purpose of this study is to determine how water management actions during drought and non-drought years, such as releasing water from reservoirs, influences reach-specific survival of winter-run Chinook salmon. USFWS will integrate these results into a comparison with collaborative Ecosystem Restoration Program (ERP) and Anadromous Fish Restoration Program (AFRP) funded projects of fall- and spring-run Chinook salmon so that all three distinct runs may be compared within the same year, but under potentially drastically different seasonal flow regimes. Differences in flow regimes affect exposure to predators via prey movement rates, predator metabolic demands, and turbidity.

Using a mark-recapture framework to estimate survival, with multiple marking and recapture locations and complete capture histories, we will relate measured survival at reaches to the factors that affect predator exposure – flow, temperature, turbidity, and timing of hatchery releases. Fish will be "marked" with uniquely coded electronic tags and "recaptured" by the receivers. The pattern of recaptures allows estimation of reach-specific survival rates and probabilities of detection at each receiver. Fish are tagged and released so that they are representative of the population being characterized. It is important to note that in using this method, fish are not actually handled when they are recaptured and rereleased; they are simply detected by the acoustic receivers.

Working with study cooperators, USFWS will annually tag and release up to 700 winter-run Chinook salmon smolts raised at LSNFH. An array of over 300 tag-detecting monitors (VR2W, VEMCO Ltd.) will be used to monitor tagged fish during their emigration through the Sacramento River, Delta, San Francisco Bay, and the coastal waters off Point Reyes. To capture cumulative in-river mortality, transects of monitors will be set up in a linear arrays at the base of the Delta, Benicia, and Golden Gate Bridges. Tag detections by acoustic monitors will be analyzed using mark-recapture models to estimate overall and reach-specific survival probabilities. Collected data will be housed in a relational database hosted at the NMFS Southwest Fisheries Science Center laboratory in Santa Cruz and will be available to collaborators via an Open Database Connectivity (ODBC) connection to allow users to remotely access live tables to keep it updated.

USFWS does not expect any mortality to result from this project but cannot completely discount the potential for either direct or indirect mortality; therefore, USFWS requests an allowance of 10 percent mortality (*i.e.*, take) of the total number of fish tagged.

Proposed operation, maintenance, and construction of hatchery facilities:

<u>Water source(s) and quantity for hatchery facilities:</u> The source of water for the LSNFH is Shasta Lake, which is also the source of water for the only population of naturally reproducing winter-run Chinook salmon in the Upper Sacramento River. Water is delivered to the hatchery by a pipe tapped directly into the penstocks of Shasta Dam. To ensure water availability in the event one or more penstocks become inoperable, the facility has the option to draw water off of alternate penstocks. Water from the penstocks is delivered to two gas equilibration columns atop an 18,000-gallon head tank. This head tank supplies the entire facility through a PVC manifold system. Total flow available to the facility is approximately 3,000 gallons per minute (gpm). The water delivery system at the LSNFH is completely automated (*e.g.*, employing computer controlled electronic valves); however, manual overrides, redundancies, and fault securities have been built into the system. In the event of a power outage, a solenoid will trip thus allowing free flow (*i.e.*, approximately 5,000 gpm) to the head tank. The head tank will overflow in this situation, however, the water supply will be uninterrupted and fish production will not be at risk. Any power outages at the Shasta Dam facilities are expected to be of short duration. Since Shasta Dam is the primary electricity generating facility in Northern California electrical grids at the facility are generally restored as a high priority.

Under normal circumstances, water quality at LSNFH is suitable for propagating winter-run Chinook salmon. Suitable water temperature is achieved through operation of various penstocks and the Temperature Control Device (TCD) at Shasta Dam. Turbidity in the hatchery water supply is generally low because most suspended solids settle out of the water column in Lake Shasta reservoir. Suspended sediments are further reduced by filtering water being delivered to eggs and alevins. No water treatment/sterilization by ozonation is required prior to use at LSNFH.

During unusually severe conditions of drought the quality of water available at the LSNFH can be compromised with regard to its suitability for the propagation of winter-run Chinook salmon. For example, brood year 2014 winter-run Chinook salmon at LSNFH were exposed to high loads of very fine suspended sediments and unusually warm and variable water temperatures during the periods of broodstock holding, egg incubation, and juvenile rearing. These conditions contributed to elevated mortality of juvenile Chinook salmon at the hatchery. Ultimately, it became necessary to install a filtration system in the incubation stacks and use water chillers to reduce temperatures and reduce daily temperature variation.

Water diversions meet NMFS screen criteria (Y/N): USFWS anticipates no take of ESA-listed or non-listed salmonids through LSNFH water intakes. LSNFH obtains its water through the penstocks of Shasta Dam, an area inaccessible to ESA-listed fishes.

Permanent or temporary barriers to juvenile or adult fish passage (Y/N): The KDFT is located at the base of Keswick Dam, the upstream limit of anadromy. The adult fish trap at the ACID Dam is manned continuously when in operation. Fish passage occurs through two fish ladders (one on each side of the dam) when the fish trap is not in operation.

Instream structures (Y/N): The ACID seasonally installs and operates a flashboard dam (ACID Dam) to divert water from the Sacramento River in Redding, California. The ACID holds a water right to divert a maximum total of 125,000 acre-feet per year during the period April 1 through October 31 of each year. The ACID Dam is located in a portion of the Sacramento River that provides critically important spawning habitat, particularly for ESA-listed winter-run Chinook salmon. Winter-run Chinook salmon spawn only within the Sacramento River, and the ACID Dam is located near the center of the winter-run Chinook salmon spawning distribution. From 2010 to 2013, approximately 90 percent of winter-run Chinook salmon spawning occurred within 2.5 miles of the ACID Diversion Dam. To facilitate salmonid passage, the ACID Dam has two fish ladders to provide access to upstream habitats; a vertical slot fish ladder is located on the north bank of the Sacramento River at Caldwell Park and a pool-and-chute fish ladder is located on the south bank, near to the intake of the ACID canal.

In 2014 USFWS received funding from the Drought Response Implementation Plan Grant Program through CDFW to complete the design, construction, and installation of a fish trap at the ACID Dam. A new fish trapping facility at the ACID was recognized as an important tool for implementing emergency actions related to the management of winter-run Chinook salmon during continuing conditions of extreme drought in California's Central Valley. With funding secured, the Service was able to expedite the design, construction and installation of the ACID Fish Trap, which were largely completed by March 2015. The ACID fish trap is located in the pool at the upstream section of the north bank fish ladder; a location that had been previously used for video monitoring associated the fish ladder when it was completed in 2001.

Streambank armoring or alterations (Y/N): The Proposed Action does not involve any alterations or armoring of the streambank.

Pollutant discharge and location(s): Water used for winter-run Chinook salmon production at LSNFH is returned to Keswick Reservoir just below Shasta Dam. Water discharged from LSNFH is regulated by a National Pollution Discharge Elimination System (NPDES) permit issued by the California Regional Water Quality Control Board (RWQCB); (http://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/general_orders/r5-2014-0161.pdf).

Negative impacts to natural-origin salmonid populations and their associated habitats are not expected to result from the discharge of water from the LSNFH. The findings of General Order (No. R5-2014-0161) NPDES Permit No. CAG135001 issued by the RWQCB concluded that discharge at the LSNFH is considered minor, and existing wastewater treatment technology is capable of consistently reducing hatchery wastewater constituents to concentrations which are below the level at which the beneficial uses of surface and/or ground water are adversely affected. Beneficial uses include preservation and enhancement of fish, wildlife, and other aquatic resources. Monthly self-monitoring of the hatchery's water supply and effluent is conducted to ensure that water quality parameters are maintained to be compliant with the General Order of the RWQCB.

1.4. Action Area

The "Action Area" means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected measured, and evaluated (50 CFR 402.02). The Action Area resulting from this analysis includes LSNFH, located in the Upper Sacramento River Basin in the northern Central Valley of Northern California (Figure 1), including one tributary (Battle Creek), downstream to the RBDD at RM 243. The hatchery is located at the base of Shasta Dam (Keswick Reservoir) on the west side of the Sacramento River approximately 12 miles upstream of the limit of anadromy at Keswick Dam. The stock location code recognized by the Pacific States Marine Fisheries Commission (PSMFC) Regional Mark Processing Center for LSNFH is 6FCSASAF LVNH.

LSNFH releases hatchery-origin winter-run Chinook salmon into the Upper Sacramento River at RM 298, compared to the upstream limit of winter-run Chinook salmon migration, which is RM 302. Juvenile releases may also occur in North Fork Battle Creek (confluence with Sacramento River is at RM 271) as efforts to reintroduce winter-run Chinook salmon into Battle Creek move forward. Adult salmonids trapped at Keswick Dam, not used as broodstock will be transported and released into the Sacramento River at Redding, California (approximately RM 292). Detection of the effects associated with hatchery propagation activities at LSNFH is limited to the Upper Sacramento River Basin, upstream of the RBDD (RM 243).

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

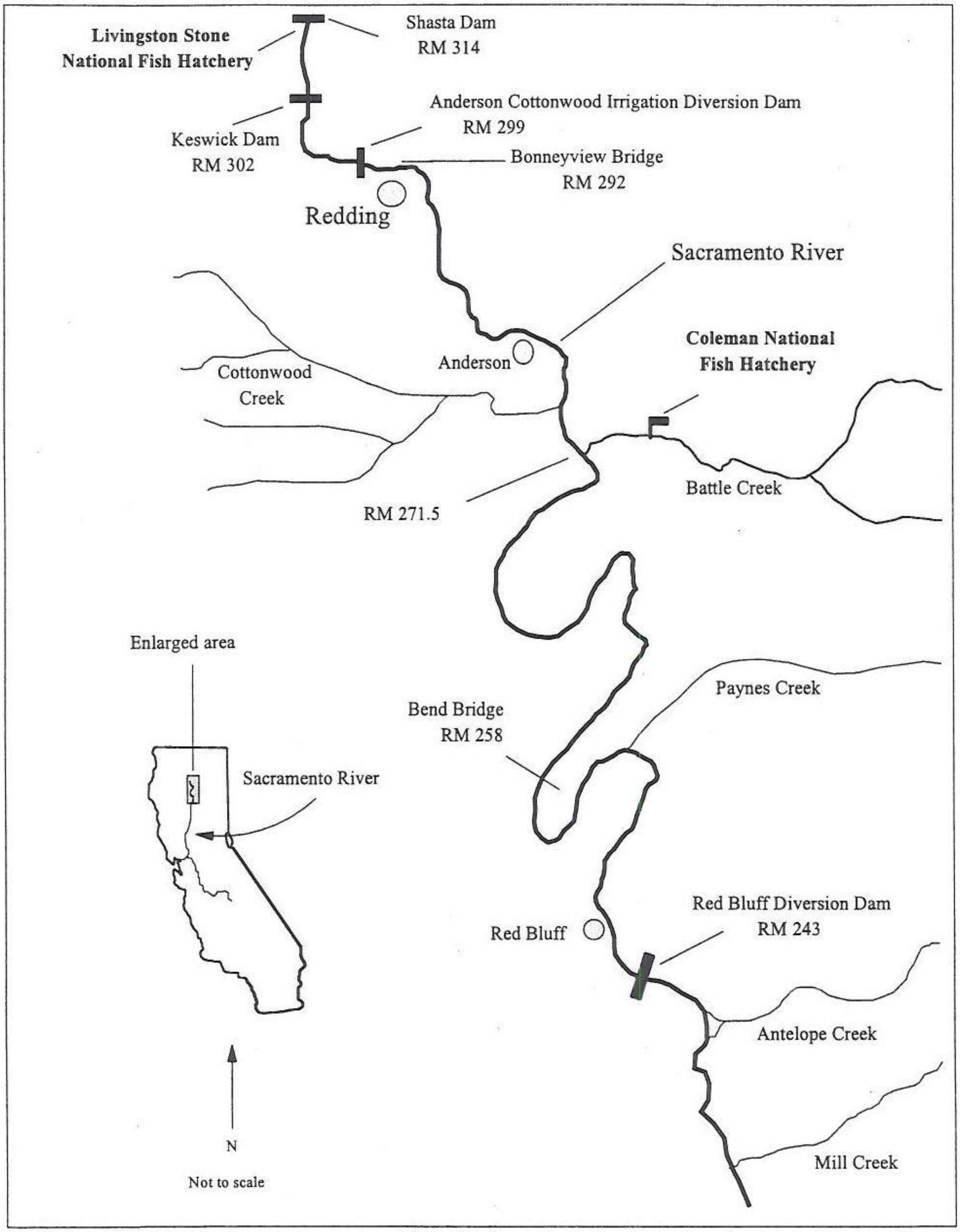

Figure 1. Location of LSNFH on the Sacramento River.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the USFWS, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

2.1. Approach to the Analysis

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts on the conservation value of designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02).

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

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

- First, the current status of listed species and designated critical habitat, relative to the conditions needed for recovery, are described in Section 2.2.
- Next, the Environmental Baseline in the Action Area is described in Section 2.3.
- In Section 2.4, we analyze the effects of the Proposed Action on both species and their habitat using an "exposure-response-risk" approach.
- Section 2.5 describes the cumulative effects in the action area, as defined in our implementing regulations at 50 CFR 402.02
- In Section 2.6, we integrate and synthesize the above factors by: (1) reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the

environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.

- Our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7.
- If our conclusion in Section 2.7 is that the Proposed Action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify designated critical habitat, we must identify a RPA to the action in Section 2.8.

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

2.2. Range-wide Status of the Species and Critical Habitat

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action. The species and the designated critical habitat that are likely to be affected by the Proposed Action, and any existing protective regulations, are described in Table 4 and Table 5. Status of the species is the level of risk that the listed species face based on parameters considered in documents such as recovery plans, status reviews, and ESA listing determinations. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the status and conservation value of critical habitat in the action area and discusses the current function of the essential physical and biological features that help to form that conservation value.

Table 4. Federal Register Notices for the Final Rules that list species, and any revised listings for ESA listed species considered in this consultation.

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*
	Central Valley spring-run Chinook salmon	**FR notice**: 64 FR 50394 **Date listed**: 9/16/1999 **Classification**: *Threatened*	**FR notice:** 70 FR 37160 **Date listed:** 6/28/2005 **Classification**: *reaffirmed classification* as *Threatened* **FR notice:** 70 FR 37204 **Date listed:** 6/28/2005 **Classification**: *Final Hatchery Listing Policy*
Steelhead *(O. mykiss)*	**California Central Valley steelhead**	**FR Notice:** 63 FR 13347 **Date listed:** 03/19/1998 **Classification:** *Threatened*	**FR Notice:** 71 FR 834 **Date listed:** 01/05/2006 **Classification:** *Threatened*

***Note:** Although CV spring-run Chinook salmon and CCV steelhead are not the target species for the proposed hatchery activities at LSNFH, they may be incidentally taken during broodstock collection and RM&E.

Table 5. Federal Register Notices for the Final Rules that designate critical habitat, or apply protective regulations to ESA-listed species considered in this consultation.

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
	Central Valley spring-run Chinook salmon	**FR notice:** 67 FR 1116 **Date:** 01/09/2002 **FR notice:** 78 FR 79622 **Date:** 12/31/2013	**FR notice:** 70 FR 52488 **Date:** 09/02/2005
Steelhead (*O. mykiss*)	**California Central Valley steelhead**	**FR notice:** 65 FR 42422 **Date:** 07/10/2000	**FR notice:** 70 FR 52488 **Date:** 09/02/2005

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

"Species" Definition: The ESA of 1973, as amended, 16 U.S.C. 1531 *et seq.* defines "species" to include any "distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature." To identify DPSs of salmon species, NMFS follows the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612, November 20, 1991). Under this policy, a group of Pacific salmon is considered a DPS and hence a "species" under the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. The group must satisfy two criteria to be considered an ESU: (1) It must be substantially reproductively isolated from other con-specific population units; and (2) It must represent an important component in the evolutionary legacy of the species. To identify DPSs of steelhead, NMFS applies the joint USFWS-NMFS DPS policy (61 FR 4722, February 7, 1996). Under this policy, a DPS of steelhead must be discrete from other populations, and it must be significant to its taxon. SR winter-run Chinook salmon and CV spring-run Chinook salmon each constitute an ESU (salmon DPS) of the taxonomic species *Oncorhynchus tshawytscha*, and CCV steelhead constitute one DPS of the species *O. mykiss*; as such, each are considered a "species" under the ESA. These ESUs and DPSs include natural-origin populations and hatchery populations, as described in the species status sections below.

2.2.1. Status of Listed Species

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: abundance, productivity, spatial structure, and diversity (McElhany *et al.* 2000). These "viable salmonid population" (VSP) criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. These parameters are also useful when describing the status of other ESA-listed fishes such as green sturgeon or eulachon. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These parameters or attributes are substantially influenced by habitat and other environmental conditions.

"Abundance" generally refers to the number of naturally-produced adults (*i.e.*, the progeny of naturally-spawning parents) in the natural environment.

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

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

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

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe VSP parameters at the population, major population group (MPG), and species scales (*i.e.*, salmon ESUs and steelhead DPSs). For species with multiple populations, once the biological status of a species' populations and MPGs have been determined, NMFS assesses the status of the entire species. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as meta-populations (McElhany *et al.* 2000).

2.2.1.1. Life History and Current Rangewide Status of the Sacramento River Winter-run Chinook Salmon ESU

Chinook salmon have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the SR winter-run Chinook salmon ESU, is at moderate risk of extinction. The distribution and timing of SR winter-run Chinook salmon varies depending on the life stage, and is shown in Table 6 below.

Table 6. The temporal occurrence of adult (a) and juvenile (b) winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

Winter-run relative abundance	High				Medium				Low			
a) Adults freshwater												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]												
Upper Sacramento River spawning[c]												
b) Juvenile emigration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff[d]												
Sacramento River at Knights Landing[e]												
Sacramento trawl at Sherwood Harbor[f]												
Midwater trawl at Chipps Island[g]												

Sources: [a] (Yoshiyama *et al.* 1998); (Moyle 2002); [b](Myers *et al.* 1998) ; [c] (Williams 2006) ; [d] (Martin *et al.* 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f,g] Delta Juvenile Fish Monitoring Program, USFWS (1995-2012).

Abundance: Historically, SR winter-run Chinook salmon population estimates were as high as 120,000 fish in the 1960s, but declined to fewer than 200 fish by the 1990s (National Marine Fisheries Service 2011b). In recent years, since carcass surveys began in 2001 (Figure 2), the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. However, from 2007 to 2013, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011 (Figure 2). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley *et al.* 2009), drought conditions from 2007-2009, and low in-river survival (NMFS 2011b) . Slight increase in 2014, with 3,015 adults, remains below the high (17,296) within the last ten years.

Although impacts from hatchery fish (*i.e.*, reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala *et al.* 2012), the SR winter-run Chinook salmon conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001–2010 average) compared to the estimated natural production that passes RBDD, which is 4.7 million per year based on the 2002–2010 average, (Poytress and Carrillo 2011). Therefore, hatchery production typically represents approximately 3-4 percent of the total in-river juvenile production in any given year.

2014 was the third year of a drought which increased water temperatures in the Upper Sacramento River Basin. This caused significantly higher mortality (95-97 percent) in the upper spawning area. Due to the anticipated lower than average survival in 2014, hatchery production from LSNFH was tripled to offset the impact of the drought. In 2014, hatchery production represented 50-60 percent of the total in-river juvenile production. Drought conditions appear to be persisting into 2015 and hatchery production will again be increased.

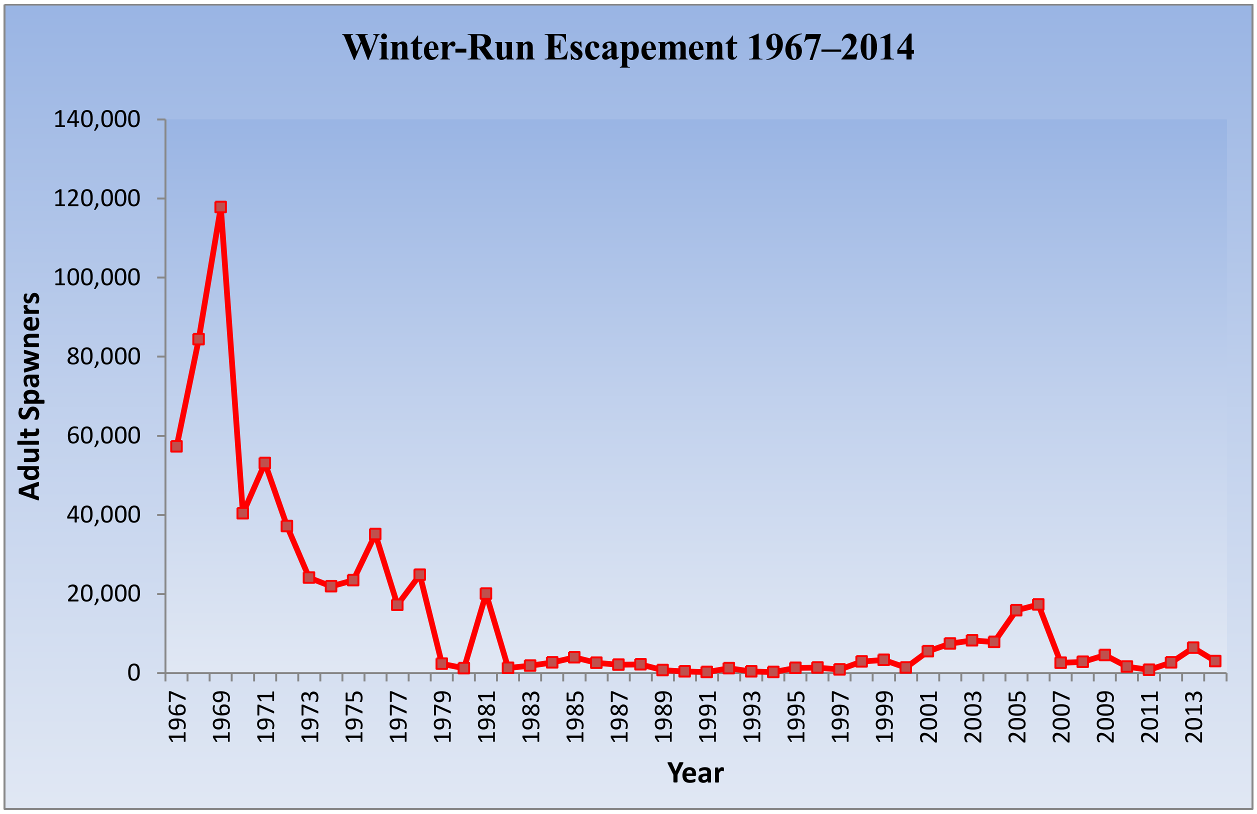

Figure 2. SR winter-run Chinook salmon escapement numbers 1970-2014, includes hatchery broodstock and tributaries, but excludes sport catch. RBDD ladder counts used pre-2000, carcass surveys post 2001 (California Department of Fish and Game 2012).

Productivity: ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative (Figure 3) with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) for the period 2007–2012 suggested a reduction in productivity (Figure 3), and indicated that the SR winter-run Chinook salmon population was not replacing itself. In 2013, and 2014, SR winter-run Chinook salmon experienced a positive CRR, possibly due to favorable in-river conditions in 2011, and 2012 (wet years), which increased juvenile survival to the ocean.

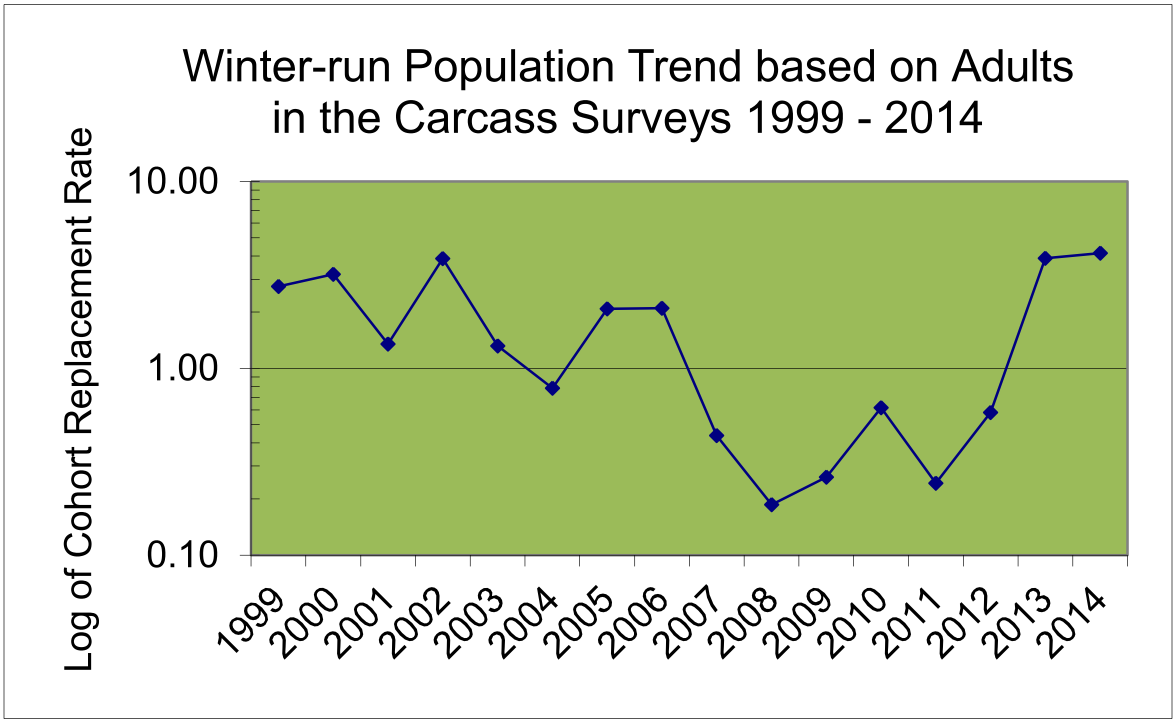

Figure 3. SR winter-run Chinook salmon population trend using cohort replacement rate derived from adult escapement, including hatchery fish, 1999–2014.

Productivity, as measured by the number of juveniles entering the Delta, or JPE, has declined in recent years from a high of 3.8 million in 2007 to 124,521 in 2014. Due to uncertainties in the various JPE factors, it was updated in 2010 with the addition of confidence intervals (Cramer Fish Sciences model), and again in 2013, and 2014 with a change in survival based on acoustic tag data (NMFS 2014b). However, juvenile SR winter-run Chinook salmon productivity is still much lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

Spatial Structure: The distribution of SR winter-run Chinook salmon spawning and initial rearing historically was limited to the Little Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963) *op. cit.* (Yoshiyama *et al.* 1998). The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which currently has its own impediments to upstream migration (*i.e.*, a number of small hydroelectric dams situated upstream of the CNFH barrier weir. The Restoration Project is currently removing these impediments, which should restore spawning and rearing habitat for SR winter-run Chinook salmon in the future. Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to SR winter-run Chinook salmon. Most components of the SR winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for SR winter-run Chinook salmon lies within its spatial structure (NMFS 2011b). The remnant and remaining population cannot access 95 percent of their historical spawning habitat, and must therefore be artificially maintained in the Sacramento River by: (1) spawning gravel augmentation, (2) hatchery supplementation, and, (3) regulating the finite cold-water pool behind Shasta Dam to reduce water temperatures. SR winter-run Chinook salmon require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2020. The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the SR winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014a). Additionally, NMFS (2009a) included a requirement for a pilot fish passage program above Shasta Dam, and planning is currently moving forward.

Diversity: The current SR winter-run Chinook salmon population is the result of the introgression of several stocks (*e.g.,* spring-run and fall-run Chinook) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good *et al.* 2005). Lindley *et al.* (2007), recommended reclassifying the SR winter-run Chinook salmon population extinction risk from low to moderate, if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery-origin winter-run Chinook salmon recovered in the Sacramento River has only been above 15 percent in two years, 2005 and 2012.

Concern over genetic introgression within the SR winter-run Chinook salmon population led to a conservation program at LSNFH that encompasses best management practices such as: (1) genetic confirmation of each adult prior to spawning, (2) a limited number of spawners based on the effective population size, and (3) use of only natural-origin spawners since 2009. These practices reduce the risk of hatchery impacts on the wild population. Hatchery-origin winter-run Chinook salmon have made up more than 5 percent of the natural spawning run in recent years and in 2012, it exceeded 30 percent of the natural run. However, the average over the last 16 years (approximately 5 generations) has been 8 percent, still below the low-risk threshold (15 percent) used for hatchery influence (Lindley *et al.* (2007).

Summary of ESU Viability: There are several criteria (only one is required) that would qualify the SR winter-run Chinook salmon ESU at moderate risk of extinction, and since there is still only one population that spawns below Keswick Dam, that population would be at high risk of extinction in the long-term according the criteria in (Lindley *et al.* 2007). Recent trends in those criteria are: (1) continued low abundance (Figure 2); (2) a negative growth rate over 6 years (2006–2012), which is two complete generations (Figure 3); (3) a significant rate of decline since 2006; and (4) increased risk of catastrophe from oil spills, wild fires, or extended drought (climate change). The most recent 5-year status review (NMFS 2011b) on SR winter-run Chinook salmon concluded that the ESU had increased to a high risk of extinction. In summary, the most recent biological information suggests that the extinction risk for the SR winter-run

Chinook salmon ESU has increased from moderate risk to high risk of extinction since 2005 (previous review), and that several listing factors have contributed to the recent decline, including drought and poor ocean conditions (NMFS 2011b) . A status review was completed during 2016, and is accessible at: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016_status_review.html

2.2.1.2. Life History and Current Rangewide Status of the Central Valley Spring-run Chinook Salmon ESU

Chinook salmon have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the CV spring-run Chinook salmon ESU, is at moderate risk of extinction.

The distribution and timing of CV spring-run Chinook salmon varies depending on the life stage, and is shown in Table 7 below.

Table 7. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult Migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[a,b]												
Sac. River Mainstem[b,c]												
Mill Creek[d]												
Deer Creek[d]												
Butte Creek[d,g]												
(b) Adult Holding[a,b]												
(c) Adult Spawning[a,b,c]												

(d) Juvenile Migration

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River Tribs[e]	Medium	Medium	Medium							Medium	High	High
Upper Butte Creek[f,g]	High	High	Medium	Medium	Medium	Low				Low	Low	High
Mill, Deer, Butte Creeks[d,g]	High	High	Medium	Medium	Medium	Low				Low	Low	Low
Sac. River at RBDD[c]	High	Low	Low	Low	Low (early May)						High	High
Sac. River at Knights Landing[h]	Medium	Medium	High	High	Medium						Medium	High

Relative Abundance: = High; = Medium; = Low

Sources: [a](Yoshiyama *et al.* 1998); [b](Moyle 2002); [c] (Myers *et al.* 1998); [d](Lindley *et al.* 2004) ; [e](CDFG 1998) ; [f](McReynolds *et al.* 2007); [g](Ward *et al.* 2003); [h](Snider and Titus 2000) ; Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

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

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRH spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population, and the potential development of a conservation strategy, for the hatchery program. Abundance from 1993 to 2004 were consistently over 4,000 (averaging nearly 5,000), while 2005 to 2014 were lower, averaging just over 2,000 (CDFW Grandtab 2015).

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem difficult to determine, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run Chinook salmon abundance. Fewer than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (USFWS 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; 2012 observed zero redds, and 2013, 57 redds in September (CDFW 2015). Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (CDFG 1998). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

For many decades, CV spring-run Chinook salmon were considered extirpated from the Southern Sierra Nevada diversity group in the San Joaquin River Basin, despite their historical numerical dominance in the basin (Fry 1961, Fisher 1994). More recently, there have been reports of adult Chinook salmon returning in February through June to San Joaquin River tributaries, including the Mokelumne, Stanislaus, and Tuolumne rivers (Franks 2014, Workman 2003, FISHBIO 2015). These spring-running adults have been observed in several years and exhibit typical spring-run life history characteristics, such as returning to tributaries during the springtime, over-summering in deep pools, and spawning in early fall (Franks 2014, Workman 2003, FISHBIO 2015). For example, 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FISHBIO 2015). Additionally, in 2014, implementation of the spring-run Chinook salmon reintroduction plan into the San Joaquin River has begun, which if successful will benefit the spatial structure, and genetic diversity of the ESU. These reintroduced fish have been designated as a 10(j) nonessential population when within the defined boundary in the San Joaquin River (78 FR 79622). Furthermore, while the San Joaquin River Restoration Project (SJRRP) is managed to imprint CV spring-run Chinook salmon to the mainstem San Joaquin River, we do anticipate that the reintroduced spring-run Chinook salmon are likely to stray into the San Joaquin tributaries at some level, which will increase the likelihood for CV spring-run Chinook salmon to repopulate other Southern Sierra Nevada diversity group rivers where suitable conditions exist.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table 8). Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over

3,000 (although 2008 was nearly 15,000 fish). During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005).

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

Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011a). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (NMFS 2011a). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased, in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 abundance was lower, just over 5,000 fish for the tributaries combined, which indicates a highly fluctuating and unstable ESU abundance. Even more concerning was returns for 2015, which were record lows for some populations. The next several years are anticipated to remain quite low as the effects of the 2012-2015 drought are fully realized.

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

From 1993 to 2007 the 5-year moving average of the CV spring-run Chinook salmon tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011 (Table 8). The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown, however the FRH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive (1.85). However, 2015 returns were very low, with a CRR of 0.14, when using Butte Creek snorkel survey numbers, the lowest on record. Using the Butte Creek carcass surveys, the 2015 CRR for just Butte Creek was only 0.02.

Table 8. Central Valley Spring-run Chinook salmon population estimates from CDFW Grand Tab (2015) with corresponding cohort replacement rates for years since 1990.

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

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

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

The Central Valley Technical Review Team estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Figure 4) (Lindley *et al.* 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks which are tributaries to the Upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence. Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2014) .

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

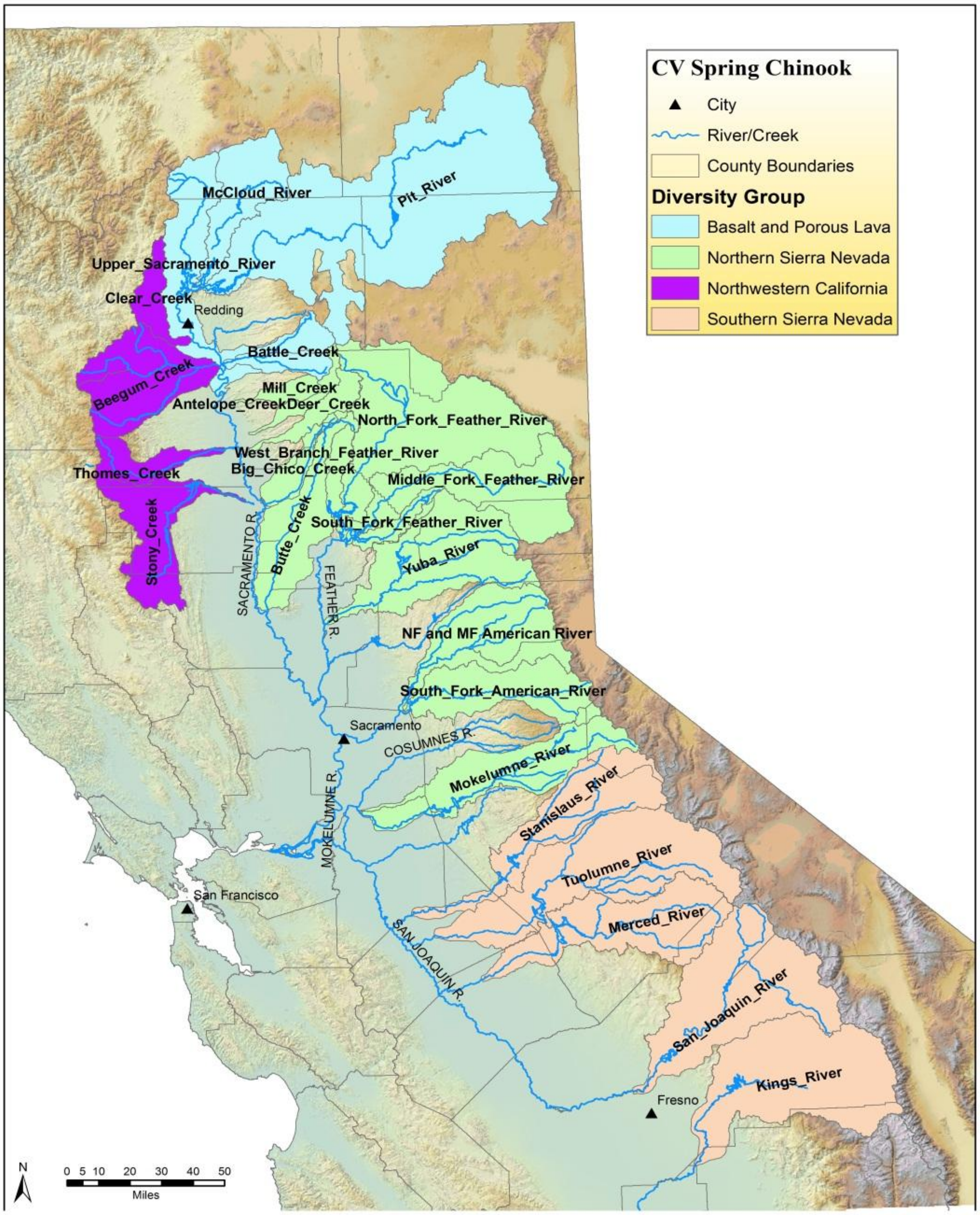

Figure 4. Diversity Groups for the Central Valley spring-run Chinook salmon ESU.

A final rule was published to designate a nonessential experimental population of CV spring-run Chinook salmon to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the SJRRP (78 FR 79622; December 31, 2013). Pursuant to ESA section 10(j), with limited exceptions, each member of an experimental population shall be treated as a threatened species. However, the rule includes proposed protective regulations under ESA section 4(d) that would provide specific exceptions to prohibitions under ESA section 9 for taking CV spring-run Chinook salmon within the experimental population area, and in specific instances elsewhere. The first release of CV spring-run Chinook salmon juveniles into the San Joaquin River occurred in April, 2014. A second release occurred in 2015, and future releases are planned to continue annually during the spring. The SJRRP's future long-term contribution to the CV spring-run Chinook salmon ESU has yet to be determined.

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

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

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

However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

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

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

In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review conducted in 2015 (NMFS 2016a), looked at promising increasing populations in 2012-2014, however the 2015 returning fish were extremely low (1,488), with additional pre-spawn mortality reaching record lows.

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

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

2.2.1.3. Life History and Current Rangewide Status of the California Central Valley Steelhead DPS

Steelhead have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration.

Abundance, Productivity, Spatial Structure, and Diversity
Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the CCV steelhead DPS, is at moderate risk of extinction.

The distribution and timing of steelhead varies depending on the life stage, and is shown in Table 9 below.

Table 9. The temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

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

Relative Abundance: = High = Medium = Low

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

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

In order to address this monitoring need, implementation of CDFW's Steelhead Monitoring Program began during the fall of 2015. Important components of the program include a Mainstem Sacramento River Steelhead Mark Recapture Program and an Upper Sacramento River Basin Adult Steelhead Video/DIDSON Monitoring Program. The monitoring program will use a temporally stratified mark-recapture survey design in the lower Sacramento River, employing wire fyke traps to capture, mark, and recapture upstream migrating adult steelhead to estimate adult steelhead escapement from the Sacramento-San Joaquin River Delta. Data collected from recaptured adult steelhead will provide additional information on tributary escapement, survival, population structure, population distribution, and spatial and temporal behavior of both hatchery- and natural-origin steelhead (Fortier *et al.* 2014).

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

CNFH operates a weir on Battle Creek, where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the CCV DPS. Steelhead returns to CNFH have increased over the last four years. After hitting a low of only 790 fish in 2010, the last two years have averaged 2,895 fish. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose fin-clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relative steady, typically 200-300 fish each year. Numbers of wild adults have ranged from 185 to 334 in the last five years (USFWS 2016)

The returns of steelhead to the FRH were very low in 2009 and 2010, with only 312 and 86 fish returning in those years (CDWR 2014). Since then the numbers have rebounded, with a high of 1,797 in 2013, and have averaged over 1,100 fish over the last five years. Escapement at this hatchery seems to be quite variable over the years, despite the fact that stocking levels have remained fairly constant and that the vast majority of fish are of hatchery origin.

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to Satterthwaite *et al*. (2010), it is likely that a large majority of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production.

Redd counts are conducted in the American River and in Clear Creek (Shasta County), but there are not yet enough data to compute all risk metrics. An average of 142 redds have been counted on the American River from 2002-2015, with only 58 counted in 2015, a new low for this survey (Hannon 2013, Cramer Fish Sciences 2015).

The Clear Creek population has shown an increasing trend in steelhead redd counts since Saeltzer Dam was removed in 2000 (Figure 4; Giovannetti *et al.* 2013, USFWS 2015). The average redd count over the last 10 years (2006-2015) is 215, representing somewhere between 215 and 431 spawning adult female steelhead. Since 2011, an average of 231 redds has been observed in Clear Creek. The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek, and adipose fin clipped steelhead are rarely observed in Clear Creek (M. Brown, USFWS, pers. comm.).

Information on steelhead escapement in Mill Creek is now available from a video monitoring station run by CDFW at Ward Dam. Counts of adult steelhead moving upstream have been made since the 2008-09 season. Adult counts have ranged from 60 to 237, with an average of 142 over the last six years (Figure 5; Killam and Johnson 2008, CDFW 2015a). All of these fish appear to be naturally produced. The recent low flows associated with recent drought years have actually improved the ability to count steelhead at this station. An interesting comparison can be made with counts from Clough Dam on Mill Creek from the 1950's and early 1960's, when steelhead were counted at a fish ladder on the dam. Counts from that time period were almost 10 times greater in magnitude (Harvey 1995), though those fish were likely a mix of hatchery and wild fish, as the state was stocking smolts in the Sacramento River at Princeton at that time, and one year (1956) released 107,000 smolts directly in Mill Creek (Hallock *et al.* 1961).

Productivity: An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley.

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

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the production of wild steelhead relative to hatchery steelhead (CDFW 2014b; ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead has declined dramatically since the early 2000's, with an overall average of 2,705 in the last ten years, as measured by expanded salvage. The percentage of wild (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 36 percent since a high of 93 percent in 1999. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated. This relatively constant hatchery production, coupled with the dramatic decline in hatchery-origin steelhead catch at the south Delta fish collection facilities suggests that either stocked hatchery fish from the Sacramento basin are utilizing a more natural outmigration path and not being pulled into the south Delta fish facilities, or the immediate survival of those stocked fish has decreased. With respect to wild steelhead, the data indicates that over the last few years fewer adults are spawning (less eggs deposited), survival of early life stages has decreased, and/or wild steelhead are experiencing reduced exposure to the south Delta fish facilities.

Spatial Structure: About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley *et al.* 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed.

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005; NMFS 2011b). Zimmerman *et al.* (2009), used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

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

The NMFS Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014a), includes recovery criteria for the spatial structure of the DPS which includes, one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group, in addition to maintaining dependent populations are needed for recovery.

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of Central Valley steelhead populations if the passage programs are implemented for steelhead. In addition, the SJRRP calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for CV spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2011b).

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

The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely make up the majority of the annual spawning runs, placing the natural population at a high risk of extinction (Lindley *et al.* 2007). There are four hatcheries (CNFH, FRH, Nimbus Fish Hatchery, and Mokelumne River Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) are not presently considered part of the DPS. The reason for the exclusion of steelhead produced at Nimbus Fish Hatchery from the CCV steelhead DPS was the known Eel River/Mad River origin of the original broodstock used at the hatchery. Based on the history of egg transfers from the Nimbus Fish Hatchery to the Mokelumne River Hatchery, the Mokelumne River Hatchery was also excluded from the DPS.

A new analysis of the genetic relationships among the four Central Valley steelhead hatcheries clearly shows that fish from the Mokelumne River Hatchery are now nearly genetically identical to fish from the FRH (Pearse and Garza 2015). This is consistent with the fact that in the last few years before the Mokelumne River Hatchery ended the practice of importing eggs from out-of-basin sources, all of its eggs came from the FRH. Given the new genetic evidence, the recent 5-

Year Status Review is recommending that the Mokelumne River Hatchery be added to the CCV steelhead DPS, as FRH fish are considered to be a native Central Valley stock and are listed as part of the DPS (NMFS 2016b).

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

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

Juvenile steelhead (parr) rear in freshwater for one to three years before migrating to the ocean as smolts (Moyle 2002). Hallock *et al.* (1961) aged 100 adult steelhead caught in the Sacramento River upstream of the Feather River confluence in 1954, and found that 70 had smolted at age-2, 29 at age-1, and one at age-3. Seventeen of the adults were repeat spawners, with three fish on their third spawning migration, and one on its fifth. Age at first maturity varies among populations. In the Central Valley, most steelhead return to their natal streams as adults at a total age of two to four years (Hallock *et al.* 1961, McEwan and Jackson 1996). In contrast to the Upper Sacramento River tributaries, Lower American River juvenile steelhead have been shown to smolt at a very large size (270 to 350 mm FL), and nearly all smolt at age-1 (Sogard *et al.* 2012).

Summary of DPS Viability: All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005; NMFS 2011b, NMFS 2016b); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish. Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

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

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011b). The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

There are some encouraging signs, as several hatcheries in the Central Valley have experienced increased returns of steelhead over the last few years. There has also been a slight increase in the percentage of wild steelhead in salvage at the south Delta fish facilities, and the percentage of wild fish in those data remains much higher than at Chipps Island. The new video counts at Ward Dam show that Mill Creek likely supports one of the best wild steelhead populations in the Central Valley, though at much reduced levels from the 1950's and 60's. Restoration and dam removal efforts in Clear Creek continue to benefit CCV steelhead. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates that natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.

2.2.2. Rangewide Status of Critical Habitat

This section of the opinion examines the range-wide status of designated critical habitat for the affected salmonid species. NMFS determines the range-wide status of critical habitat by examining the condition of its physical and biological features (PBFs, also called "primary constituent elements," or PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (*e.g.*, sites with conditions that support spawning, rearing, migration and foraging).

2.2.2.1. Critical Habitat and Physical and Biological Features (PBFs) for Sacramento River winter-run Chinook salmon

In the Sacramento River, designated critical habitat includes the river water, river bottom, and the adjacent riparian zone. The following descriptions of the physical and biological features considered to be essential for the conservation of SR winter-run Chinook salmon:

Adult Migration Corridors: Adult SR winter-run Chinook salmon generally migrate to spawning areas during the winter and spring. At that time of year, the migration route is accessible to the appropriate spawning grounds on the upper 60 miles of the Sacramento River, however much of this migratory habitat is degraded and they must pass through a fish ladder at the ACID Dam. In addition, the many flood bypasses are known to strand adults in agricultural drains due to inadequate screening (Vincik and Johnson 2013). Since the primary migration corridors are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

Spawning Habitat: Spawning habitat is defined as "the availability of clean gravel for spawning substrate." Suitable spawning habitat for SR winter-run Chinook salmon exists in the upper 60 miles of the Sacramento River between Keswick Dam and RBDD. However, the majority of spawning habitat currently being used occurs in the first 10 miles below Keswick Dam. The available spawning habit is completely outside the historical range utilized by SR winter-run Chinook salmon upstream of Keswick Dam. Because Shasta and Keswick dams block gravel recruitment, the Reclamation annually injects spawning gravel into various areas of the Upper Sacramento River Basin. With the supplemented gravel injections, the Upper Sacramento River reach continues to support a small naturally-spawning SR winter-run Chinook salmon population. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

Adequate River Flows: Adequate River flows are defined as providing "adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles."

Water Temperatures: Water temperatures are defined as "water temperatures at 5.8–14.1 degrees Celsius (°C) (42.5–57.5 degrees Fahrenheit [°F]) for successful spawning, egg incubation, and fry development." Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of SR winter-run Chinook salmon migration, spawning, egg incubation, fry development, and emergence. This pattern, the opposite of the pre-dam hydrograph, benefits SR winter-run Chinook salmon by providing cold water for miles downstream during the hottest part of the year.

Habitat and Adequate Prey Free of Contaminants: Water quality conditions have improved since the 1980s due to stricter standards and Environmental Protection Agency (EPA) Superfund site cleanups. However, legacy contaminants such as mercury (and methyl mercury), polychlorinated biphenyls, heavy metals and persistent organochlorine pesticides continue to be found in watersheds throughout the Central Valley. In 2010, the EPA, listed the Sacramento River as impaired under the Clean Water Act, section 303(d), due to high levels of pesticides, herbicides, and heavy metals (http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml).

Adequate prey for juvenile salmon to survive and grow. Exposure to these contaminated food sources such as invertebrates may create delayed sublethal effects that reduce fitness and survival (Laetz *et al.* 2009).

Riparian and Floodplain Habitat: Riparian and floodplain habitat is defined as providing "for successful juvenile development and survival." Nevertheless, the current condition of degraded riparian habitat along the mainstem Sacramento River restricts juvenile growth and survival (Michel 2010, Michel *et al.* 2012).

Juvenile Emigration Corridors: Juvenile emigration corridors are defined as providing "access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean." Freshwater emigration corridors should be free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. Migratory corridors are downstream of the Keswick Dam spawning areas and include the mainstem of the Sacramento River to the Delta, as well as non-natal rearing areas near the confluence of some tributary streams.

Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to as rearing habitat and as an area of transition to the ocean environment.

2.2.2.2. Critical Habitat and PBFs for Central Valley spring-run Chinook salmon

Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488). Critical habitat for CV spring-run Chinook salmon is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Following are the PBFs for CV spring-run Chinook salmon.

Spawning Habitat: The majority of primary spawning habitat occurs in the tributaries to the Sacramento River, located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

Freshwater Rearing Habitat: Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Freshwater rearing habitat has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

Freshwater Migration Corridor: For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PBF. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

Estuarine Areas: This PBF is outside of action area for the proposed project. The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

2.2.2.3. Critical Habitat and PBFs for California Central Valley Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River (up to the confluence with the Merced River), including its tributaries, and the waterways of the Delta. Critical habitat for CCV steelhead is defined as specific areas that contain the PBFs and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PBFs for CCV steelhead.

Spawning Habitat: Tributaries to the Sacramento and San Joaquin rivers with year-round flows have the primary spawning habitat for CCV steelhead. Most of the available spawning habitat is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

Freshwater Rearing Habitat: Tributaries to the Sacramento and San Joaquin rivers with year-round flows have the primary rearing habitat for CCV steelhead. Intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Freshwater rearing habitat has a high conservation value even if the current conditions are significantly degraded from their natural state.

Freshwater Migration Corridors: Migration corridors contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value even if the migration corridors are significantly degraded compared to their natural state.

Estuarine Areas: This PBF is outside of action area for the proposed project. The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

2.2.3. Climate Change

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

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

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

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

For SR winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of SR winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates *et al.* 2008). The long-term projection of operations of the CVP/SWP expects to include the effects of climate change in one of three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or, earlier spring snow melt (BOR 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008, Beechie *et al.* 2012, Dimacali 2013). These factors will compromise the quantity and/or quality of SR winter-run Chinook salmon habitat available downstream of Keswick Dam. It is imperative for additional populations of SR winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (NMFS 2014a) .

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

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

Under the expected climate warming of around 5°C, substantial salmonid habitat would be lost in the Central Valley, with significant amounts of habitat remaining primarily in the Feather and Yuba rivers, and remnants of habitat in the Upper Sacramento, McCloud, and Pit rivers, Battle and Mill creeks, and the Stanislaus River (Lindley *et al.* 2007). Under the less likely but still possible scenario of an 8°C warming, spring-run Chinook salmon habitat would be found only in the upper-most reaches of the north fork Feather River, Battle Creek, and Mill Creek (Lindley *et al.* 2007). Battle Creek offers important cold water inputs for spring-run and steelhead populations, that could prove to provide some of the Central Valley's best protection against extinction for these species as climate change effects take place.

In summary, observed and predicted climate change effects are generally detrimental to the species (McClure 2011, Wade *et al.* 2013), so unless offset by improvements in other factors, the status of the species and critical habitat is likely to decline over time. The climate change projections referenced above cover the time period between the present and approximately 2100. While there is uncertainty associated with projections, which increases over time, the direction of change is relatively certain (McClure *et al.* 2013).

2.3. Environmental Baseline

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

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

Wide varieties of human activities have affected ESA-listed salmonids in the Central Valley and their PFBs within the Action Area. These activities, more recently, include BOR actions that are having beneficial effects. The Sacramento River originates near Mt. Shasta, and flows south for 447 miles before reaching the Sacramento–San Joaquin River Delta and San Francisco Bay. Shasta Dam, which is located at RM 311 on the Sacramento River near Redding, California, was completed in 1945. It serves to control floodwaters and store surplus winter runoff for irrigation in the Sacramento and San Joaquin Valleys, maintain navigation flows, provide flows for the conservation of fish in the Sacramento River and water for municipal and industrial use, protect the Sacramento-San Joaquin Delta from intrusion of saline ocean water, and generate hydroelectric power. Keswick Dam (RM 302) was constructed nine miles downstream from Shasta Dam to create a 23,800 acre-foot afterbay for Shasta Lake and the Trinity River Division, which stabilizes uneven water releases from the power plants. Below Keswick Dam, the ACID Dam (RM 297) is seasonally in place to raise the water level for diversions into the ACID canal. The 59 mile reach of the Sacramento River between Keswick Dam and RBDD is commonly referred to as the Upper Sacramento River.

Coarse sediment from the upper watershed is prevented from being transported downstream by Shasta and Keswick dams, resulting in an alluvial sediment deficit and reduction in fish habitat quality within the Upper Sacramento River reach (Wright and Schoellhamer 2004). In addition to the reduction of sediment supply, recruitment of large woody material to the river channel and floodplain has also declined due to a reduction in bank erosion and blockage of wood transport by Shasta Dam.

The combination of degraded physical habitat characteristics, fish passage barriers, and changes in hydrology resulting from dams and diversions since the mid-1800s has been associated with salmonid and green sturgeon declines within the Sacramento River watershed.
Battle Creek enters the Sacramento River (at river mile 273) approximately five miles southeast of the Shasta County town of Cottonwood. It flows into the Sacramento Valley from the east, draining a watershed of approximately 360 square miles (DWR 2009). Battle Creek is comprised of three main branches - the North Fork (approx. 29.5 miles in length from headwaters to confluence), the South Fork (approximately 28 miles in length from headwaters to confluence), and the mainstem valley reach (approximately 15.2 miles from the confluence of the North and South forks to the Sacramento River), in addition to numerous tributaries (Kier Associates 1999).

Battle Creek is a tributary to the Upper Sacramento River and is one of the only watersheds of significant size remaining in the Cascade region that is accessible to anadromous salmonids. It also has habitat types similar to those in which the now scarce runs of winter- and spring-run Chinook salmon evolved (USFWS 1995). Prior to the hydroelectric development in Battle Creek watershed more than a century ago, prime habitat for Chinook salmon and steelhead extended from the confluence with the Sacramento River upstream to natural barrier waterfalls on North Fork and South Fork Battle Creek.

Hydrology: Flows in the Sacramento River in the 65 mile reach between Shasta Dam and RBDD are regulated by Shasta Dam and again, just downstream at Keswick Dam. Water stored in the reservoirs during the winter and spring is released in the summer and fall for municipal and industrial supply, irrigation, water quality, power generation, recreation, and fish and wildlife purposes. Historically, the Upper Sacramento River Basin was highly responsive to periodic precipitation events and seasonal variation. Since completion of the dams, flows are now lower in the winter and spring and higher in the summer and fall. During July, August, and September, the mean monthly flows of the Sacramento River at Keswick since 1963 are nearly 400 percent higher than the mean monthly flows prior to 1943 (DWR 1981, as cited in SRCAF Handbook (2003). In this reach, flows are influenced by tributary inflow. Major west-side tributaries to the Sacramento River in this reach of the river include Clear and Cottonwood creeks. Major east-side tributaries to the Sacramento River in this reach of the river include Battle, Bear, Churn, Cow, and Paynes creeks.

Battle Creek flows have been diverted for hydroelectric development, irrigation, and hatchery operations (USFWS 2011). Flows vary seasonally and range from 30 cfs in August to 8,000 to 20,000 cfs during spring. The current anadromous habitat in the Battle Creek watershed is strongly influenced by the Hydroelectric Project. Dam construction and operations had extirpated most of the original salmonid populations in Battle Creek by the early 1900s, and continue to have an impact on salmon and steelhead by limiting their habitat and availability of water during high water demands (NMFS 2006).

Land Use: As reported by SRCAF (2003), the Keswick-RBDD Reach has a variety of land uses—urban, residential, industrial, and agricultural. About 35 percent of the area is in agriculture, and about 12 percent is urban, residential, or industrial. Industrial land uses within this reach include lumber mills and gravel removal operations. Residential and commercial land uses in the cities of Redding, Anderson, and Red Bluff are common as well. In addition, this reach has the most recreational facilities on the Sacramento River (SRCAF 2003). Historically, the river between Redding and Anderson supported several gravel mining operations (SRCAF 2003).

Water Quality: The main sources of water in the Sacramento River below Keswick Dam are rain and snowmelt that collect in upstream reservoirs and are released in response to water needs or flood control. The quality of surface water downstream of Keswick Dam is also influenced by other human activities along the Sacramento River downstream of the dam, including historical mining, agricultural, and municipal and industrial activities. The quality of water in the Sacramento River is relatively good; only during conditions of stormwater-driven runoff are water quality objectives typically not met (Domagalski *et al.* 2000). Water quality issues within the Upper Sacramento River include the presence of mercury, pesticides such as organochlorine, trace metals, turbidity, and toxicity from unknown origin (CALFED 2000).

The Central Valley RWQCB has determined that the 25-mile segment of the Upper Sacramento River between Keswick Dam and the mouth of Cottonwood Creek is impaired by levels of dissolved cadmium, copper, and zinc that periodically exceed water quality standards developed to protect aquatic life (RWQCB 2002). The reach is also listed under Clean Water Act (CWA) 303(d) by the Central Valley RWQCB for unknown sources of toxicity (RWQCB 2007). Water temperature in the Sacramento River is controlled by releases from Shasta, Whiskeytown, and Keswick reservoirs. NMFS issued an opinion on the long-term operation of the CVP and SWP (NMFS 2009), which included Upper Sacramento River water temperature requirements to protect listed anadromous fish and their critical habitats. However, the ability to meet temperature requirements has proven extremely difficult during drought years.

Predation: Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate downstream of Keswick Dam and prey on juvenile salmon in the tail waters. The Sacramento pikeminnow is a species native to the Sacramento River basin and has co-evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g.*, warm water, low-irregular flow, standing water, and water diversions) compared to its natural state and function decades ago in the pre-dam era, are more conducive to warm water species such as Sacramento pikeminnow and striped bass than to native salmonids. Tucker *et al.* (1998), reported that predation during the summer months by Sacramento pikeminnow on juvenile salmonids increased to 66 percent of the total weight of stomach contents in the predatory pikeminnow.

Fisheries and Aquatic Habitat: The Upper Sacramento River between Keswick Dam (RM 302) and RBDD (RM 243) currently serves as the only spawning ground for winter-run Chinook salmon, and is an important migration corridor for adult and juvenile spring-run Chinook salmon and steelhead, particularly populations from Cottonwood Creek, Clear Creek, Cow Creek and Battle Creek, as well as other smaller tributaries. Green Sturgeon utilize the Upper Sacramento River as a migratory corridor as well as for spawning and juvenile rearing.

Shasta and Keswick dams have presented impassable barriers to anadromous fish since 1943 (Moffett 1949 as cited in Poytress *et al.* 2014). ACID Dam and RBDD presented partial barriers to salmonid migration until improvements were made in 2001 and 2012 (NMFS 2009, 2014a), respectively, although ACID Dam continues to present an impassable barrier to green sturgeon (NMFS 2009).

Battle Creek has had persistent spawning populations of spring-run Chinook salmon and steelhead in the reaches currently accessible on the mainstem, North Fork and South Fork in recent years, although the populations have been relatively small. Until recently, the Battle Creek Watershed had eight dams blocking upstream migration of salmonids to much of the suitable and historic habitat; however, through implementation of the Restoration Project, 21 miles of currently blocked historical habitat will be re-opened, and will restore and enhance a total of 48 miles of habitat. The Restoration Project provides increased instream flows and an AMP to evaluate the effectiveness of these flows, though implementation of the AMP has not begun.

Early fisheries investigators claimed that Battle Creek was the most important salmon-producing tributary to the Sacramento River when its ecosystem had its original form and function before settlement in the 1850s (Rutter 1904; CDFG 1993 *as cited in* Kier Associates 1999). It is anticipated that the Battle Creek watershed, once restored, will be a conservation stronghold for CV spring-run and SR winter-run Chinook salmon and CCV steelhead (Battle Creek AMP). Battle Creek provides the only remaining currently accessible habitat (post Restoration Project) in the Sacramento River watershed, other than the Sacramento River, that is thought to be suitable for populations of SR winter-run Chinook salmon. Also, Battle Creek offers the best opportunity for restoration of wild steelhead populations in the Upper Sacramento River Basin (McEwan and Jackson 1996). Battle Creek has been identified as having high potential for successful fisheries restoration, because of its relatively high and consistent flow of cold water (Newton *et al*. 2008). It has the highest base flow (i.e., dry-season flow) of any tributary to the Sacramento River between the Feather River and Keswick Dam (Ward and Kier 1999, as cited in Newton *et al*. 2008). As these cold water inputs and good flows still exist, this system, if restored, will allow access by fish to these key areas upstream where cold water is more available.

Sacramento River winter-run Chinook salmon: The distribution of Sacramento River winter-run Chinook salmon spawning and rearing is currently limited to the Upper Sacramento River, with managed flows out of Shasta Dam. Keswick Dam re-regulates flows from Shasta Dam and mixes it with water diverted from the Trinity River through the Spring Creek tunnel to control water temperatures below ACID pursuant to actions in the NMFS opinion, to provide cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (NMFS 2009). Approximately, 299 miles of tributary spawning habitat in the Upper Sacramento River above the dams is now inaccessible to winter-run (NMFS 2014a). The proportion of the winter-run Chinook salmon spawning above ACID has increased since the ladder improvements in 2001. Although variable, between 2002 and 2014, an average of 45 percent spawn between Keswick Dam and ACID Dam, and the last three years, an average of 66 percent (CDFW 2014 unpublished aerial redd counts). Data on the temporal distribution of winter-run Chinook salmon upstream migration suggest that in wet years about 50 percent of the run has passed the RBDD by March, and in dry years, migration is typically earlier, with about 72 percent of the run having passed the RBDD by March (Poytress *et al.* 2014).

The Upper Sacramento River Basin contains the only remaining habitat that is currently used by spawning winter-run Chinook salmon. As reported by NMFS (2014a), historical winter-run population estimates, were as high as over 230,000 adults in 1969, but declined to under 200 fish in the 1990s (Good *et al.* 2005). A rapid decline occurred from 1969 to 1979 after completion of the RBDD. Over the next 20 years, the population eventually reached a low point of only 186 adults in 1994. At that point, winter-run Chinook salmon were at a high risk of extinction, as defined by Lindley *et al.* (2007). However, several conservation actions, including a very successful conservation hatchery and captive broodstock program at LSNFH, construction of the TCD on Shasta Dam, maintaining the RBDD gates up for much of the year, and restrictions in ocean harvest, have likely prevented the extinction of natural-origin winter-run Chinook salmon. LSNFH, which is located at the base of Keswick Dam, annually supplements the in-river production by releasing on average 210,000 winter-run smolts into the Upper Sacramento River. The LSNFH operates under strict guidelines for propagation that includes genetic testing of each pair of adults and spawning no more than 10 percent of the hatchery returns. This program and the CBP (phased out in 2007, reinstated in 2015) were instrumental in stabilizing the winter-run Chinook population following very low returns in the 1990s.

More recently, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. However, from 2007 to 2012, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011. This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley *et al.* 2009), drought conditions from 2007-2009, and low in-river survival (NMFS 2011b) . In 2013, the population increased to 6,075 adults, and in 2014, 3,015, which are both well above the 2007–2012 average, but below the high for the last ten years.

2014 was the third year of a drought which increased water temperatures in the Upper Sacramento River Basin. This caused significantly higher mortality (95-97 percent) in the upper spawning area. Due to the expected lower than average survival in 2014, hatchery production from the LSNFH conservation program was tripled to offset the impact on the naturally spawning fish. Normally LSNFH produced an average of 176,348 fish per year, with in-river natural production resulting in an average of 4.7 million. In 2014, hatchery production represented 50-60 percent of the total in-river juvenile production, compared to 3 to 4 percent on average in a normal year. Drought conditions persisted into 2015 and hatchery production was increased once again.

Central Valley spring-run Chinook salmon: The status of the spring-run population within the mainstem Sacramento River above RBDD appears to have declined from a high of 25,000 in the 1970s to an average low of less than 800 counted at RBDD beginning in 1991. Significant hybridization with fall-run has made identification of a spring-run population in the mainstem very difficult to determine, and there is speculation as to whether a true spring-run population still exists below Keswick Dam. This shift may have been an artifact of the manner in which spring-run were identified at RBDD. More recently, fewer spring-run were counted at RBDD because an arbitrary date, September 1, was used to determine spring-run, and gates are now (beginning in 2012) open year round (NMFS 2014a). The extent of non-hybridized spring-run spawning in the Sacramento River mainstem is unknown. However, the physical habitat conditions below Keswick Dam is capable of supporting spring-run, although in some years high water temperatures can result in substantial levels of egg mortality. Current redd surveys (2001-2014) have observed an average of 41 salmon redds in September, from Keswick Dam downstream to the RBDD, ranging from zero to 105 redds (CDFW, unpublished data, 2015). This is typically when spring-run spawn, however, there is no peak that can be separated out from fall-run spawning, so these redds also could be early spawning fall-run. Additionally, even though habitat conditions may be suitable for spring-run occupancy, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning it is likely to have caused extensive introgression between the populations (CDFG 1998).

California Central Valley steelhead: Estimates of CCV steelhead abundance in the mainstem Sacramento River typically use the RBDD counts for historical trend data. Since 1991, the RBDD gates have been opened after September 15, making estimates of CCV steelhead pass RBDD unreliable. Since the RBDD gates started operation in 1967, the CCV steelhead abundance in the Upper Sacramento River has declined from 20,000 to less than 1,200 on average beginning in 1992. CCV steelhead passage above RBDD after 1991 can be estimated based on the average of the 3 largest tributaries (*i.e.*, Battle Creek, Clear Creek and Cottonwood Creek). The average of these tributaries for the last 14 years (1992 through 2005) is 1,282 adults, which represents a continuous decline from the 1967 through 1991 average RBDD count of 6,574. Actual estimates of CCV steelhead spawning in the mainstem Sacramento River below Keswick Dam have never been made due to high flows and poor visibility during the winter time.

2.4. Effects on ESA Protected Species and on Designated Critical Habitat

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

2.4.1. Factors That Are Considered When Analyzing Hatchery Effects

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

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

When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as "isolated". Generally speaking, isolated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or steelhead DPS. They promote domestication or selection in the hatchery over selection in the wild and select for and culture a stock of fish with different phenotypes, for example different ocean migrations and spatial and temporal spawning distribution, compared to the native population (extant in the wild, in a hatchery, or both). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany *et al.* 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes: abundance, productivity, spatial structure, and diversity and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS. "Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation" (Hard *et al.* 1992). A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability, including abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (70 FR 37215, June 28, 2005). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. "Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness and productivity of the ESU". NMFS also analyzes and takes into account the effects of hatchery facilities, for example, weirs and water diversions, on each VSP attribute and on designated critical habitat.

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information on the general type of effect of that aspect of hatchery operation in the context of the specific application in the Sacramento River. This allows for quantification (wherever possible) of the various factors of hatchery operation to be applied to each applicable life-stage of the listed species at the population level (in Section 2.4.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.6).

The effects, positive and negative, for two categories of hatchery programs are summarized in Table 10. Generally speaking, effects range from beneficial to negative for programs that use local fish[1] for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock[2]. Hatchery programs can benefit population viability but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. The range in effects for a specific hatchery program are refined and narrowed after available scientific information and the circumstances and conditions that are unique to individual hatchery programs are accounted for.

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

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

Table 10. Overview of the range in effects on natural population viability parameters from two categories of hatchery programs. The range in effects are refined and narrowed after the circumstances and conditions that are unique to individual hatchery programs are accounted for.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The risk of adverse competitive interactions between hatchery-origin and natural-origin fish can be minimized by:

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

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[3] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

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

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are still too sparse to allow many

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

generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986, Hawkins and Tipping 1999, Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999, Naman and Sharpe 2012). Hatchery steelhead timing and release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe *et al.* 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (Coho salmon and cutthroat, predominately) than their hatchery counterparts.

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

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

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

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

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

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

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

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

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

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

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

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

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

2.4.2. Effects of the Proposed Action

Analysis of the Proposed Action identified one factor that is likely to have a beneficial effect on ESA-listed winter-run Chinook salmon and their designated critical habitat. All other factors considered are likely to have a negligible effect on the ESA-listed salmonids considered in this opinion and their designated critical habitat (Table 11). An overview of the analysis is described below.

Table 11. A summary of the effects of the LSNFH program on SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead and on their designated critical habitat. The framework NMFS followed for analyzing effects of the hatchery program is described in Section 2.4.1 of this opinion.

Factor	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
The hatchery program does promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS	Negligible to negative effect	**Negligible effect:** Hatchery propagated winter-run Chinook salmon from the IRSP are managed to be integrated with the natural population of winter-run Chinook salmon in the Upper Sacramento River and are intended to supplement natural production, thereby providing a demographic enhancement to aid in the rebuilding and recovery of that population. Winter-run Chinook salmon produced at the LSNFH are intended to return as adults to the Upper Sacramento River Basin, spawn in the wild, and become reproductively and genetically assimilated into the natural spawning population. The CBP is conducted by withholding from release a portion of the juveniles produced annually in the IRSP and rearing them to maturity at the LSNFH.
Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities	Negligible to negative effect	**Negligible effect:** Negligible effects are reasonably likely to occur after weighing both positive and negative effects associated with this factor. The Proposed Action: 1. Is designed to reduce the potential for genetic divergence of the hatchery fish from the natural fish and to manage both the hatchery- and natural-origin fish as one population. Indigenous winter-run Chinook salmon are the only source of hatchery broodstock for LSNFH. Naturally spawning winter-run Chinook salmon are collected at the KDFT, the migration terminus of the Upper Sacramento River, and the ACID Dam fish trap. 2. Selection of winter-run Chinook salmon broodstock is accomplished by screening all collected adults using several diagnostic criteria developed to reliably discriminate winter-run Chinook salmon. To be selected as winter-run Chinook broodstock at LSNFH, an adult salmon must satisfy phenotypic criteria (run and spawn timing, location of capture, physical appearance indicators) and genetic criteria (based on seven loci that provide a high-level of discrimination).

Factor	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
		In combination, the phenotypic and genetic criteria used to select winter-run Chinook salmon broodstock provide an accurate and precise discriminatory tool. 3. A factorial-type spawning scheme is used to increase the effective population size of hatchery-origin winter-run Chinook salmon and to limit the spawning of related individuals. 4. Is not likely to result in increased competition for spawning sites (*i.e.*, redd superimposition).
Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas	Negligible to negative effect	**Negligible effect:** Winter-run Chinook salmon juveniles are released at the pre-smolt stage, with the intent that they rear in the freshwater environment prior to smoltification. Releases occur generally around late January or early February; however, actual release timing may occur outside of this target window in order to time the release of winter-run Chinook salmon juveniles to coincide with a high flow and high turbidity event. Winter-run Chinook salmon are released into the Sacramento River at Caldwell Park, Redding, California (RM 298). An objective of the IRSP is that hatchery-origin pre-smolts integrate with natural-origin winter-run Chinook salmon in the Sacramento River. Potential negative effects of competition/displacement between hatchery- and natural-origin winter-run Chinook salmon would likely occur at low levels because: 1) Rearing habitats in the Upper Sacramento River Basin are not considered to be a factor limiting the abundance of winter-run Chinook salmon; 2) Hatchery- and natural-origin winter-run Chinook salmon are of similar size at the time of the hatchery release; 3) Hatchery-origin winter-run Chinook are released after natural-origin winter-run Chinook salmon have established home-territories; and 4) Releases are timed to coincide with high flow events (and increased turbidity) to encourage emigration and decrease ecological interactions in the Upper Sacramento River Basin.

Factor	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
		The average size of hatchery-origin winter-run Chinook salmon pre-smolts at the time of release in January or February is 88 mm FL (range: 46-123 mm, SD = 8.4). Natural-origin winter-run Chinook salmon potentially co-occurring with hatchery-origin winter Chinook salmon (after their release) range in size from 55 to 135 mm. Because hatchery- and natural-origin winter-run Chinook salmon are approximately equal in size during their co-residence in the Sacramento River, predatory interactions are unlikely. Detrimental effects to other races of salmon are unlikely, because of the low number of winter-run Chinook salmon juveniles released annually from LSNFH.
Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean	Negligible to negative effect	**Negligible effect** Effects of the Proposed Action are not detectable. Available information does not show the level of hatchery production that leads to measureable competition, nor does it identify how and to what extent ESA-listed species would be disadvantaged. The conditions under which competitive interactions occur, and competitive advantages and disadvantages for different life-history stages, populations, ESUs and DPSs, and for hatchery and natural-origin fish are not detectable.
RM&E that exists because of the hatchery program	Beneficial to negative effect	**Beneficial effect** Benefits to winter-run Chinook salmon are reasonably certain to occur. The information provided by RM&E will inform adaptive management and that will benefit the survival of the SR winter-run Chinook salmon population. RM&E will include: 1) *Winter Chinook Carcass Survey*: This effort is conducted annually to estimate the abundance of winter-run Chinook salmon spawners in the Upper Sacramento River and to gather information to assist in the evaluation of the IRSP at LSNFH.

Factor	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
		2) *Acoustic tracking of winter-run Chinook salmon adults collected at the KDFT*: This study was developed to help reconcile discordant information resulting from broodstock collections at the KDFT and the winter-run Chinook salmon Carcass Survey. The original purpose of this study was to track the movements of winter-run Chinook salmon following their capture at the KDFT and subsequent release into the Sacramento River to elucidate how and when winter-run Chinook salmon use various habitat types during pre-spawn staging, spawning, and post-spawn senescence. An additional purpose of this project is to examine incidental impacts associated with trapping winter-run Chinook salmon broodstock at the KDFT. Information resulting from this project will be used to assess possible biases associated with the carcass survey methodology and possible incidental impacts associated with trapping broodstock at the KDFT. 3) *Acoustic tracking of juvenile winter-run Chinook salmon released from LSNFH*: The purpose of this study is to determine how water management actions during drought and non-drought years, such as releasing water from reservoirs, influences reach-specific survival of winter-run Chinook. Differences in flow regimes affect exposure to predators via prey movement rates, predator metabolic demands, and turbidity.
Construction, operation, and maintenance of facilities that exist because of the hatchery program	Beneficial to negative effect	**Negligible effect** Construction of the Livingston Stone NFH was completed in 1998. LSNFH is constructed on a 0.4 acre BOR-owned site located approximately 0.5 miles downstream of Shasta Dam on the Keswick Reservoir. The hatchery is situated on the west bank of the Sacramento River, outside the flood plain. No new construction is proposed. Except for the fish trap entrance at Keswick Dam, facilities are located away from the river (upstream of the limit of anadromy) and do not effect designated critical habitat. There is no hatchery weir, Keswick Dam serves this purpose.

Factor	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
		USFWS anticipates no take of ESA-listed or non-listed salmonids through LSNFH water intakes. LSNFH obtains its water through the penstocks of Shasta Dam, an area inaccessible to ESA-listed fishes. Negative impacts to naturally producing salmonid populations and their associated habitats are not expected to result from the discharge of water from LSNFH. The findings of General Order (No. R5-2014-0161) NPDES Permit (No. CAG135001) issued by the RWQCB concluded that discharge at LSNFH is considered minor, and existing wastewater treatment technology is capable of consistently reducing hatchery wastewater constituents to concentrations which are below the level at which the beneficial uses of surface and/or ground water are adversely affected. Beneficial uses include preservation and enhancement of fish, wildlife, and other aquatic resources. Monthly self-monitoring of the hatchery's water supply and effluent is conducted to ensure that water quality parameters are maintained to be compliant with the General Order of the RWQCB.
Fisheries that exist because of the hatchery program	Beneficial to negative effect	**NA**. Fisheries are not proposed as part of the Proposed Action and there are no fisheries that exist because of the Proposed Action.

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

Negligible effect: The overarching goal of the hatchery programs at LSNFH is Preservation/Conservation of the SR winter-run Chinook salmon ESU. Winter-run Chinook salmon are propagated at the LSNFH to conserve genetic resources of a single fish population at low abundance and endangered of extinction. A potential complementary goal of the winter-run Chinook salmon programs at LSNFH is restoration. When the need arises, this goal will be achieved by providing a source of winter-run Chinook salmon to re-establish naturally spawning populations in historical habitats. Reintroductions contribute to preservation and conservation by improving spatial structure, productivity, diversity, and abundance of the SR winter-run Chinook salmon ESU, thereby reducing the likelihood of extinction.

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

Negligible Effect: LSNFH is comprised of two interrelated programs; 1) the Winter Chinook IRSP and the Winter Chinook CBP. In the Winter Chinook IRSP, hatchery propagated winter-run Chinook salmon are managed to be integrated with the natural population in the Upper Sacramento River and are intended to supplement natural production, thereby providing a demographic enhancement to aid in the rebuilding and recovery of that population. Winter-run Chinook salmon produced at LSNFH are intended to return as adults to the Upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated into the natural spawning population. The Winter Chinook CBP is conducted by withholding from release a portion of the juveniles produced annually in the IRSP and rearing them to maturity at LSNFH.

Considerable effort has been made to minimize any adverse genetic or ecological effects to the natural population. For example, winter-run Chinook salmon are collected and spawned throughout the duration of run timing to maintain phenotypic and genetic variability. A factorial-type spawning scheme is used to increase the effective population size of hatchery-produced winter-run Chinook salmon. Phenotypic and genetic broodstock selection criteria are used to ensure that hybridization with other runs does not occur in the hatchery. Further, limits have been established for the collection of natural-origin winter-run Chinook salmon broodstock; the proposed annual limit for broodstock collection is 60 females and up to 120 males, totaling up to 180 adult natural-origin winter-run Chinook salmon. These limits guard against removing too many fish from the naturally spawning population and increase the effective population size of the hatchery component of the population. During years when environmental conditions result in the need for increased hatchery production (limited to a maximum of 400 adult winter-run Chinook salmon for use as broodstock), broodstock collection targets will be determined collaboratively by USFWS, NMFS, and CDFW. Factors such as expected adult escapement, expected environmental conditions, expected juvenile survival, and the number of tagged juveniles available for fishery assessments will be considered when determining whether program expansion is warranted.

Additionally, the program preferentially uses only natural-origin broodstock to reduce the perpetuation of traits associated with domestication selection; however, an exception to this strategy has been made during years when the program was expanded to mitigate for effects caused by severe drought when natural reproduction of winter-run Chinook salmon in the Sacramento River was believed to be jeopardized. Until 2009, the proportion of hatchery-origin winter-run Chinook salmon included as broodstock was limited to 10 percent. Beginning in 2010, USFWS completely discontinued the spawning of hatchery-origin winter-run Chinook salmon, using only natural-origin adults as broodstock. This practice was temporarily suspended during 2014, 2015, and 2016 in order to partially mitigate for extremely poor conditions faced by naturally spawning winter-run Chinook in the Sacramento River resulting from extended drought in California's Central Valley.

In the future, when the program is operated at standard production levels, the IRSP will again strive to exclude hatchery-origin fish from being used as hatchery broodstock. However, USFWS anticipates that there may be a need to consider exceptions to this strategy during some years. For example, it is expected that the spawning escapement during 2017 and 2018 will be comprised of a majority of hatchery-origin fish as a result of increased hatchery production and poor in-river spawning success in 2014 and 2015. Therefore, it will likely be necessary to increase the proportion of hatchery-origin broodstock when the progeny from the 2014-2016 spawning seasons return as adults during subsequent years.

Equal numbers of males and females are targeted for collection in attempt to equalize sexes for a 1:1 spawning ratio. When broodstock collection results in substantially unequal sex ratios, USFWS may alter their broodstock collection strategy. If left uncorrected, an unequal sex ratio would result in a marked reduction in the effective population size and confer undesirable genetic consequences. Therefore, under these circumstances, USFWS may retain hatchery-origin adults, as necessary, to equalize the sex ratios. These hatchery-origin adults would have genetic parentage analysis conducted concurrent with the "rapid response" run verification so to prevent the retention of full siblings, thus keeping genetic diversity as high as possible. Chinook salmon are semelparous and female winter-run Chinook salmon broodstock at LSNFH are therefore killed at the time of spawning. Male broodstock may be used in multiple matings, and spawning events of an individual male may occur over several days, thus males are kept alive until after they are spawned for the final time.

Selection of winter-run Chinook salmon broodstock is accomplished by screening all collected adults using several diagnostic criteria developed to reliably discriminate winter-run Chinook salmon. To be selected as hatchery broodstock, adult salmon must satisfy both phenotypic criteria (run/spawn timing, collection location, and physical appearance) and genetic criteria (based on 96 SNP markers that provide effective discrimination of winter-run Chinook salmon plus another GHpsi marker to identify gender). In combination, the genetic and phenotypic criteria enable accurate and precise identification of winter-run Chinook salmon for use as broodstock at LSNFH.

Operation of the KDFT varies seasonally and between years, depending on broodstock needs and the numbers of fish volunteering into the trap. The trap entrance is opened to collect fish during the day and closed at night. This diurnal operation strategy was developed to exclude predacious river otters from entering the trap at night. When the number of fish entering the trap is high, trapping may be further restricted during daylight hours to preclude the over-collection of broodstock. The KDFT is generally emptied twice per week during the period of winter-run Chinook salmon broodstock collection. Emptying of the trap typically occurs on Tuesdays and Fridays. Therefore, the maximum duration any fish could be confined within the trap is four days. For example, if the trap is emptied on a Friday then it would generally be emptied again the following Tuesday, for a maximum duration of four days.

Fin punch (tissue) samples are collected from captured Chinook salmon. Fin samples from putative broodstock are mailed to the USFWS Abernathy Fish Technology Center within a day after the trap is emptied. A genetic run determination generally requires less than two days, and genetic results are then immediately sent to LSNFH. Confirmed winter-run Chinook salmon broodstock are transferred from the quarantine tank to a holding tank and non-winter Chinook with an intact adipose fin are transferred to the Sacramento River near Redding where they are released. Non-winter-run Chinook salmon with a missing adipose fin (*i.e.*, either stray late-fall Chinook salmon from the CNFH or stray spring-run Chinook salmon from the FRH) are culled and their CWT recovered.

ESA-listed natural-origin CCV steelhead or CV spring-run Chinook salmon may also be trapped at the KDFT while trapping for winter-run Chinook salmon broodstock. Several methods are used to reduce incidental impacts of trapping at the KDFT. First, incidental impacts to non-target stocks of Chinook salmon are reduced by installing a fish counter at the entrance of the KDFT. The fish counter automatically closes the trap door at a pre-determined count; thereby limiting the numbers of fish allowed to enter the trap and prevents overcrowding. Additionally, USFWS recently increased the frequency that the KDFT is emptied, from one day a week to twice weekly. This reduces the duration that non-target fishes will be held captive prior to their release. Lastly, in 2004, USFWS modified trapping protocols at the Keswick Dam to control a problem of otter predation. Since that year broodstock trapping has been restricted to daylight hours to prevent the nocturnal otters from predating upon trapped fishes. A video monitoring program was established at the same time to monitor the area within the fish trap to observe for signs of otter activity.

Even with the measures described above, some of the fish encountered during the collection of hatchery broodstock may be incidentally injured or killed during the process of trapping, transportation, anaesthetization, handling, or during their retention at hatchery prior to spawning. Lethal take of this type, occurring while fish are held captive, is characterized as "pre-spawn mortality" in hatchery records. Pre-spawn mortality of winter-run Chinook salmon is expected to be less than 15 percent of the number of adults retained as broodstock. Pre-spawn mortality results in losses of genetic information and causes lost productivity. Pre-spawn mortality resulting from winter-run Chinook salmon trapping, transportation, handling, sampling, and anaesthetization during years of standard production levels (*i.e.*, >120 broodstock) ranged from 4 to 19 annually from 2000 to 2013. Additional mortality should be expected when the program size is increased, such as was conducted in 2014 and is again being implemented in 2015 to mitigate for effects of prolonged severe drought. For example, in 2014 a total of 64 winter Chinook, nearly 16.5 percent of the number retained, died prior to spawning at the LSNFH.

Incidental mortality of unmarked ESA-listed spring-run Chinook salmon ranged from 0 to 2 annually between 2000 and 2014. Adipose fin-clipped spring-run Chinook salmon from the FRH, which are sacrificed when captured at the KDFT, are not included in these totals. Only one *O. mykiss* mortality has been documented at the KDFT since 2000; an adipose-clipped hatchery-origin steelhead was sacrificed in 2005 to inspect for the presence of a CWT.

It is difficult to quantify the non-lethal effects resulting from stress or injuries occurring during the course of broodstock collection. When an injured fish is encountered in the fish trap it is generally unfeasible to ascertain whether an injury occurred while a fish was captive in the trap or if the fish had been previously injured and subsequently entered the trap. If a fish is known to be injured during the course of trapping activities or during handling it is generally retained for broodstock and is considered pre-spawn mortality if it dies prior to spawning. If it cannot be ascertained that an injury resulted from trapping or handling activities, an injured fish will not likely be retained for use as broodstock; natural spawning success of these fish is unknown.

Information are not available to confidently estimate levels of take to fish that are trapped at the Keswick Dam but not retained for use as hatchery broodstock. Lethal take of fishes trapped and released from the KDFT has previously been estimated at 5 percent of the total number released; however, data are not available to confidently support or refute this estimate. Fishes not meeting phenotypic and genetic criteria, winter-run Chinook salmon in excess of monthly collection targets, and all hatchery-origin winter Chinook, are released into the Sacramento River at Redding, California. The intent of releasing these fish is that they integrate and spawn with the naturally reproducing population. Prior to their release, non-retained winter-run Chinook salmon are externally tagged with two dart-type tags. Tagging enables these fish to be identified if they are subsequently recaptured at the KDFT or encountered as carcasses on the Winter Chinook Carcass Survey. It is not uncommon for dart tagged winter-run Chinook salmon to re-enter the KDFT multiple times during a collection season. Some fish have been trapped at the KDFT as many as six times, with capture dates extending more than four months after the initial collection (USFWS Red Bluff FWO, unpublished data). This information suggests that trapping and handling is not necessarily detrimental to survival, at least for some fishes. However, observations of dart tagged fish on the Winter Chinook Carcass Survey occur far less frequently than would be expected given the numbers of tagged fish released and recent estimates of winter-run Chinook salmon abundance. The lack of observations of tagged winter-run Chinook salmon on the Carcass Survey suggests that released fish may not be successfully contributing to the natural spawning population. Considered together, these data are confounding and do not provide the resolution necessary to characterize the effects of broodstock collection activities on the reproductive success of winter-run Chinook salmon that are not retained as broodstock. USFWS is currently studying movements of winter-run Chinook salmon after they have been trapped at the KDFT and released into the Sacramento River using acoustic telemetry (see Section 2.4.2.5). It is anticipated that these studies will help to elucidate delayed effects of trapping and handling upon released fishes, which can then be used to better quantify estimates of this manner of take.

The new fish trap constructed at ACID Dam has not been previously operated, thus, there is no past take of ESA-listed salmonids at that location. An operator will be present at the trapping site at all times during its operation to prevent overcrowding. When the trap is not in operation, the adjustable fyke panels upstream and downstream of the fish basket will be locked in the open position, thereby affording unimpeded passage to fishes through the fish ladder.

If a Chinook salmon is observed to be within the trap, the operator will lower a floating mesh lid onto the water's surface above the fish basket. Then floating mesh lid prevents fish from jumping from the trap. With the lid covering the top of the basket, the operator will continue to raise the basket to the surface of the water. When the rim of the fish basket is above the water's surface, to a level sufficient to prevent additional inflow of fresh water, the operator will open the valve on the carbon dioxide tank to begin to anaesthetize the fish in the elevated basket. When the fish has calmed to the point where it can be safely handled, the operator will raise the trap to the highest elevation, remove the mesh lid, and inspect the salmon for characteristics of targeted broodstock (*i.e.*, displays phenotypic characteristics of winter Chinook, good physical condition of fish, satisfies targeted sex). If the salmon will be retained for use as hatchery broodstock, the fish will be netted from the elevated basket and transferred to a stock tank, located nearby.

Data collection, tagging, and collection of a sample of fin tissue (identical sampling as conducted at the KDFT) may occur either while fish are in the stock tank or later, when fish arrive at the LSNFH. Transfer from the stock tank to the transport truck will occur in a vinyl bag containing an amount of water sufficient to cover the gills. Water shall be maintained in the sampling tank and fish transport vehicle at all times the trap is being operated. Temperature and oxygen levels will be maintained at levels suitable for winter-run Chinook salmon. Temperature of the water in the sampling tank and fish transport tank shall be maintained to within 2°F of the Sacramento River at the trapping location. Fish that are not retained as hatchery broodstock will be dart tagged and returned to the fish basket, and lowered to an elevation such that fresh water is allowed to flow through the basket. When the fish have the ability to maintain their position in the current and appear to have fully recovered from the effects of anesthesia, the upstream fyke panels will be fully opened, thereby allowing the fish to volitionally swim out of the trap in the upstream direction. Genetic samples from fish retained as broodstock will be submitted to the USFWS Abernathy Fish Technology Center, Longview, Washington for genetic analysis. Non winter-run Chinook salmon would be released upstream of the ACID Dam at Caldwell Park within a week of capture.

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

Negligible Effect: Potential ecological effects of releasing juvenile hatchery-origin winter-run Chinook from the LSNFH include predation, competition/displacement, and disease. Deleterious ecological impacts to winter-run Chinook salmon or other ESA-listed salmonids are not anticipated, primarily due to the small size of the winter-run Chinook salmon program. Production levels in the IRSP are limited to a maximum of 180 adult broodstock annually (60 females and up to 120 males). Numbers of broodstock may be increased up to 400 in the IRSP when the operating under a drought-related program expansion or when contributing to reintroduction efforts, including those proposed for Battle Creek (ICF International 2016). Juvenile production levels increase and decrease with the number of broodstock spawned, with an average of approximately 200,000 pre-smolts being released during a standard production year and up to 750,000 possible during a year of expanded production. Again, program expansion will be determined collaboratively by USFWS, NMFS, and CDFW and will be based on factors such as expected adult escapement, expected environmental conditions, expected juvenile survival, and the number of tagged juveniles available for fishery assessments. The low number of juveniles produced in IRSP, relative to most propagation programs in the Central Valley, limits the potential for negative ecological impacts to ESA-listed fish stocks. More detailed explanations of potential ecological interactions resulting from hatchery-propagated winter-run Chinook salmon are provided below:

Predation: The average size of hatchery-origin winter Chinook salmon smolts at the time of release in late January or early February is 88 mm FL; (range 46-123 mm, SD = 8.4). ESA-listed juvenile salmonids present in the Upper Sacramento River Basin at that time are expected to be equal in size or larger than hatchery-origin winter-run Chinook salmon, making predation very unlikely. For example, naturally produced juvenile winter-run Chinook salmon are expected to range in size from 55 to 135 mm on February 1 (Daily Length-at-Date chart; DWR). Because hatchery-origin and natural-origin winter-run Chinook salmon are approximately the same size during their co-residence in the Sacramento River, intraspecific predation is not likely.

Table 12. Length ranges of natural-origin Chinook salmon and steelhead potentially co-occurring in the Upper Sacramento River Basin with hatchery-origin winter-run Chinook salmon (range: 46 - 123 mm) during January and February.

	Fork Length (mm)	
	Young-of-Year	Yearling
Fall Chinook [a]	0 - 50	202 - 270
Late-fall Chinook [a]	none	111 - 246
Spring Chinook [a]	41 - 67	202 - 270
Winter Chinook [a]	55 - 135	none
Steelhead [b]	none	140 - 200

[a] Length ranges for natural-origin Chinook salmon were taken from a daily length increment table (Sheila Green, DWR).
[b] Steelhead length ranges were back-calculated from scale analysis for the Upper Sacramento River (CDFG, unpublished data).

The timing of winter-run Chinook salmon releases are scheduled to coincide with winter storm events. Cool water temperatures, high flows, and elevated turbidity levels associated with winter storm events create conditions that are both favorable for rapid downstream emigration (Godin 1981) and unfavorable for foraging (Gregory and Levings 1998). Water temperatures in Battle Creek and the Sacramento River are commonly below 10°C during January, reducing the metabolic requirements of predators, and consequently reducing consumption by salmonids. Sacramento River Basin flows during January are highly variable and erratic depending on precipitation events. Dramatic increases of flow in the Sacramento River are usually accompanied by elevated turbidity. Migration of juvenile salmonids is commonly associated with floods and increased water turbidity which reduce underwater light transmission (see review in Godin 1981). The strong tendency of salmonid juveniles to emigrate during periods of high flow and turbidity has been considered an adaptation to avoid predation.

Competition/Displacement: An objective of the IRSP is that hatchery-origin fish integrate with naturally produced winter-run Chinook salmon. Potential negative effects of competition/displacement are not expected to result in deleterious effects for the following reasons: 1) juvenile hatchery-origin winter Chinook are approximately equal in size or smaller than co-occurring natural-origin salmonids; 2) hatchery-origin winter Chinook are released after the vast majority of naturally produced winter-run and spring-run Chinook juveniles have left the upper river system and those that remain have established home territories; 3) the number of winter-run Chinook salmon released from the LSNFH is small compared to the number of juveniles produced annually in the Upper Sacramento River and Battle Creek and the number of juvenile Chinook salmon produced in other hatchery programs; and 4) rearing habitats in the Upper Sacramento River Basin are generally not considered to be limiting the abundance of winter-run Chinook salmon. If juvenile winter-run Chinook salmon are released into Battle Creek as part of the reintroduction effort or if adult Captive Broodstock (or their resulting progeny) are released to "jumpstart" the reintroduction, they will be released into the North Fork of Battle Creek, an area not currently accessible to other hatchery-origin salmonids (access limited by operation of CNFH Weir).

It is possible that size differences between salmonids of hatchery- and natural-origin may lead to differences in habitat selection, thereby reducing the potential for competition/displacement. Hampton (1988) reports larger juveniles select deeper water and faster velocities and fry use low velocity areas at the stream margin where substrate irregularities and other instream features create velocity breaks. As juveniles grow, they move away from the shoreline into higher velocity areas, especially for feeding (Rich 1997 in CDFG 1998).

Disease: Increased transmission or amplification of disease is not expected to result from releasing juvenile winter-run Chinook salmon from LSNFH. Juvenile winter-run Chinook salmon released from LSNFH have been notably healthy and free of disease problems. Lack of disease outbreaks at the LSNFH is attributed to effective prophylactic treatments, good fish culture practices, and a supply of "clean" source water from deep in Shasta Lake. No water disinfection system is currently used to treat water prior to use at LSNFH, but may be necessary in the near future to allay concerns of transmitting disease into the hatchery if anadromous adult salmon are to be introduced to the watershed upstream of Shasta Dam.

Sanitary conditions are maintained during fish rearing by disinfecting (with iodophor) all equipment between uses in raceways. The CA-NV FHC conducts applied research on-site to control disease epizootics. Fish are observed on a daily basis for mortalities and behavioral irregularities. Dead and moribund fish are removed from rearing units daily. In cases of high levels of mortality, necropsies are conducted on diseased and dead fish to diagnose cause of death. Examinations of live juveniles are performed routinely to assess health status and detect problems before they progress into clinical disease or mortality. Appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) are used to alleviate disease-contributing factors.

The CA-NV FHC conducts fish health inspections to observe for indications that disease is present. A pre-release examination is conducted 30 days prior to the scheduled release of juveniles. Tissue samples are screened for viral, bacterial, and parasitic fish pathogens. The pre-release examination is conducted using methods described in the AFS Blue Book and the USFWS Aquatic Animal Health Handbook. The hatchery receives an inspection report that lists the pathogens present, if any.

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

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

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

More recently, NMFS has reviewed the literature for new and emerging scientific information over the role and the consequences of density-dependent interactions in estuarine and marine areas. While there is evidence of density-dependent effects to salmon survival, the currently available information does not support a meaningful causal link to a particular category of hatchery programs. Our conclusion, based on available information, is that hatchery production on the scale proposed in this action and considered in this opinion will have a negligible effect on the survival and recovery of the SR winter-run Chinook salmon ESU. Upon release into the natural environment, following a year of hatchery rearing, less than half of these fish survive the journey to the Pacific Ocean to join tens of millions of other juvenile salmon and steelhead. There is CWT recovery information from fish harvest at sea but these data do not give us insight into fish behavior nor inter-specific interactions among stocks in the ocean (Palmer-Zwahlen and Kormos 2013).

Consequently, as the Proposed Action contributes so little to the potential issue and the science does not show a likelihood of impacts generally, we are confident that the effects of the Proposed Action on the SR winter-run Chinook salmon ESU in the migration corridor, in the estuary and in the Pacific Ocean are negligible.

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

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

Beneficial effect: The Proposed Action addresses the five factors that NMFS takes into account when it analyzes and weighs the beneficial and negative effects of hatchery RM&E (Section 2.4.1. Research, Monitoring, and Evaluation). It includes RM&E to monitor compliance with this opinion and to inform future decisions over how the hatchery program can make adjustments that further reduce risks to ESA-listed winter-run Chinook salmon. The potential for lethal or sub-lethal effects to SR winter-run Chinook salmon are negligible.

Hatchery fish from the Proposed Action will not confuse or conceal the status of any natural population(s) or the effects of the hatchery program on any natural population(s). SR winter-run Chinook salmon have very different life-history characteristics, relative to other runs of Chinook salmon, and it is expected that there will be little spatial or temporal overlap in distribution between the species to cause masking. In addition, hatchery-origin winter-run Chinook salmon will be 100 percent adipose fin-clipped and 100 percent will receive CWTs.

USFWS is currently involved with three research and monitoring projects directly involved with evaluating the effects of the Winter Chinook IRSP: 1) the Upper Sacramento River Winter Chinook Carcass Survey; 2) the Adult Acoustic Telemetry Study to monitor the movements of adult winter-run Chinook salmon that are captured at the KDFT and not retained for broodstock; and 3) the Juvenile Acoustic Tracking Study using acoustic tags to study emigration patterns and survival of juvenile hatchery-origin winter-run Chinook salmon. The Winter Chinook Carcass Survey is permitted through a separate Section 10(a)(1)(A) Permit (#1415-3A), which covers most of the monitoring activities conducted out of the USFWS Red Bluff Fish and Wildlife Office.

Winter Chinook Carcass Survey:
The two primary purposes of the Winter Chinook Carcass Survey project are to estimate the abundance of winter-run Chinook salmon spawners and to gather information to assist in the evaluation of the winter-run Chinook salmon propagation activities at the LSNFH. The estimate of winter-run Chinook salmon abundance is used by the NMFS to develop the JPE, which is used to determine allowable take limits of juvenile winter-run Chinook salmon at the State and Federal pumping facilities (CVP/SWP) in the Sacramento-San Joaquin Delta. Estimates of winter-run Chinook salmon abundance resulting from this project will also be used by the fishery agencies to assess progress towards ESA delisting.

A second objective the Winter Chinook Carcass Survey is to gather information to evaluate the Winter Chinook IRSP at LSNFH. This project is the primary source of information to assess the propagation program and to recommend refinements to increase benefits leading to restoration of a self-sustaining natural population.

Another benefit of this project is that CWTs recovered on this project are used by a multi-agency team to conduct a cohort reconstruction analysis of SR winter-run Chinook salmon. This cohort analysis provides the basis for evaluating the effects of ocean harvest upon this endangered species.

No live fish are handled during the course of conducting this monitoring activity. USFWS anticipates take, in the form of short term and minor disturbance will occur to winter-run Chinook salmon as a result of conducting this monitoring project. This effort monitors the abundance of winter-run Chinook salmon during a time when they are spawning in the Upper Sacramento River. Because this project is conducted during this sensitive and critical life stage, and because this project covers the entire spawn timing and spawning distribution, it is possible that any and all fish in the spawning run could be minimally disturbed by project activities; specifically, operating a motor boat in the vicinity of spawning areas. However, the effects of a disruption are expected to be minor and of short duration and are not expected to affect the spawning success of winter-run Chinook salmon.

Acoustic tracking of winter Chinook adults collected at the KDFT:
This study was developed to help reconcile discordant information resulting from broodstock collections at the KDFT and the Winter Chinook Carcass Survey. The original purpose of this study was to track the movements of adult winter-run Chinook salmon following their capture at the KDFT and subsequent release into the Sacramento River to elucidate how and when these winter-run Chinook salmon use various habitat types during pre-spawn staging, spawning, and post-spawn senescence. An additional purpose of this project is to examine incidental impacts associated with trapping winter-run Chinook salmon broodstock at the KDFT. Information resulting from this project will be used to assess possible biases associated with the carcass survey methodology and possible incidental impacts associated with trapping broodstock at the KDFT.

USFWS anticipates a low level of take (up to 50 winter-run Chinook salmon spawners annually) in the form of minimal additional handling of fish trapped in the KDFT and possible behavioral modifications and mortality resulting from insertion of radio tags into adult winter-run Chinook salmon. Potential effects of gastrically applying acoustic tags may affect the behavior and physiology of SR winter-run Chinook salmon through:

- Increased stress and/or physical harm to the fishes during radio tagging using the gastric insertion method;
- Increased susceptibility to predation and displacement following the release of adults into the Sacramento River;
- Potential mortality associated with tag antenna snagging on debris, although the tag manufacturer has designed the antenna to minimize this possibility.

USFWS does not anticipate direct or indirect mortality to result from this study but also cannot completely discount the potential occurrence. USFWS requests an allowance of 10 percent mortality (*i.e.*, lethal take of five fish) of the total number of fish tagged. This study will be conducted concurrently with winter-run Chinook salmon broodstock collection to minimize or eliminate any additional stress associated with collection, anesthetization, and transport. Gastric insertion of acoustic tags requires minimal additional handling above and beyond that used in normal broodstock collection activities and will not require additional anesthetization or "mutilation" as no surgery will be performed.

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH:
The purpose of this study is to determine how water management actions during drought and non-drought years, such as releasing water from reservoirs, influences reach-specific survival of winter-run Chinook salmon. We will integrate these results into a comparison with collaborative ERP and AFRP funded projects of fall- and spring-run Chinook so that all three distinct runs may be compared within the same year, but under potentially drastically different seasonal flow

regimes. Differences in flow regimes affect exposure to predators via prey movement rates, predator metabolic demands, and turbidity.
Using a mark-recapture framework to estimate survival, with multiple marking and recapture locations and complete capture histories, USFWS and collaborators will relate measured survival at reaches to the factors that affect predator exposure – flow, temperature, turbidity, and timing of hatchery releases. Fish will be "marked" with uniquely coded electronic tags and "recaptured" by the receivers. The pattern of recaptures allows estimation of reach-specific survival rates and probabilities of detection at each receiver. Fish are tagged and released so that they are representative of the population being characterized. It is important to note that in using this method, fish are not actually handled when they are recaptured and rereleased; they are simply detected by the acoustic receivers.

Acoustically tagged winter-run Chinook salmon may experience sub-lethal effects, such as decreased swimming performance, or direct mortality from the implantation of acoustic tags; however, based on previous experience there little evidence of such tag effects. A sub-sample of tagged fish are retained to assess the rate of tag retention and any potential effects associated with the surgical implantation of acoustic tags.

Implantation of micro-acoustic tags by surgery or syringe will be conducted by trained and experienced staff. All of the releases yield smolts with average fork lengths adequate to handle the tag burdens of this proposed study. Tag burdens will not exceed 7.6 percent, following recommendations by previous laboratory studies on acceptable ratios of tag mass to body mass that will not affect juvenile survival.

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

Negligible effect: Operations and maintenance activities included in the Proposed Action will have a negligible effect on ESA-listed species in the Upper Sacramento River Basin and on designated critical habitat. There are no construction activities included in the Proposed Action. Construction of LSNFH was completed in 1998 on a 0.4 acre BOR-owned site located approximately 0.5 miles downstream of Shasta Dam on the Keswick Reservoir. The hatchery is situated upstream of the limit of anadromy, on the west bank of the Sacramento River, outside the flood plain.

Broodstock Collection Facilities
Adult winter-run Chinook salmon broodstock are collected from the Sacramento River at a fish trap constructed onto the face of the Keswick Dam and a supplemental collection facility at the ACID Dam.

The KDFT and associated structures are located in the center of the dam between the powerhouse and the spillway. Broodstock collection facilities consist of a twelve-step fish ladder, a brail-lift, and a 1,000-gallon fish-tank elevator. Salmon and steelhead are attracted to the fish ladder with a 340 cubic feet per second (cfs) jet pump. Additional flow for attracting fish is supplied through diffusers within the ladder floor. The fish ladder is approximately 170- feet long by 38- feet wide, and contains weirs which create pools. The top of the ladder leads to a fyke weir. After passing through the fyke weir, adult fish are contained in a large fiberglass brail enclosure. When the brail is raised, fish are directed into a 1,000-gallon elevator which transports them up the face of the dam to a fish distribution vehicle. Several modifications to the KDFT and associated structures occurred prior to 2001 and resulted in improved operation and maintenance of the structure. Modifications to these structures since 2001 include replacement of the hoist motor and brake system and installation of cameras and an automatic gate, which enable the trap to be monitored and operated to eliminate otter predation. Incidental impacts to non-target stocks of Chinook salmon are reduced by installing a fish counter at the entrance of the KDFT. The fish counter automatically closes the trap door at a pre-determined count; thereby limiting the numbers of fish allowed to enter the trap and prevents overcrowding.

A supplementary fish trap at the ACID Dam provides benefits that may alleviate many of the concerns associated with relying solely on the existing trapping facility at the Keswick Dam. To facilitate salmonid passage, the ACID Dam has two fish ladders to provide access to upstream habitats; a vertical slot fish ladder is located on the north bank of the Sacramento River at Caldwell Park and a pool-and-chute fish ladder is located on the south bank, near to the intake of the ACID canal.

The broodstock trapping facility at the ACID Dam consists of a basket-type trap with enclosed within vertical bar fyke weirs located within the north bank fish ladder. This small-scale trap is designed to be staffed continuously during operation and, as such, it is expected to be limited in the number of fish that may be expected to be captured. While the design and size of the ACID trap impose limits on the numbers of fish that are expected to be collected, the ACID fish trap offers the advantage of being located near to the center of the winter-run Chinook salmon spawning distribution, and thus offers the benefit of improved geographical representation of the entire spawning population as compared to the KDFT.

The ACID fish trap will be staffed continuously by a trained operator when it is being fished. When the trap is not in operation, the adjustable fyke panels upstream and downstream of the fish basket will be locked in the open position, thereby affording unimpeded passage to fishes through the fish ladder.

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

There are no fisheries-related effects associated with the Proposed Action. As indicated above, fisheries are not part of this proposed action and there are no fisheries that exist because of the proposed hatchery program, *i.e.* the "but for" test does not apply and therefore they are not interrelated and interdependent actions.

Winter-run Chinook salmon propagated at the LSNFH are not intended for harvest, although some are incidentally harvested in fisheries targeting non-listed salmon. Most incidental harvest occurs in the ocean recreational fishery south of San Francisco Bay. The primary goal of the IRSP is to provide a demographic enhancement to the natural spawning population in the Upper Sacramento River, assisting in the recovery of that population. As a source of coded-wire tagged winter-run Chinook salmon, the program also indirectly benefits harvest management; recovery of CWTs from winter-run Chinook salmon originating from LSNFH are used to monitor the effectiveness of harvest regulations and to inform decisions related to harvest management, which are aimed at reducing the harvest of SR winter-run Chinook salmon.

Harvest regulations have been enacted to reduce impacts to winter-run Chinook salmon, including time-area restrictions of fisheries and minimum size limits. Recovery of CWTs applied to juvenile winter Chinook salmon released from LSNFH is the source of empirical data used to monitor impact fishery rates. Estimates of ocean harvest hatchery-origin winter-run Chinook salmon from brood years 1998 to 2011 are shown in Table 13 below.

Table 123. Estimated ocean harvest of Sacramento River winter-run Chinook salmon from LSNFH, 1998-2011. Data Source: http://www.rmpc.org.

Brood Year	Freshwater Sport	Ocean Sport	Ocean Troll	Total Harvest
1998	146	131	28	305
1999	0	68	11	79
2000	0	70	26	96
2001	0	39	0	39
2002	0	593	140	733
2003	0	319	30	349
2004	0	20	0	20
2005	0	30	0	30
2006	9	0	0	9
2007	16	0	2	18
2008	0	7	3	10
2009	0	212	31	243
2010	0	21	33	54
2011	4	96	26	126

2.4.2.8. Effects of the Action on Critical Habitat

Negligible effect: This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined that operation of the hatchery program will have a negligible effect on PFBs in the Action Area.

Existing hatchery facilities have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity and no new facilities are proposed. Except for the fish trap entrance at the base of Keswick Dam, hatchery facilities are located away from the river and do not effect designated critical habitat. The fish trap associated with the ACID Dam was recently installed within the existing structure. This installation did not result in the need for consultation, as it was determined that there would be no effect to ESA-listed species or their critical habitat. Trap construction was completed in the existing dry concrete fish ladder on the north bank of the Sacramento River.

Operation of the facilities at LSNFH is not expected to degrade water quality. Water will be returned to the river, upstream of Keswick Dam (in Keswick Reservoir) as authorized by the current NPDES Permit.

No hatchery maintenance activities are expected to adversely modify designated critical habitat.

2.5. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). For the purpose of this analysis, the Action Area is the Upper Sacramento River Basin from Keswick Dam (RM 302) downstream to the RBDD (RM 243) as described in Section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline (whether they are Federal, state, tribal or private). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state or private), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing tribal, state or private activities may become the subject of section 10(a)(1)(B) incidental take permits in the future. The effects of such activities are treated as cumulative effects unless and until an opinion for the take permit has been issued.

Currently-occurring non-Federal actions described in the Baseline section are expected to continue to affect SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead in the Upper Sacramento River Basin at similar levels of intensity.

State, tribal, and local governments have developed plans and initiatives to benefit ESA-listed species and these plans must be implemented and sustained in a comprehensive manner for NMFS to consider them "reasonably foreseeable" in its analysis of cumulative effects. The Federally approved Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014a) is such a plan and it describes, in detail, the on-going and proposed Federal, state, tribal, and local government actions that are targeted to reduce known threats to ESA listed SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead in the Sacramento River. It is acknowledged, however, that such future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits and that government actions are subject to political, legislative and fiscal uncertainties.

Water Diversions

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

Most of the 370 water diversions operating in Suisun Marsh are unscreened (Herren and Kawasaki 2001).

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

Agricultural Practices

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

Conservation Agreements and Easements

Several conservation agreements and easements have been developed and implemented throughout the riparian corridors and uplands of the Sacramento River Watershed. Implementation of these agreements is expected to maintain the current quality of riparian and aquatic habitat in the Sacramento River, and could potentially improve the condition of these habitats for salmonids.

Aquaculture and Fish Hatcheries

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

Increased Urbanization

The Delta, East Bay, and Sacramento regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties are expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial, and Residential Real Estate Directory 2002). A population increase of this magnitude will result in increased urbanization and housing developments, which can impact habitat by altering watershed characteristics, including changing both water use and stormwater runoff patterns. For example, the General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. The city of Manteca (2007) anticipated 21 percent annual growth through 2010 reaching a population of approximately 70,000 people. The City of Lathrop (2007) expected to double its population by 2012, from 14,600 to approximately 30,000 residents. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from water bodies, will not require Federal permits, and thus will not undergo review through the Section 7 consultation process with NMFS.

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

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

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

Global Climate Change

The world is about 1.3°F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide (CO_2) and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change [IPCC] 2001). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Huang and Liu (2000) estimated a warming of about 0.9°F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g.*, salt marsh, riverine, mud flats) affecting salmonid PCEs. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Coast and in the interior of the northwest Pacific coastlines will cause decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to overtake native fish species and impact predator-prey relationships (Petersen and Kitchell 2001, Stachowicz *et al.* 2002).

Global warming is predicted to increase temperature in California's Central Valley between 2°C and 7°C by 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004), with a drier hydrology predominated by precipitation rather than snowfall. The cold snowmelt that furnishes the late spring-run and early summer runoff will be replaced by warmer precipitation runoff. Altered river runoff patterns will transform the tributaries that feed the Central Valley. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Summer temperatures and flow levels in some areas of the Central Valley will become unsuitable for salmonid survival. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead) that must hold below the dam over the summer and fall periods.

Activities within the Nearshore Pacific Ocean

These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in the subsections pertaining to cumulative effects, above, whether future non-Federal actions will lead to an increase in effects to the survival and recovery of listed species. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

2.6. Integration and Synthesis

The Integration and Synthesis Section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (Section 2.4.2) to the environmental baseline (2.3) and to cumulative effects (2.5) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected population(s) in recovery (Sections 2.2.1, 2.2.2, and 2.2.3).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in Section 2.4.2., above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciable reduce the likelihood of survival and recovery of the listed species and their designated critical habitat.

2.6.1. Sacramento River winter-run Chinook Salmon

Best available information indicates that the overall viability of SR winter-run Chinook salmon ESU has declined since the 2010 Viability Assessment (Williams *et al.* 2011). New information indicates an increased extinction risk to this ESU. 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 an increased risk of extinction (Williams *et al.* 2016).

As set out in the Environmental Baseline (Section 2.3), commercial and recreational fisheries that target other stocks of Chinook salmon may result in incidental impacts to winter-run Chinook salmon; however, the impacts associated with commercial and recreational fisheries are not part of the Proposed Action covered in this opinion. These effects are analyzed in a separate ESA consultation (NMFS 2010). Fisheries and harvest managers reevaluate exploitation rates and harvest strategies on an annual basis to reduce impacts to the SR winter-run Chinook salmon ESU.

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

NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.1) and for the Proposed Action at LSNFH, the majority are expected to have negligible or beneficial effects.

Proposed Action-related stressors could reduce the abundance, productivity, and diversity of winter-run Chinook salmon; however the level of impacts resulting from hatchery activities at LSNFH are generally low. This is primarily due to the fact that LSNFH is operated as a Conservation Hatchery with the overall purpose of enhancing the natural population of winter-run Chinook salmon in the Upper Sacramento River Basin, while promoting the recovery of the species through contribution to reintroduction efforts. Proposed activities at LSNFH are not likely to negatively affect the spatial structure of winter-run Chinook salmon because the hatchery is located outside of the area currently used by juvenile and adult winter-run Chinook salmon.

Broodstock Collection: Adverse effects associated with the Proposed Action may occur as handling, stress, delayed migration, injury, or mortality. Although annual abundance levels are currently low, the overall impact of adult capture and handling during broodstock collection is projected to be low. The primary trapping facility (KDFT) is located at the upstream terminus of anadromy in the Sacramento River and is unlikely to result in the capture of a significant portion of the overall number of adults returning to the Upper Sacramento River in a given year. Therefore this activity is expected to have a low level of impact to the winter-run Chinook salmon ESU.

Some of the fish encountered during the collection of hatchery broodstock may be incidentally injured or killed during the process of trapping, transportation, anaesthetization, handling, or during their detention at LSNFH prior to spawning. Lethal effects of this type, occurring while fish are held captive, is characterized as “pre-spawn mortality” in hatchery records. Pre-spawn mortality of winter-run Chinook salmon is expected to be less than 15 percent of the total number of adults retained as broodstock. Pre-spawn mortality can result in the loss of genetic information and productivity. Pre-spawn mortality resulting from winter-run Chinook salmon trapping at KDFT, transportation, handling, sampling, and anaesthetization during years of standard production levels (*i.e*., >120 broodstock) ranged from 4 to 19 annually from 2000 to 2013.

Information are not available to confidently estimate levels of take to fish that are trapped at the Keswick Dam but not retained for use as hatchery broodstock. Lethal effects to fishes trapped and released from the KDFT has previously been estimated at 5 percent of the number released; however, data are not available to confidently support or refute this estimate. Fishes not meeting phenotypic and genetic criteria, winter-run Chinook salmon in excess of monthly collection targets, and all hatchery-origin winter-run Chinook salmon (during years of normal operation), are released back into the Sacramento River at Redding, California. The intent of releasing these fish is that they integrate and spawn with the naturally reproducing population. USFWS is currently studying movements of winter-run Chinook salmon after they have been trapped at the KDFT and released into the Sacramento River using acoustic telemetry (see Section 2.4.2.5). It is anticipated that these studies will help to elucidate delayed effects of trapping and handling upon released fishes, which can then be used to better quantify estimates of this manner of take.

Research, Monitoring and Evaluation: RM&E will also result in potential adverse effects to winter-run Chinook salmon. However, the overall impact of RM&E is considered to be negligible, if not beneficial. For over two decades, research and monitoring activities conducted on anadromous salmonids in California have provided resource managers with a wealth of important and useful information regarding anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, and acoustic tagging efforts have increased the knowledge of anadromous fish abundance as we as migration timing and survival. By issuing research authorizations—including those being contemplated in this opinion—NMFS has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions to sustain anadromous salmonid populations, mitigate adverse impacts on endangered and threatened salmon and steelhead, and implement recovery efforts. The resulting information continues to improve our knowledge of the respective species' life histories, specific biological requirements, genetic make-up, migration timing, responses to human activities (positive and negative), and survival in the rivers and ocean. And that information, as a whole, is critical to the species' survival.

Thus, we expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult abundance and productivity. And because these reductions are so slight, the actions—even in combination—would have no appreciable effect on the species' diversity or structure. Moreover, we expect the actions to provide lasting benefits for the ESA-listed fish and that all habitat effects would be negligible. Added to the Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the action area. To the extent those same activities are reasonably certain to occur in the future, their future effects are included in the cumulative effects analysis. Many of the state and private activities identified in the Baseline are anticipated to occur at similar levels of intensity into the future. The Final Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014a) describes, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed winter-run Chinook salmon in the Sacramento River. It is acknowledged, however, that such future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits and that government actions are subject to political, legislative and fiscal uncertainties.

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

2.6.2. Central Valley spring-run Chinook Salmon

At the ESU level, the spatial diversity within the CV spring-run Chinook salmon ESU is increasing and spring-run are present (albeit at low numbers in some cases) in all diversity groups. The recolonization of CV spring-run Chinook salmon to Battle Creek and increasing abundance in Clear Creek is benefiting the viability of CV spring-run Chinook salmon. Similarly, the reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in rivers where they were once extirpated. Active reintroduction efforts on the Yuba River and below Friant Dam on the mainstem San Joaquin River show promise and will be necessary to make the ESU viable. The CV spring-run Chinook salmon ESU is trending in a positive direction towards achieving at least two populations in each of the four historical diversity groups necessary for recovery with the Northern Sierra Nevada region necessitating four populations (NMFS 2014).

Best available information indicates that the viability of the CV spring-run Chinook salmon ESU has likely improved since the 2010 Viability Assessment (Williams *et al.* 2011). Largest improvements are due to the increase in spatial diversity with historically extirpated populations trending in the positive direction. However, these improvements, evident in the moderate and low risk of extinction of the three independent populations, are certainly not enough to warrant a downgrading of the ESU extinction risk. The recent catastrophic declines of many of the dependent populations, high pre-spawn mortality during the 2012–2015 drought, uncertain juvenile survival due to the drought and variable ocean conditions, as well as the level of straying of FRH spring-run Chinook salmon to other spring-run Chinook salmon populations are all causes for concern for the long-term viability of the ESU (Williams *et al*. 2016).

As set out in the Environmental Baseline (Section 2.3), the CV spring-run Chinook salmon ESU may be affected by fisheries. The effects of this take are analyzed in separate ESA consultations (NMFS 2000). Fisheries and harvest managers reevaluate exploitation rates and harvest strategies on an annual basis to ensure that fisheries for fall- and late fall-run Chinook salmon provide for the survival and recovery of the listed ESUs.

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

NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.1) and for the Proposed Action at LSNFH, all of the factors considered are expected to have negligible effects or no effect on CV spring-run Chinook salmon.

Proposed Action-related stressors could reduce the abundance and productivity of CV spring-run Chinook salmon; however the level of impacts resulting from the project are generally low. Proposed activities at LSNFH are not likely to affect spatial structure or diversity of spring-run Chinook salmon because the hatchery is located outside of the area currently used by juvenile and adult spring-run Chinook salmon and the adult trapping location is at the terminus of anadromous fish migration in the Sacramento River.

Broodstock Collection: Impacts may occur as handling, stress, delayed migration, injury, or mortality. Although information is limited on the annual abundance of CV spring-run Chinook salmon in the Upper Sacramento River, the number of spring-run Chinook salmon likely to be affected by broodstock collection activities is low. Therefore this activity is expected to have a low level of impact to the CV spring-run Chinook salmon ESU.

ESA-listed natural-origin CV spring-run Chinook salmon may be trapped at the KDFT while trapping for winter-run Chinook salmon broodstock. Several methods are used to reduce incidental impacts of trapping at the KDFT. First, incidental impacts to non-target stocks of Chinook salmon are reduced by installing a fish counter at the entrance of the KDFT. The fish counter automatically closes the trap door at a pre-determined count; thereby limiting the numbers of fish allowed to enter the trap, preventing overcrowding. Additionally, USFWS recently increased the frequency that the KDFT is emptied, from one day a week to twice weekly. This reduces the duration that non-target fishes will be held captive prior to their release.

Lastly, in 2004, USFWS modified trapping protocols at the Keswick Dam to control otter predation. Since that year broodstock trapping has been restricted to daylight hours to prevent the nocturnal river otters from predating upon trapped fishes. Additionally, a video monitoring program was established to monitor the area within the fish trap to observe for signs of otter activity.

Information are not available to confidently estimate levels of delayed mortality or adverse impacts to fish that are trapped at the Keswick Dam but not retained for use as hatchery broodstock. Incidental mortality of unmarked ESA-listed spring-run Chinook salmon ranged from 0 to 2 annually between 2000 and 2014. Adipose fin-clipped spring-run Chinook salmon from the FRH, which are sacrificed when captured at the KDFT (for CWT extraction and analysis), are not included in these totals. According to the Final 4(d) Protective Regulations for Threatened Salmonid ESUs (70 FR 37160), NMFS will apply Section 4(d) protections to natural and hatchery fish with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed prior to release into the wild. Hatchery-origin spring-run Chinook salmon from the FRH are not afforded 4(d) Protective Regulations due to their status and origin (threatened, adipose fin-clipped) allowing for the sacrifice of these fish when captured at KDFT.

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

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

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

2.6.3. California Central Valley Steelhead

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

As set out in the Environmental Baseline (Section 2.3), extensive habitat elimination and degradation has been a primary factor leading to the threatened status of CCV steelhead. Physical habitat modifications (*e.g*., dam construction and river straightening and associated riprap applications) and many other anthropogenic effects on habitat have greatly diminished the viability of the DPS. The general baseline stress regime for steelhead in the freshwater, estuarine, and marine environment is similar to that of winter-run and spring-run Chinook salmon, with an exception that there is no targeted ocean fishery for steelhead. Detailed descriptions of baseline stressors to CCV steelhead are provided in Sections 2.2 and 2.3.

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

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

NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.1) and for the Proposed Action at LSNFH, all of the factors considered are expected to have negligible effects or no effect on CCV steelhead.

Proposed Action-related stressors could reduce the abundance and productivity of CCV steelhead; however the level of impacts resulting from the project are generally low. Proposed activities at LSNFH are not likely to affect spatial structure or diversity of CCV steelhead because the hatchery is located outside of the area currently used by juvenile and adult CCV steelhead and the adult trapping location is at the terminus of anadromous fish migration in the Sacramento River.

Broodstock Collection: Take may occur as handling, stress, delayed migration, injury, or mortality. Although information is limited on the annual abundance of CCV steelhead in the Upper Sacramento River, estimated take is low, therefore this activity is expected to have a low level of impact to the CCV steelhead salmon ESU.

ESA-listed natural-origin CCV steelhead may be trapped at the KDFT while trapping for winter-run Chinook salmon broodstock; however, the number of steelhead trapped in past years has remained low. Several methods are used to reduce incidental impacts of trapping at the KDFT. See the CV spring-run Chinook salmon section above (Section 2.6.2) for more information on these methods.

It is difficult to quantify the non-lethal effects resulting from stress or injuries occurring during the course of broodstock collection. However, the maximum annual number of *O. mykiss* (steelhead/rainbow trout) trapped at the KDFT while collecting winter-run Chinook salmon broodstock is 104 adults (in 2004). Moreover, only one *O. mykiss* mortality has been documented at the KDFT since 2000; an adipose fin-clipped hatchery-origin steelhead was sacrificed in 2005 to inspect for the presence of a CWT.

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

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

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

2.6.4. Critical Habitat

Critical habitat for ESA-listed SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead is described in Section 2.2.2 of this opinion. After reviewing the Proposed Action and conducting the effects analysis, NMFS has determined that the Proposed Action will not impair PFBs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes nor will it reduce the overall conservation value of critical habitat in the Action Area.

The hatchery water diversion and discharge pose only a negligible effect on designated critical habitat in the Action Area (Section 2.4.2) since all diversions and discharges occur upstream of Keswick Dam. Existing hatchery facilities have not contributed to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity and no new facilities or changes to existing facilities are proposed. ESA-listed salmonids do not spawn or rear in the vicinity of the water diversion or in that reach of the river between the point of diversion and point of water return (Keswick Reservoir). The Final Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014a) identified a number of limiting factors and threats to Central Valley salmonids, including water quality, sediment routing dysfunction, blocked and impaired fish passage, degraded floodplain and channel structure, and hydrologic alterations. None of these factors will be affected in a measureable way by the Proposed Action.

2.7. Conclusion

After reviewing the current status of the listed species, the Environmental Baseline within the Action Area, the effects of the Proposed Action, including effects of the Proposed Action that are likely to persist following expiration of the Proposed Action, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of the SR winter-run Chinook salmon ESU, the CV spring-run Chinook Salmon ESU, and the CCV steelhead DPS or destroy or adversely modify their designated critical habitat.

2.8. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. For the purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or substantially altered.[4] Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not prohibited under the ESA, if that action is performed in compliance with the terms and conditions of the ITS.

2.8.1. Amount or Extent of Take

NMFS analyzed seven factors and identified two that are likely to result in take: 1) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities; and 2) research, monitoring, and evaluation that exists because of the hatchery program.

[4] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The U.S. Fish and Wildlife Service defines "harass" in its regulations as an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the U.S. Fish and Wildlife interpretation of the term.

Encounters with natural-origin and hatchery fish at adult collection facilities*:* In the course of collecting winter-run Chinook salmon for hatchery broodstock, the Proposed Action is expected to handle both hatchery-origin and natural origin adult SR winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead. These are fish that volunteer into the KDFT or ACID Dam fish trap.

Research, Monitoring, and Evaluation: USFWS is currently involved with three research and monitoring projects directly involved with evaluating the effects of the Winter Chinook IRSP: 1) the Upper Sacramento River Winter Chinook Carcass Survey; 2) Adult Acoustic Telemetry Study to monitor the movements of adult winter-run Chinook salmon that are captured at the KDFT and not retained for broodstock; and 3) Juvenile Acoustic Tracking Study using acoustic tags to study emigration patterns and survival of juvenile hatchery-origin winter-run Chinook salmon. The Winter Chinook Carcass Survey project is permitted through a separate Section 10(a)(1)(A) Permit #1415-3A, which covers most of monitoring activities conducted by the USFWS Red Bluff Fish and Wildlife Office.

Table 13. Annual Authorized Take by ESU, Life Stage, Origin, and Activity for Broodstock Collection at the KDFT or ACID Dam for LSNFH.

ESU/ Species[1]	Life Stage	Origin[2]	Take Activity	Take Action	Requested Take	Unintentional Mortality
SR winter-run Chinook salmon	Adult	Natural and Hatchery	Intentional Directed Mortality	Broodstock Collection	400[3]	0
SR winter-run Chinook salmon	Adult	Natural and Hatchery	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Broodstock Collection	825	100[4]
CV spring-run Chinook salmon	Adult	Natural	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Broodstock Collection	175	25
CV spring-run Chinook salmon	Adult	Hatchery	Intentional Directed Mortality	Broodstock Collection	120	0
CCV steelhead	Adult	Natural	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Broodstock Collection	80	2
CCV steelhead	Adult	Hatchery	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Broodstock Collection	20	1
SR winter-run Chinook salmon	Adult	Natural and Hatchery	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Adult Acoustic Telemetry Study	100	10

[1] Take prohibitions to not apply to hatchery-origin (adipose fin clipped) salmonids listed as threatened under the ESA (70 FR 37160). Therefore the take estimates described for hatchery-origin CV spring-run Chinook salmon and CCV steelhead are for tracking purposes only.
[2] Both natural-origin and hatchery-origin winter-run Chinook salmon are considered part of the SR winter-run Chinook salmon ESU. Therefore, the effects to the ESU resulting from the take described above are the same regardless of origin.
[3] Broodstock collection targets shall be limited to a maximum of 180 adult winter-run Chinook salmon adults (60 females and up to 120 males). During years when environmental conditions result in the need for increased hatchery production, broodstock collection targets will be determined collaboratively by USFWS, NMFS, and CDFW.
[4] This estimate for unintentional mortality includes both pre-spawn mortality at LSNFH (400 x 15 percent = 60) and unintentional mortality associated with collecting broodstock at the KDFT and ACID Dam, including loss of fish during transport or holding prior to spawning or prior to release into the wild (825 x 5 percent = 40).

Table 14. Annual Authorized Take by ESU, Life Stage, Origin, and Activity for maintenance of the Captive Broodstock Program and releases of winter-run Chinook salmon from LSNFH.

ESU/ Species	Life Stage	Origin	Take Activity	Take Action	Requested Take	Unintentional Mortality
SR winter-run Chinook salmon	Juvenile	Hatchery	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Juvenile Release	750,000[1]	330,000[2]
SR winter-run Chinook salmon	Juvenile	Hatchery	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Juvenile Acoustic Telemetry Study (Sacramento River)	700	70
SR winter-run Chinook salmon	Juvenile	Hatchery	Capture/Mark, Tag, Sample Tissue	Reared to Maturity for Captive Broodstock Program	1035	518[3]
SR winter-run Chinook salmon	Juvenile	Hatchery (Captive Broodstock Progeny)	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Juvenile Release	375,000[4]	165,000[2]
SR winter-run Chinook salmon	Juvenile	Hatchery	Capture/Mark, Tag, Sample Tissue/Transport/Release Live Animal	Juvenile Acoustic Telemetry Study (Battle Creek)	700	70

[1] The juvenile release target under normal conditions is approximately 200,000 pre-smolts. During years when environmental conditions result in the need for increased hatchery production, releases may be increased up to a maximum of 750,000.

[2] Unintentional Mortality estimate is based on minimum overall (*i.e.*, egg to release) survival from 1998-2014 (range: 56% - 91%).

[3] Based on previous performance of the Winter Chinook Captive Broodstock Program, USFWS anticipates that at least 50% of the fishes retained as Captive Broodstock will survive to sexual maturity, thereby producing approximately 518 mature winter-run Chinook salmon adults per brood year.

[4] During years when Captive Broodstock are in excess of hatchery program needs, adult Captive Broodstock (or their resulting progeny) may be released into North Fork Battle Creek in an effort to "jumpstart" the reintroduction of winter-run Chinook salmon.

2.8.2. Effect of the Take

In Section 2.7, NMFS determined that the level of anticipated take, coupled with other effects of the Proposed Action, is not likely to result in jeopardy to the SR winter-run Chinook salmon ESU, the CV spring-run Chinook Salmon ESU, and the CCV steelhead DPS or in the destruction or adverse modification of designated critical habitat.

2.8.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in Section 7(a)(2) to apply.

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. This opinion requires that the Action Agencies, USFWS and BOR:

1. Minimize the number of hatchery-origin winter-run Chinook salmon that are used as broodstock, to the extent possible, based on the estimated adult escapement and the presence of adequate spawning and rearing conditions in the Upper Sacramento River.
2. Minimize impacts to adult winter-run Chinook salmon that are captured at the KDFT, transported, and subsequently released back into the Upper Sacramento River.
3. Ensure that 100 percent of the juvenile winter-run Chinook salmon released from LSNFH are marked (adipose fin-clipped) and tagged (using CWTs), providing a life-long indicator of origin. Alternative marking and tagging strategies may be used for Captive Broodstock Progeny to differentiate them from fish originating from the Integrated-Recovery Supplementation Program.
4. Provide a source of winter-run Chinook salmon for reintroduction efforts and research and monitoring activities, as approved by USFWS, NMFS, and CDFW.
5. Implement the hatchery programs as described in the HGMPs and monitor their operation and effects on ESA-listed species.
6. Secure additional infrastructure (round tanks, *etc*.) as necessary, to ensure that both hatchery programs (IRSP and CBP) can be maintained securely and successfully at LSNFH.

2.8.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Action Agencies have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) will lapse.

This opinion requires that the Action Agencies, USFWS and BOR:

1a. Develop a Winter Chinook Adult Trapping Plan and Schedule for Broodstock Collection Activities annually. The plan should include details such as the proposed number of broodstock to be collected, the proportion of hatchery-origin winter-run Chinook salmon to be included in the broodstock, the schedule for trapping activities, *etc*. The Adult Trapping Plan and Broodstock Collection Schedule must be approved by NMFS, prior to its implementation.

1b. The SR winter-run Chinook salmon broodstock collection target shall be limited to a maximum of 180 adult winter-run Chinook salmon adults (60 females and up to 120 males). During years when environmental conditions result in the need for increased hatchery production, broodstock collection targets will be determined collaboratively by USFWS, NMFS, and CDFW.

2a. USFWS shall continue to investigate the impacts of trapping at the KDFT and the subsequent release of those fish not used as broodstock at LSNFH. Adjust broodstock collection timeframes as necessary to reduce impacts to winter-run Chinook salmon that are trapped at KDFT and released back into the Upper Sacramento River, increasing the likelihood of successful contribution to the population.

3a. Develop a Juvenile Pre-Release Report annually. The report will include information on the proposed number of juvenile winter-run Chinook salmon to be released, the release location, the tentative date(s) of release, and CWT data. Each year's Juvenile Pre-Release plan must be approved by NMFS, prior to its implementation.

4a. Continue to investigate reach-specific survival of hatchery-origin winter-run Chinook salmon juveniles released from LSNFH (using acoustic telemetry) in order to identify those reaches with higher levels of mortality and potential causes for increased mortality.

4b. Ensure that adequate monitoring and evaluation activities are planned and permitted for releases of winter-run Chinook salmon occurring in North Fork Battle Creek to "jumpstart" reintroduction efforts.

5a. Conduct surveys, annually, to determine the timing, abundance, and distribution of hatchery origin winter-run Chinook salmon that spawn in the Upper Sacramento River.

6a. Provide an annual summary describing the current capacity at LSNFH (within Annual Reports, Pre-Release Reports or as a stand-alone report), taking into account both the IRSP and CBP. This will allow resource managers to keep track of infrastructure needs at LSNFH, ensuring that both hatchery programs remain operational and serve their intended purposes.

The USFWS shall implement the hatchery programs as described in two HGMPs and the Section 10(a)(1)(A) enhancement permit application (16477). The NMFS California Central Valley Area Office must be notified in advance of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

USFWS shall provide a comprehensive annual report to NMFS each year through NMFS' Authorizations and Permits for Protected Species (APPS) site https://apps.nmfs.noaa.gov. The annual report for Permit 16477 should describe the permitted hatchery activities, RM&E activities, and the actual take of ESA-listed salmonids that occurred during the year. USFWS shall also provide the following on an annual basis: 1) A Winter Chinook Trapping Plan and Broodstock Collection Schedule; and 2) A Juvenile Pre-Release Report (as described in Term and Condition 1a and 3a). All reports, as well as all other notifications required in the permit, shall be submitted electronically to the NMFS point of contact for this program:

Amanda Cranford (916) 930-3706, Amanda.Cranford@noaa.gov

Written materials may also be submitted to:

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

2.9. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat (50 CFR 402.02). NMFS has identified one conservation recommendation appropriate to the Proposed Action:

1. The USFWS, in cooperation with the NMFS and other entities, should participate in discussions regarding the prioritization and use of winter-run Chinook salmon produced as part of the CBP. Captive Broodstock may be available to fulfill the following needs: 1) to provide a refugial population of winter-run Chinook salmon 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; 2) contribute to multi-agency efforts to reintroduce winter-run Chinook salmon upstream of Shasta Dam or into the restored habitats of Battle Creek; and 3) to be a source of winter-run Chinook salmon for research projects approved by USFWS, NMFS, and CDFW.

2.10. Reinitiation of Consultation

As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In addition, reinitiation is required if implementation of the Proposed Action is to continue beyond December 31, 2027.

2.11. "Not Likely to Adversely Affect" Determinations

NMFS has determined that, while the Proposed Action may affect SDPS green sturgeon, due to their presence in the Sacramento River and Southern Resident killer whales, due to their dependence on Chinook salmon as a prey item, the Proposed Action is not likely to adversely affect SDPS green sturgeon or Southern Resident killer whales. This determination was made pursuant to Section 7(a)(2) of the ESA implementing regulations at 50 CFR 402, and agency guidance for preparation of letters of concurrence[5], and is described here.

The applicable standard to find that a Proposed Action is "not likely to adversely affect" ESA listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial[6]. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are extremely unlikely to occur.

2.11.1. Southern DPS of North American Green Sturgeon Determination

Several environmental organizations petitioned for listing the North American green sturgeon under the Endangered Species Act in June 2001. A study of the species' status determined that North American green sturgeon is comprised of two DPSs: the northern DPS and the southern DPS. The Northern DPS of green sturgeon consists of populations north of and including the Eel River. The Southern DPS of green sturgeon consists of populations originating from coastal watersheds south of the Eel River and the Central Valley of California. In 2003, NMFS determined that listing was not warranted, but both DPSs were added to the list of candidate species (68 FR 4433; January 29, 2003). Because of remaining uncertainties about the structure of the population and status of the species, NMFS added both the northern and southern DPS to the list of Species of Concern (69 FR 19975: April 15, 2004). A subsequent status review of the two DPSs resulted in a NMFS proposal to list the southern DPS of green sturgeon, but NMFS reaffirmed its earlier determination that the northern DPS did not warrant listing (70 FR 17386; April 6, 2005). The Southern DPS of green sturgeon was listed as threatened on April 7, 2006 (71 FR 17757), and a final rule with protective regulations under ESA Section 4(d) for this DPS was published on June 2, 2010 (75 FR 30714).

Critical habitat was designated for the SDPS green sturgeon on October 9, 2009 (74 FR 52300). A full and exact description of all SDPS green sturgeon critical habitat, including excluded areas, can be found at 50 CFR 226.219. Critical habitat includes the stream channels and waterways in the Delta to the ordinary high water line. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, the Feather River upstream to the fish barrier dam adjacent to the FRH, and the Yuba River upstream to Daguerre Dam. Coastal marine areas include waters out to a depth of 60 fathoms, from Monterey Bay in California, to the Strait of Juan de Fuca in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for SDPS green sturgeon.

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

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

The viability of SDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (National Marine Fisheries Service 2010a). Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany *et al.* 2000b). The best available scientific information does not indicate that the extinction risk facing SDPS green sturgeon is negligible over a long term (~100 year) time horizon; therefore the SDPS is not believed to be viable. To support this statement, the population viability analysis (PVA) that was done for SDPS green sturgeon in relation to stranding events (Thomas *et al.* 2013) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

Although the population structure of SDPS green sturgeon is still being refined, it is currently believed that only one population of SDPS green sturgeon exists. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to SDPS green sturgeon directly, it could be said that SDPS green sturgeon face a high extinction risk. However, the position of NMFS, upon weighing all available information (and lack of information) has stated the extinction risk to be moderate (NMFS 2010a).

SDPS green sturgeon and their critical habitat are present in the Action Area. However, the proposed fish propagation activities at LSNFH are not expected to result in direct or incidental take of SDPS green sturgeon. Substantive differences of life history and habitat use between green sturgeon and winter-run Chinook salmon produced at LSNFH make interactions between these species unlikely to occur. SDPS green sturgeon spawn primarily in the Sacramento River in the spring and summer. Although there is some overlap in timing with spawning adult winter-run Chinook salmon, they utilize different areas of the Upper Sacramento River for spawning. ACID Dam (RM 298.5) is considered the upriver extent of SDPS green sturgeon migration in the Sacramento River (71 FR 17757; April 7, 2006), whereas the majority of winter-run Chinook salmon spawning occurs upstream of ACID Dam where cold water releases from Shasta and Keswick dams provide the thermal refugia necessary for successful spawning and egg incubation (NMFS 2016). This spatial separation is further supported by the fact that SDPS green sturgeon have not been captured at the KDFT during winter-run Chinook salmon broodstock collection activities for LSNFH (USFWS 2016b)

Emigration of juvenile winter-run Chinook salmon fry and pre-smolts past RBDD (RM 242) may begin as early as mid-July, but typically peaks at the end of September, and can continue through March in dry years (Vogel and Marine 1991). Hatchery releases from LSNFH typically occur in January or February depending on environmental conditions. Larval green sturgeon hatch in the late spring or summer (peak in July) (Adams *et al.* 2002) and presumably progress downstream towards the Delta as they develop into juveniles. It is uncertain when juvenile SDPS green sturgeon enter the Delta or how long they rear before entering the ocean. Again, there may be some overlap in the timing of juvenile emigration for SDPS green sturgeon and winter-run Chinook salmon. However, habitat utilization and diet varies among the two species as a result of physiological and morphological differences.

In the mainstems of larger rivers (i.e., the Upper Sacramento River), juvenile Chinooks salmon tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet deep, juvenile salmon tend to inhabit the surface waters (Healey 1982). As they enter the Delta, juvenile Chinook salmon forage in shallow areas with protective cover such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods (Corophium), and larvae of Diptera, as well as small arachnids and ants, are common prey items (Kjelson *et al.* 1982, Sommer *et al*. 2001, MacFarlane and Norton 2002). Alternatively, juvenile green sturgeon are opportunistic benthic feeders that use their barbels and protruding ventral mouth to find prey. In the estuary sturgeon may feed on amphipods, opossum shrimp, clams, or anchovies. (Moyle 2002).

Although SDPS green sturgeon and winter-run Chinook salmon produced at LSNFH may inhabit the Upper Sacramento River during similar times of the year, the substantial differences in morphology, habitat utilization, and diet described above significantly reduce the likelihood for interactions among the two species. SR winter-run Chinook salmon released from LSNFH will not deprive SDPS green sturgeon of their food source or compete for habitat. Therefore any effects to SDPS green sturgeon and their critical habitat as a result of the Proposed Action will be insignificant and discountable.

2.11.2. Southern Resident Killer Whales Determination

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

Southern Resident killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San

Juan Islands. By early autumn, the range of the whales, particularly J pod, expands to Puget Sound. By late fall, the Southern Resident killer whales make frequent trips to the outer coast and are seen less frequently in the inland waters. In the winter and early spring, Southern Resident killer whales move into the coastal waters along the outer coast from southeast Alaska south to central California.

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

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

2.11.3. Conclusion

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

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

NMFS has determined that adverse effects on Pacific Salmon Essential Fish Habitat (EFH) are not expected. No construction is expected to occur under the Proposed Action and no other activities are proposed that will rise to the level of adversely affecting EFH. NMFS expects some benefit will accrue from carcasses of hatchery-origin winter-run Chinook salmon that will slightly increase the level of marine-derived nutrients in the Upper Sacramento River Basin. Therefore, consultation is not necessary.

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) ("Data Quality Act") specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, document compliance with the Data Quality Act, and certifies that this opinion has undergone pre-dissemination review.

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. NMFS has determined, through this ESA Section 7 Consultation that operation of LSNFH as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an Incidental Take Statement. The intended users of this opinion are the USFWS and the BOR (funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of salmonids to the Sacramento River, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of Central Valley salmonids. This information will improve scientific understanding of hatchery-origin Chinook salmon effects that can be applied broadly within the West Coast Region for managing benefits and risks associated with hatchery operations. This opinion will be posted on NMFS' West Coast Region web site (http://www.westcoast.fisheries.noaa.gov). The format and naming adheres to conventional standards for style.

4.2. Integrity

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

4.3. Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased, and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 *et seq*., and the MSA implementing regulations regarding EFH, 50 CFR 600.920(j).

Best Available Information: This consultation and supporting documents use the best available information, as described in the references section. The analyses in this biological opinion/EFH consultation contain more background on information sources and quality.
Referencing: All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

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

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