

FINAL ENVIRONMENTAL ASSESSMENT

ISSUANCE OF AN ENDANGERED SPECIES ACT SECTION 10(A)(1)(A) ENHANCEMENT PERMIT

TO THE U.S. FISH AND WILDLIFE SERVICE

FOR HATCHERY AND GENETIC MANAGEMENT PLANS ASSOCIATED WITH LIVINGSTON STONE NATIONAL FISH HATCHERY



**Prepared by the
National Marine Fisheries Service
West Coast Region, California Central Valley Office**

Cover Sheet

Title of Environmental Review: Issuance of an Endangered Species Act Section 10(A)(1)(A) Permit to the U.S. Fish And Wildlife Service for Hatchery and Genetic Management Plans associated with Livingston Stone National Fish Hatchery

**Evolutionarily Significant Units/
Distinct Population Segments:** Sacramento River winter-run Chinook salmon ESU

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Legal Mandate: Endangered Species Act (ESA) of 1973, as amended and implemented – 50 CFR Part 223

Location of Proposed Activities: Upper Sacramento River watershed in Northern California

Activity Considered: Operation of two hatchery programs for the conservation and recovery of Sacramento River winter-run Chinook salmon. The operator is the United States Fish and Wildlife Service. The Federal action considered in this environmental assessment is the National Marine Fisheries Service's proposed issuance of a Section 10(a)(1)(A) enhancement permit for these hatchery programs.

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LIST OF ACRONYMS

ACID	Anderson-Cottonwood Irrigation District
BOR	United States Bureau of Reclamation
CA-NV-FHC	California-Nevada Fish Health Center
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CEQ	Council on Environmental Quality
cfs	cubic feet per second
CRWQCB	California Regional Water Quality Control Board
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWT	Coded Wire Tag
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DPS	Distinct Population Segment
EA	Environmental Assessment
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
GCID	Glenn-Colusa Irrigation District
gpm	gallons per minute
HGMP	Hatchery and Genetic Management Plan
KDFT	Keswick Dam Fish Trap
LSNFH	Livingston Stone National Fish Hatchery
mmFL	millimeters Fork Length
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
PFMC	Pacific Fishery Management Council
RBDD	Red Bluff Diversion Dam
RM	River Mile
RPA	Reasonable and Prudent Alternative
SWP	State Water Project
USFWS	United States Fish and Wildlife Service

1 PURPOSE AND NEED

1.1 Background

The Sacramento River winter-run Chinook salmon Evolutionarily Significant Unit (ESU) is listed as endangered under the Endangered Species Act (ESA). They were first listed under emergency provisions in August of 1989 (54 FR 32085) and formally listed as threatened in November 1990 (55 FR 46515). In June 1992, NOAA's National Marine Fisheries Service (NMFS) proposed that winter-run Chinook salmon be reclassified as an "endangered" species (57 FR 27416). The final rule that re-classified winter-run Chinook salmon as endangered went into effect on January 4, 1994 (59 FR 440). NMFS determined that winter-run Chinook salmon in the Sacramento River warranted listing as an endangered species because of several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the "take" of winter-run Chinook salmon (65 FR 42422).

The ESU currently includes only one naturally spawning population that is limited to the Upper Sacramento River (below Keswick Dam) in California's Central Valley (June 28, 2005, 70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212).

1.2 History of the Winter Chinook Propagation Program

Livingston Stone National Fish Hatchery (LSNFH) was constructed by the United States Bureau of Reclamation (BOR) in 1997 for the explicit purpose of propagating ESA-listed winter-run Chinook salmon to partially mitigate for the construction of Shasta Dam. 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 United States Fish and Wildlife Service (USFWS) initially attempted to propagate winter-run Chinook salmon at Coleman National Fish Hatchery (Coleman NFH) in 1955. This first attempt, as well as subsequent efforts from 1958 through 1967, was largely unsuccessful. From 1978 through 1985, attempts to propagate winter-run Chinook salmon at Coleman NFH were again met with limited success. High water temperatures at Coleman NFH resulted in considerable mortality of adult broodstock, eggs, and juveniles.

In 1988, a Cooperative Agreement between NMFS, BOR, USFWS, and the California Department of Fish and Game (CDFG) outlined a 10-point plan to implement actions to improve the status of winter-run Chinook salmon in the Sacramento River basin. Included in this plan was the development of an artificial propagation program at Coleman NFH, including necessary facilities and operations to meet hatchery production goals. With the population of winter-run Chinook salmon in severe decline, USFWS reinitiated a winter-run Chinook salmon propagation program at Coleman NFH in 1989. The goal of the winter-run Chinook salmon hatchery propagation program was to supplement natural spawning in the upper Sacramento River. To improve the likelihood that fish reared at the Coleman NFH would return to the upper Sacramento River and integrate with the naturally spawning population, juvenile winter-run Chinook salmon were released at the pre-smolt stage in the vicinity of Redding, California.

The first major production group of winter-run Chinook salmon juveniles from the Coleman NFH was released in 1992; however, none of the fish from this release were observed during monitoring efforts in the upper Sacramento River in 1994, the year the majority of these fish were expected to return. Subsequently, monitoring conducted by the USFWS Hatchery Evaluation Program observed that a considerable portion of hatchery-propagated winter-run Chinook salmon adults were returning to Battle Creek and not assimilating with the natural population in the Sacramento River. These observations suggested that rearing and release strategies intended to imprint hatchery-origin winter Chinook juveniles to the mainstem Sacramento River were ineffective. This situation, combined with evidence of possible hybridization with spring-run Chinook salmon in the propagation program, resulted in a two year (1996-1997) moratorium on the capture of natural winter-run Chinook salmon broodstock. Hatchery spawning of winter-run Chinook salmon adults in 1996 and 1997 was limited to only a small number of adults that were available from the Captive Broodstock Program.

Construction of a new mainstem Sacramento River facility (LSNFH) in 1997 and the implementation of refined genetic methods for broodstock selection ameliorated concerns of straying and hybridization that led to the moratorium, so collection of winter-run Chinook salmon broodstock was re-initiated in 1998. Juvenile winter Chinook were first released from LSNFH in April 1998.

1.3 Purpose and Need Statement

NMFS is reviewing the ESA Section 10(a)(1)(A) permit application submitted by the USFWS to evaluate whether the application meets applicable criteria specified in Section 10(a)(1)(A) of the ESA and NMFS' implementing regulations. Additionally, NMFS is reviewing under ESA Section 7 whether issuance of the permit is likely to jeopardize the continued existence of any endangered or threatened species or result in

the destruction or adverse modification of any critical habitat designated for such species under the ESA. As provided in ESA Section 10(a)(1)(A), the purpose for such a permit is for scientific purposes or to enhance the propagation or survival of the affected species, which is the Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) for this permit application. If NMFS determines that the application meets all of the applicable criteria, NMFS shall issue the ESA Section 10(a)(1)(A) permit for implementation of the programs proposed in the permit application and associated Hatchery and Genetic Management Plans (HGMPs). Issuance of an ESA Section 10(a)(1)(A) permit is a Federal action subject to analysis for potential environmental impacts under NEPA.

1.4 Action Area

The Action Area of the Proposed Action includes LSNFH, located in the upper Sacramento River Basin of Northern California, downstream to the Red Bluff Diversion Dam (RBDD) including tributaries (i.e., Battle Creek). 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. See Figure 1-1 for a map of the action area.

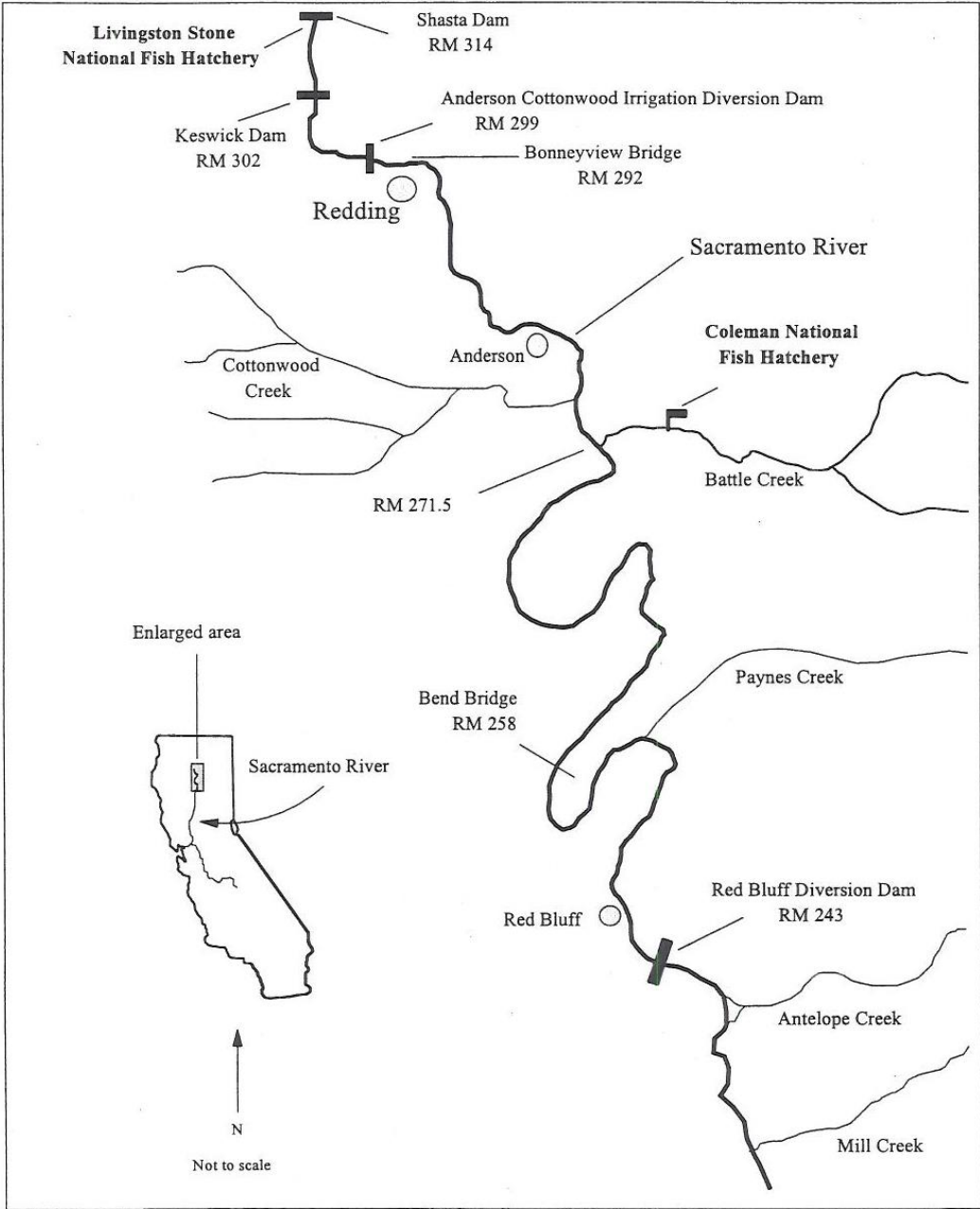


Figure 5-1. Action Area for the Proposed Action

1.5 Public Involvement

1.5.1 Scoping

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,b). The HGMPs described the Proposed Action and the

potential effects of the action on Sacramento River winter-run Chinook salmon, Central Valley (CV) spring-run Chinook salmon, and California Central Valley (CCV) steelhead. As part of the scoping process the following events occurred:

- On August 22, 2016, NMFS published a Notice of Receipt in the *Federal Register*, requesting public comment on the submitted section 10(a)(1)(A) permit application and the associated HGMPs. No comments were received from the public.

2 ALTERNATIVES

2.1 Alternatives to be Analyzed

Two alternatives are considered in this EA: (1) do not issue the permit, do not approve HGMPs (No-action), and (2) issue the permit with conditions and approve HGMPs (Proposed Action/Preferred Alternative).

2.1.1 Alternative 1: Do Not Issue the Permit, Do Not Approve the HGMPs (No-action Alternative)

Under a No-action Alternative, NMFS concludes that the permit application does not meet the ESA section 10(a)(1)(A) permit issuance criteria and approval of the associated HGMPs is not warranted. NMFS would not issue the ESA section 10(a)(1)(A) permit to USFWS authorizing take of ESA-listed species associated with the requested hatchery propagation activities. For the purpose of this analysis, this alternative would not allow the activities necessary for successful hatchery supplementation program, nor would it allow for continued operation of a captive broodstock program. Consequently, any directed take of winter-run Chinook salmon for the purpose of artificial propagation would result in a violation of section 9 of the ESA. Therefore, it is unclear at this point how USFWS would continue hatchery operations at LSNFH.

2.1.2 Alternative 2: Issue the Section 10(a)(1)(A) Permit with Conditions and Approve the HGMPs (Proposed Action/Preferred Alternative)

The Proposed Action is to issue a permit under section 10(a)(1)(A) of the ESA to USFWS, for a period of ten years authorizing the implementation of two HGMPs at LSNFH: (1) the Winter Chinook Integrated-Recovery Supplementation Program, and (2) the Winter Chinook Captive Broodstock Program. The section 10(a)(1)(A) enhancement permit application and the associated HGMPs have been submitted by the USFWS to fulfil their obligation for consultation under section 7(2)(a) of the Federal ESA. The submitted HGMPs are intended to provide a single, comprehensive source of information to describe and assess the impacts of current and proposed operations of LSNFH on ESA-listed Central Valley populations of anadromous salmonids and the Southern Distinct Population Segment (SDPS) of North American green sturgeon. As a result of permit issuance, an exception to the take prohibitions described in 50 CFR § 223.203 would apply to the authorized activities. These activities are outlined in the permit application and associated HGMPs and include actions related to propagation of winter-run Chinook salmon at LSNFH (as described below in Section 2.1.2.1) and monitoring of winter-run Chinook salmon in the Sacramento River (as described below in Section 2.1.2.3). Through implementation of the HGMPs,

the Winter Chinook Integrated-Recovery Supplementation Program and Winter Chinook Captive Broodstock Program will be operated to conserve listed species.

2.1.2.1 Artificial Propagation Activities

The HGMPs include a number of biologically-based hatchery management strategies, all directed toward improving the propagation of winter-run Chinook salmon at LSNFH in a manner consistent with conservation of salmonid species. The management strategies and activities in the HGMPs submitted by USFWS have been incorporated into the section 10(a)(1)(A) permit, and are summarized as follows:

Table 7-1. Integrated-Recovery Supplementation Program details under current conditions

Program	Facility	Start Date	Broodstock Numbers	Broodstock Collection Method	Target Juvenile Release ¹	Release River ²	Adult Release	Mark Percentage	Mean Adult Escapement
Sacramento River winter-run Chinook salmon	Livingston Stone National Fish Hatchery	1998	60 females and up to 120 males	Keswick Dam Fish Trap	200,000-250,000 (750,000)	Sacramento River at Caldwell Park (RM 299)	Sacramento River	100	4,485 (2005-2015)

Source: USFWS 2016a,b

¹ Numbers in parentheses () indicate potential expanded production levels due to poor environmental conditions or contribution to initiate reintroduction efforts.

² In the event production is increased for contribution to reintroduction efforts, juveniles may also be released into North Fork Battle Creek. In these situations, potential expansion of program goals will be determined collaboratively by USFWS, NMFS, and CDFW.

Table 2-2. Winter Chinook Captive Broodstock Program details under current conditions

Program	Facility	Start Date	Broodstock Numbers	Broodstock Collection Method	Target Juvenile Release	Release River ²	Adult Release	Mark Percentage
Sacramento River winter-run Chinook salmon	Livingston Stone National Fish Hatchery	1991 ¹ and 2015	Up to 1,000 juveniles withheld annually	Juveniles from Integrated-Recovery Program withheld from release and maintained as Captive Broodstock	N/A	To be determined	N/A	100

Source: USFWS 2016a,b

¹ A Captive Broodstock Program for Sacramento River 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 Captive Broodstock Program was reinitiated in 2015, as a result of a mutual decision by USFWS, NMFS, and CDFW.

² Captive Broodstock and their progeny could be used for future reintroduction efforts (i.e., above Shasta Dam). However, those reintroduction efforts have yet to be permitted. Release of fish originating from the Captive Broodstock Program for reintroduction purposes will be permitted separately. During years when Captive Broodstock adults or their progeny are in excess of the current needs and are deemed unnecessary, they may be released into North Fork Battle Creek in order to “jumpstart” reintroduction efforts rather than allowing all unused fish to intentionally senesce (i.e., expire or die) in the hatchery.

Broodstock Collection and Mating: Broodstock for the Winter Chinook Integrated-Recovery Supplementation Program are obtained from the main stem Sacramento River, primarily at the Keswick Dam Fish Trap (KDFT). USFWS has recently completed the construction of a secondary trapping facility for winter-run Chinook salmon at the Anderson-Cottonwood Irrigation District (ACID) Dam. This trapping facility will benefit from being situated near the center of the distribution of winter-run Chinook salmon spawning. Trapping for winter-run Chinook salmon broodstock occurs from approximately mid-February through July. Adult (age-3 and older) and "jack" (age-2) winter-run Chinook salmon are collected for broodstock. Age-2 winter-run Chinook salmon are spawned at their rate of occurrence at the trapping facilities. Monthly broodstock collection targets are established to ensure appropriate representation of the complete run timing of winter-run Chinook salmon.

Adult broodstock for the Winter Chinook Integrated-Recovery Supplementation Program are transported to the LSNFH in either an aerated and insulated 2,000-gallon or 250-gallon fish hauling truck. Transport to LSNFH requires less than one hour. Upon arrival at the hatchery, fish are sedated by infusing carbon dioxide into the water or allowing them to deplete oxygen levels to the point they can be handled. Sedated fish are then sorted based on phenotypic factors. All fish initially identified by phenotypic characteristics as a potentially being winter-run Chinook salmon are subsequently subjected to genetic verification of run determination. Tissue samples are taken from each candidate broodstock prior to placement into a quarantine tank, and a color-coded and numerically labeled dart-type tag is attached near the dorsal fin. Within 24 hours, tissue samples are sent to the USFWS Abernathy Fish Technology Center for genetic analyses. Run determination from the genetic analyses is usually available 24 to 48 hours after tissue samples arrive at the laboratory. Quarantined salmon that are genetically confirmed as being winter-run Chinook salmon are treated with an injection of antibiotics. Malachite green is also used to treat fish as an anti-fungal. Fish are then transferred into a second 20-foot diameter circular tank for holding until ready to spawn.

Pairing of winter-run Chinook salmon used as broodstock for both the Captive Broodstock Program and the Integrated-Recovery Supplementation Program is informed by a genetic analysis that assesses kinship amongst broodstock that are ready for spawning. Based on the results of the kinship analysis, most-distantly related parent pairs are preferentially mated together. This strategy is intended to reduce the potential for mating siblings and closely related fish. A factorial mating scheme is used to promote the retention of genetic variability from winter-run Chinook salmon broodstock and increase the effective population size.

Unlike typical production-oriented hatchery programs, the Winter Chinook Integrated-Recovery Supplementation Program does not have a fixed annual target for juvenile production. Rather, production levels are dictated by the number of broodstock that are collected and spawned annually, which is dependent upon the estimated upriver escapement. 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 per brood year (*i.e.*, when run sizes are greater than 800). In emergency situations, such as the extreme drought that was experienced during the summers of 2014 and 2015, production of winter-run Chinook salmon was 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. This temporary expansion of winter-run Chinook salmon propagation activities 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. In the future should the need arise, potential expansion of program goals (in response to poor environmental conditions in the upper Sacramento River or to jump-start reintroduction efforts in Battle Creek) will be determined collaboratively by USFWS, NMFS, and CDFW.

Since the inception of LSNFH, the majority of hatchery broodstock have been of natural-origin. Prior to 2010, hatchery broodstock included up to 10 percent hatchery-origin winter-run Chinook salmon. Beginning in 2010, USFWS discontinued spawning hatchery-origin broodstock to limit the effects of domestication selection. This practice was temporarily modified during 2014, 2015, and 2016, when the Integrated-Recovery Supplementation Program was substantially increased in size (*i.e.*, approximately three-fold larger) to mitigate for continued extreme drought. In order to obtain sufficient broodstock to increase the size of the program, it was necessary to utilize hatchery-origin winter-run Chinook salmon for broodstock. In the future, when operating at standard production levels, the Integrated-Recovery Supplementation Program will again strive to exclude hatchery-origin fish from being used as 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 for 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 during 2014 and 2015. Therefore, the principal differences in broodstock collection activities planned for 2017 and 2018 include the following three changes: (1) the desire 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.

Egg Incubation, Rearing, and Release: The eggs from each female winter-run Chinook salmon are divided into two lots of approximately equal size, and each lot receives the milt from a different male creating two half-sibling 'family groups'. The eggs of each female are incubated in a single egg tray, separated by a partition such that half-sibling family groupings are maintained separately. Incubating eggs in this manner enables estimation of contribution by each parent pair to the total production. Once hatched, winter-run Chinook salmon sac-fry (alevin) remain in incubator trays until button-up, at which time they are transferred, by groupings of families, to 30-inch diameter (10.2 cubic foot) circular tanks and are started on commercial feed. Juvenile winter-run Chinook salmon are reared outdoors to provide exposure to natural patterns of daylight. Overhead cover is used on outdoor rearing tanks to provide shading, reduce exposure to humans, and decrease the risk of predation. Automated feeder belts are used to reduce habituation to humans.

Winter-run Chinook salmon produced at LSNFH are released at the pre-smolt stage. 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. Releases will be timed to coincide with storm events, to the extent practicable, resulting in increased flow and turbidity. The preferred release timing is January-February, however, releases may be delayed into March, if necessary, to synchronize with favorable release conditions. Releasing hatchery-origin winter-run Chinook salmon in January-March reduces concurrent residence (and thus reduces ecological interactions) with naturally produced winter-run Chinook salmon in the upper Sacramento River watershed. This approach also encourages smoltification at the same time and size as naturally produced winter-run Chinook salmon. Releases will occur at dusk and be timed to coincide with storm events resulting in increased flow and turbidity, to the extent possible, to reduce the likelihood of predation soon after release.

Juvenile winter-run Chinook salmon are transported approximately 11 miles to the release site at Caldwell Park (Redding, California) 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. Winter-run Chinook salmon from LSNFH are not acclimated prior to their release. Because releases occur near their rearing location (*i.e.*, minimal travel time), using 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 juvenile winter-run Chinook salmon in acclimation pens prior to release.

All juvenile winter-run Chinook salmon propagated at LSNFH are marked prior to release by removing (clipping) the adipose fin. Additionally, a coded-wire tag (CWT) is inserted into their snout. A portion of the juvenile winter-run Chinook salmon that are released may also receive an acoustic tag, which provides information on survival and timing of emigration.

During some years Captive Broodstock adults and/or their progeny may be in excess of the current needs and may be deemed unnecessary for supplementation, research, or reintroduction purposes. In these instances, excess Captive Broodstock adults or their progeny may be released into North Fork Battle Creek in order to “jumpstart” reintroduction efforts rather than allowing all unused fish to intentionally senesce (*i.e.*, expire or die) in the hatchery. It is important to note that Captive Broodstock and their progeny could be used for future reintroduction efforts (*i.e.*, above Shasta Dam). However, planning is still underway and those reintroduction efforts have yet to be permitted. Release of fish originating from the Captive Broodstock Program for reintroduction purposes will be permitted separately. The proposed release of Captive Broodstock into North Fork Battle Creek considered here will only occur when adults or their progeny are in excess of the current needs and these releases are intended to serve as a preliminary effort, until the formal plan for reintroducing winter-run Chinook salmon to Battle Creek can be permitted and enacted.

2.1.2.2 Research, Monitoring, and Evaluation (RM&E)

USFWS is currently involved with three research and monitoring projects directly involved with evaluating the effects of the Winter Chinook Integrated-Recovery Supplementation Program: 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 Telemetry 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, which covers most of the monitoring activities conducted out of the USFWS Red Bluff Fish and Wildlife Office (RBFWO). All

information pertaining to the Winter Chinook Carcass Survey (including authorized take levels) can be found within USFWS' section 10(a)(1)(A) permit 1415-3A.

The Adult Acoustic Telemetry 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.

The purpose of the Juvenile Acoustic Telemetry 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. 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 will relate measured survival at reaches to the factors that affect predator exposure such as 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 re-released; they are simply detected by the acoustic receivers.

2.2 Alternatives Considered and Eliminated from Further Consideration

NMFS concluded that the alternatives described below would not achieve the objective to enhance the propagation or survival of the Sacramento River winter-run Chinook salmon ESU consistent with the Purpose and Need for the Proposed Action. Thus, NMFS will not analyze these alternatives in detail in this EA.

2.2.1 Eliminate Hatchery Production/Improve Habitat

Under this alternative, the LSNFH winter-run Chinook salmon programs would be eliminated and mitigation goals would focus on improving habitat in the upper Sacramento River basin below Keswick Dam.

Water temperature in the Sacramento River is controlled by releases from Shasta, Whiskeytown, and Keswick reservoirs. NMFS issued a biological opinion on the long-term operation of the Central Valley Project (CVP) and the State Water Project (SWP), hereafter referred to as the OCAP BO, which included upper Sacramento River water temperature requirements to protect ESA-listed anadromous fish and their critical habitats (NMFS 2009). However, the threat of warm water releases from Shasta and Keswick dams still remains a significant stressor to winter-run Chinook salmon, especially given the recent extended drought in California from 2012 through 2015. The combination of low precipitation and high temperatures results in less cold water available in the Shasta reservoir to control instream water temperatures downstream in the Sacramento River. The resulting increased in-river water temperature resulting from such drought conditions reduces the availability of suitable holding, spawning, and rearing conditions in the Sacramento River. The lack of cold water stored behind Shasta Dam, in combination with water release decisions, led to a loss of stream temperature control below Shasta Dam in September 2014. Warm water releases from Shasta Lake during 2014 and 2015 contributed to 5.6 percent and 4.2 percent egg-to-fry survival rates to the Red Bluff Diversion Dam (RBDD) in 2014 and 2015, respectively. Under varying hydrologic conditions from 2002 to 2013, winter-run Chinook salmon egg-to-fry survival ranged from three to nearly 10 times higher than in 2014 and 2015.

Even with improvements to habitat in the upper Sacramento River, unfavorable water temperatures during summer months could still adversely impact naturally spawning winter-run Chinook salmon and their progeny. While winter-run Chinook salmon have historically been able to withstand droughts, the currently diminished habitat, abundance, spatial structure, and diversity of the ESU, and the increased frequency and duration of droughts predicted to occur as climate change progresses suggest that winter-run Chinook salmon are likely much more vulnerable to drought today than they were historically. Prolonged drought and shifts in the timing and/or amount of snowmelt runoff could easily render most existing winter-run Chinook salmon habitat unsuitable due to elevated water temperatures. Without the ability to supplement natural winter-run Chinook salmon production with juveniles produced at LSNFH during years of drought (or other potentially catastrophic events), the population may experience a complete year-class failure, resulting in a severe genetic bottle neck, significantly reducing the overall viability of the Sacramento River winter-run Chinook salmon ESU.

2.2.2 Reduce Hatchery Production

Under this alternative, hatchery production would be reduced by 50 percent resulting in the annual release of approximately 100,000 pre-smolts. USFWS would collect up to 30 adult natural-origin winter-run Chinook salmon females and up to 60 males for use as broodstock at LSNFH.

Different rates of reductions in program size (*i.e.*, 25 percent or 75 percent) were not considered further for this analysis. Given the low level of production that is currently proposed (Proposed Action/Preferred Alternative), a 25 percent reduction in hatchery production is not expected to significantly change the level or severity of impacts associated with the current production target for LSNFH. Moreover, a reduction in hatchery production at rates greater than 50 percent (*i.e.*, 75 percent) would result in a smaller number of fish used as broodstock, increasing the probability that inbreeding and gene swamping would occur in the population (Ryman and Laikre 1991). Both effects can result in decreased effective population size and fitness. It would also be difficult to collect broodstock (both at the hatchery and in the wild) that represent the full range of life history diversity present in the population. The fewer the number of fish collected, the more likely that hatchery operations will decrease diversity. Similarly, the smaller the number of fish released from a hatchery program, the higher the probability that random events may result in unexpected low adult returns. Reducing the number of fish released from the hatchery increases the probability that an entire brood year may be lost due to random variation in post-release survival.

Under this alternative, winter-run Chinook salmon produced by LSNFH would act as a gene bank for the population (protecting species diversity), ensuring that enough fish return each year to reduce demographic risks associated with low natural production. The reduction in juvenile release numbers proposed under this alternative could also decrease possible competition and predation impacts to natural-origin juveniles. However, it is important to note that fish produced at LSNFH are the only source of coded-wire-tagged winter-run Chinook salmon. Changes to production levels at LSNFH can affect the minimum sample size of tagged individuals, thereby impacting the likelihood of tag recovery which has broad implications for management of the ESU and fisheries off the West Coast.

State and federal fishery managers involved in the Pacific Fishery Management Council (PFMC) process continue to develop management recommendations for ocean commercial and sport fisheries premised on recovery of tagged (CWT) winter-run Chinook salmon encountered in these fisheries. The PFMC and its advisors use the CWT recovery information to recommend appropriate management measures that comply with ESA consultation standards. Escapement information from previous seasons is used to

establish an allowable fishery impact rate on the Sacramento River winter-run Chinook salmon stock before each fishing season, which is then evaluated post-season based on the CWT recoveries. Reducing the number of tagged juveniles below average levels (approximately 250,000) means a reduction in the likelihood of recovering those fish in ocean fisheries two years later. Effectiveness of management that relies on tag recoveries becomes more uncertain when tag recoveries become extremely rare events, which could result in reduced protection for the Sacramento River winter-run Chinook salmon ESU. Therefore, in order to maintain adequate protections for winter-run Chinook salmon during ocean commercial and sport fisheries, USFWS should ensure that at least 200,000 juveniles (with CWTs) are released from LSNFH annually, except when predicted escapement estimates warrant reduced broodstock collection levels.

2.2.3 Eliminate Integrated-Supplementation Program/Maintain Captive Broodstock Program

Under this alternative, the Winter Chinook Captive Broodstock Program would be maintained to serve as a source of winter-run Chinook salmon in the event of a catastrophic decline in the abundance of winter-run Chinook spawners in the Sacramento River.

The Integrated-Recovery Supplementation Program and the Captive Broodstock Program are closely allied; genetic material for the Captive Broodstock Program is obtained from juveniles produced in the Integrated-Recovery Supplementation Program to prevent severe in-breeding which often results in reduced fitness and survival. For this reason, the Winter Chinook Captive Broodstock Program could not exist without Integrated-Recovery Supplementation Program as a source of gametes.

3 AFFECTED ENVIRONMENT

The affected environment in this analysis is defined as that portion of the physical, biological, and social environment that may be affected by implementation of the alternatives. The Proposed Action would impact resources in the upper Sacramento River basin and could impact resources in the marine environment because winter-run Chinook salmon released from LSNFH migrate to the ocean. Resources that could be impacted and are part of this environmental analysis include water resources (water quality and hydrology), biological resources (including fish species and fish-eating birds), and socioeconomics. The Proposed Action is not expected to have effects on other resources (*i.e.*, geologic resources, air quality, noise, visual resources, vegetation, and species of wildlife other than those addressed), so these other resources are not specifically addressed in this analysis.

3.1 Water Resources

The water resources potentially affected by the Proposed Action are those within the Sacramento River Basin below Shasta Dam downstream to the RBDD. Shasta Dam, located at river mile (RM) 311 on the Sacramento River near Redding, California, was completed in 1945. The water supply for LSNFH is provided by a pipe tapped directly into the penstocks of Shasta Dam. Water used for winter-run Chinook salmon production at LSNFH is returned to Keswick Reservoir just below Shasta Dam, upstream of the limit of anadromous fish migrations.

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.

3.1.1 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 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 (California Department of Water Resources 1981, as cited in Sacramento River Conservation Area Forum Handbook [2003]). In this reach, flows are also influenced by tributary inflow. Major west-side tributaries to the Sacramento River in this reach 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.

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

However, the threat of warm water releases from Shasta Dam still remains a significant stressor to winter-run Chinook salmon, especially given the recent extended drought in California from 2012 through 2015. A number of measures have been taken to reduce this threat and improve Shasta Reservoir cold water pool management. A full description of these measures can be found in the 5-Year Status Review for Sacramento River winter-run Chinook salmon (NMFS 2016b). Other efforts to reduce the threat of warm water releases from Shasta Dam include improving reservoir, meteorological, and hydrologic modeling and monitoring in order to most efficiently manage the reservoir's limited amount of cold water, installation of additional temperature monitoring stations in the upper Sacramento River to better monitor real-time water temperatures, and enhanced redd, egg, and juvenile winter-run Chinook salmon monitoring.

3.1.2 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 storm water-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 Regional Water Quality Control Board (CVRWQCB) 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 (CVRWQCB 2002). The reach is also listed under Clean Water Act (CWA) 303(d) by the CVRWQCB for unknown sources of toxicity (CVRWQCB 2007).

3.2 Biological Resources

The biological resources potentially affected by the Proposed Action are those within the Sacramento River Basin below Keswick Dam downstream to the RBDD. The status of listed and unlisted salmonid species is discussed below, as well as the status of other fish species in the Basin.

3.2.1 Salmon and Steelhead

3.2.1.1 Sacramento River winter-run Chinook salmon

The Sacramento River winter-run Chinook salmon ESU, currently listed as endangered, was listed as a threatened species under emergency provisions of the ESA on August 4, 1989 (54 FR 32085), and formally listed as a threatened species in November 1990 (55 FR 46515). On January 4, 1994, NMFS reclassified winter-run as an endangered species (59 FR 440). NMFS concluded that winter-run in the Sacramento River warranted listing as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the “take” of winter-run (August 15, 2011, 76 FR 50447).

The winter-run Chinook salmon ESU currently consists of only one population that is confined to the upper Sacramento River (spawning below Shasta and Keswick dams) in California’s Central Valley. In addition, the artificial propagation program at LSNFH produces winter-run that are considered to be part of this ESU (June 28, 2005, 70 FR 37160). Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. Remaining spawning and rearing areas are completely dependent on cold water releases from Shasta Dam in order to sustain the remnant population.

Sacramento River winter-run Chinook salmon were historically abundant and comprised of populations in the McCloud, Pit, Little Sacramento, and Calaveras rivers. Evidence also indicates that winter-run Chinook salmon inhabited Battle Creek at least on an intermittent basis. Most of these populations have since been isolated from historic native spawning areas by the construction and operation of Shasta Dam. Currently available spawning habitats are restricted to the main stem Sacramento River between Keswick Dam and the city of Red Bluff, California.

Recovery criteria for winter-run Chinook salmon have been developed and are included in the Final Recovery Plan for ESA-listed Central Valley Salmon and Steelhead (NMFS 2014). The recovery criteria incorporate four parameters into the assessments of population viability, including: diversity, spatial structure, productivity, and abundance. In order for winter-run Chinook salmon to achieve the recovery criteria, three viable populations must exist at low risk of extinction (NMFS 2014).

3.2.1.2 Central Valley spring-run Chinook salmon

CV spring-run Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent listing decision (70 FR 37160, June 28, 2005). Although FRFH spring-run Chinook salmon production is included in the ESU, these fish are not subject to section 9 take prohibitions (70 FR 37160, June 28, 2005).

Spring-run Chinook salmon were once the predominant run in the Central Valley. Present day abundance of spring-run Chinook salmon has declined dramatically from historical levels. Commercial harvest data comparing average catch from 1916 through 1949 and 1950 through 1957 showed a 90 percent reduction in spring-run Chinook salmon harvest over that time period (Skinner 1958). Dam construction and habitat degradation have eliminated spring Chinook populations from the entire San Joaquin River Basin and from many tributaries to the Sacramento River Basin.

Current spawning habitats for spring-run Chinook salmon in the Upper Sacramento River include the mainstem Sacramento River downstream of Keswick Dam and Clear, Beegum, Battle, Antelope, Mill, Deer, and Butte creeks. CV spring-run Chinook salmon also occur in Feather and Yuba Rivers, and are currently being reintroduced as an experimental population into the San Joaquin River (NMFS 2014).

The Final Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014) contains ESU-level and population-level recovery criteria for CV spring-run Chinook salmon. In order to meet the recovery criteria for this ESU and thereby delist the species, there must be at least eight populations at a low risk of extinction distributed throughout the Central Valley, as well as additional populations at a moderate risk of extinction. As described in Williams et al. (2016), these recovery criteria are not currently being met.

3.2.1.3 California Central Valley steelhead

CCV steelhead were originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good et al. 2005) and after application of the agency's hatchery listing policy, NMFS reaffirmed its status as threatened and also listed the FRFH and Coleman NFH stocks as part of the DPS in 2006 (71 FR 834). In June 2004, after a complete status review of 27 West Coast salmonid ESUs and DPSs, NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS (71 FR 834). On May 5, 2016, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2016a).

Run size estimates are not available for the CCV steelhead DPS prior to the construction of Shasta Dam. Early salvage investigations associated with the construction of Shasta Dam documented steelhead runs to the upper Sacramento River to be of "negligible" size (Hanson et al. 1940), and it is likely that steelhead populations in the upper Sacramento River had already been depleted considerably at that time. From 1966 through 1993 estimates of steelhead abundance in the upper Sacramento River were conducted by counting passage through the fish ladders at RBDD. Abundance of steelhead in the upper Sacramento River declined from the 1980s through 1993, when fish ladder counts at the RBDD were discontinued in mid-September. Average escapement past RBDD for the years 1966 - 1977 (15,000) is more than eight times higher than the average return for the years 1989 - 1993 (1,855), a decline of about 9 percent per year. Since 1998 all hatchery-origin steelhead in the Central Valley have been marked with an adipose fin-clip. The number of non-clipped (wild) steelhead has declined since 1998 in the Chipps Island Trawl and CVP/SWP salvage data while the number of adipose fin-clipped steelhead has remained the same, further supporting conclusions of the trend of declining abundance of naturally spawned steelhead.

The Final Recovery Plan for Central Valley Salmon and Steelhead (NMFS 2014) includes specific, measurable criteria for recovery of the CCV steelhead DPS. The plan calls for a minimum of two viable populations of steelhead within the Basalt and Porous Lava Diversity Group, one within the Northwestern California Diversity Group, four within the Northern Sierra Nevada Diversity Group, and two within the Southern Sierra Nevada Diversity Group. The best chance for eventual delisting of this species is expansion of their range, as it was the creation of dams that has removed them from over 80 percent of their original spawning and rearing habitat in the Central Valley (Williams et al. 2016).

3.2.1.4 Central Valley Late-fall Chinook Salmon and Central Valley fall-run Chinook salmon

Central Valley fall-run and late-fall Chinook salmon are not listed under the ESA or the California ESA (CESA) at present. Natural populations of these Central Valley stocks are identified as candidates for listing (September 16, 1999, 50 FR 50394). The ESU includes all naturally spawned fall-run Chinook salmon in the San Joaquin and Sacramento Basins, east of Carquinez Strait, California.

Currently, late fall-run Chinook salmon are found primarily in the Sacramento River, where most spawning and rearing of juveniles takes place in the reach between RBDD and Redding (Keswick Dam). Although late fall-run Chinook salmon occur in tributary streams to the Sacramento River, most spawn in the mainstem Sacramento River. The primary population depends on dam operations for maintenance of suitable habitat. While affected to a lesser degree than fall-run Chinook salmon, this run remains of ongoing concern due to the strong influence of salmon hatchery stocks in the Central Valley and associated potential ecological and genetic impacts to the sustainability of the run. Abundance estimates of late-fall Chinook salmon are depressed from historic levels, but have been stable relative to the dramatic fluctuations of abundance observed for Central Valley fall-run Chinook salmon. Less management is directed to benefit late fall-run Chinook salmon than for any other run in the Sacramento River, because little is known about the run and it is considered a race within the fall-run Chinook ESU. A key to conserving late fall-run Chinook is to develop and implement specific measures tailored to its unique life history.

Fall-run Chinook salmon are the most abundant run of salmon in the Central Valley. The historic abundance of fall-run Chinook salmon is difficult to estimate, because populations declined before extensive monitoring occurred and good records were kept. Hydraulic mining operations during the Gold Rush Era buried spawning and rearing areas under mining debris before the first estimates of salmon numbers were made. Construction of large dams throughout the Central Valley in the 1940s-60s further reduced wild Chinook salmon numbers. However, the extent of these impacts on Central Valley Chinook

populations is uncertain because artificial propagation began in this era and no effort was made to differentiate wild Chinook from those produced in hatcheries. Until recent years, escapement estimates for fall-run salmon included both hatchery and natural-origin fish with the relative proportions unknown.

Currently, Central Valley fall-run Chinook salmon are supported by a large-scale hatchery programs that produce a total of approximately 32 million juveniles annually. The effects of hatchery production on abundance and population dynamics of fall-run Chinook has been poorly documented, but recent studies are allowing a better analysis of stock composition in the Central Valley. Data from the Constant Fractional Marking Program indicates that a high proportion of fall-run Chinook salmon spawning in-river are of hatchery origin, particularly in streams with large hatchery facilities. Recent studies of otolith microchemistry suggest the same (Barnett-Johnson et al. 2007, Johnson et al. 2012, Kormos et al. 2012). In addition, stray rates between river basins are variable and in some cases relatively high (Kormos et al. 2012). Genetic evidence suggests that Central Valley fall-run Chinook populations are now genetically homogenous (Williamson and May 2005, Lindley et al. 2009).

3.2.2 Other Fish Species

3.2.2.1 Southern Distinct Population Segment of North American Green Sturgeon

Two DPSs of North American green sturgeon have been identified; a northern DPS (NDPS) and a southern DPS (SDPS). While individuals from the two DPSs are visually indistinguishable and have significant geographical overlap, current information indicates that they do not interbreed or utilize the same natal streams. The SDPS of green sturgeon include those that spawn south of the Eel River, specifically within the Sacramento and Feather rivers and possibly also the Yuba River.

In June of 2001, NMFS received a petition to list green sturgeon and designate their critical habitat under the ESA. After completion of a status review (Adams et al. 2002), NMFS found that the species was comprised of two DPS's that qualify as species under the ESA, but that neither DPS warranted listing. In 2003, this decision was challenged in federal court and NMFS was asked to reconsider available life history information. In April of 2005, NMFS revised its "not warranted" decision and proposed to list the SDPS as "threatened" (71 FR 17757). In 2006, in its final decision to list SDPS green sturgeon as threatened, NMFS cited the presence of the only known spawning population limited to a single river (Sacramento River), in California's Central Valley. It also cites the loss of historical spawning habitat, mounting threats regarding habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based on salvage data from the State and Federal salvage facilities (71 FR 17757). Since the original 2006 listing decision, new information has become available, reaffirming

NMFS concerns that SDPS green sturgeon face substantial threats to their viability and recovery (Israel and Klimley 2008).

3.2.2.2 Pacific Lamprey

Pacific lamprey (*Lampetra tridentata*) occur along the Pacific coast from Hokkaido Island, Japan (Morrow 1980), through Alaska and south to Rio Santo Domingo in Baja California (Ruiz-Campos and Gonzalez-Guzman 1996). Their populations have declined in abundance and have become restricted in distribution throughout California, Oregon, Washington, and Idaho. In the Central Valley, their upstream range appears to be limited by impassable dams that exist on all large rivers, primarily on the valley floor and foothills. The lower reaches of most west-side streams are seasonally dry or have low, warm flow and probably do not provide rearing habitat for ammocoetes (larvae), but they can function as migration corridors for both upstream migrating adults and downstream migrating juveniles. The principal accessible higher elevation streams are in the Mill-Big Chico hydrologic unit (HUC), which flow off the southwest slopes of Mt. Lassen and generally still maintain substantial runs of anadromous salmonids.

In 2003, USFWS received a petition to federally list the Pacific lamprey in Oregon, Washington, Idaho, and California as threatened or endangered under the ESA. In 2004, the USFWS found that the petition did not provide the required information to indicate that listing the species may be warranted and, therefore, a status review was not initiated.

3.2.3 Fish Eating Bird Species

3.2.3.1 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*) occur in North America from central Alaska and Canada south to northern Mexico (USFWS 1995). They are found primarily along coasts, inland lakes, and large rivers, but may also be found along mountain ranges during migration. Although the bald eagle is greatly reduced in abundance from historical levels, the current distribution is essentially the same (USFWS 1976). According to the U.S. Forest Service (2002), “The Shasta and Trinity Units currently support at least 38 pairs of resident eagles; 25 pairs at Shasta Lake, 10 pairs at Trinity Lake and 3 pairs at Lewiston Lake. This constitutes close to 20 percent of nesting bald eagles in California.

3.2.3.2 Osprey

The osprey (*Pandion haliaetus*) breeds in northern California from Cascade Ranges south to Lake Tahoe, and along the coast south to Marin County. Regular breeding sites include Shasta Lake, Eagle Lake, Lake

Almanor, and other inland lakes and reservoirs (Polite 2008). Ospreys are found only in association with lakes, reservoirs, coastal bays, or large rivers. They feed predominantly on fish, although some mammals, birds, reptiles, and amphibians are also eaten. Ospreys are known to use riparian forests near the Sacramento River mainstem and are visible near Shasta Lake from March through October; peak nesting occurs during May and June (Watchable Wildlife 2005).

3.3 Socioeconomics

Shasta County is one of the northernmost counties in California. The largest city is Redding, which has approximately 90,200 residents. The recreation industry is the principal source of economic activity in the county, with Shasta Lake and Lassen Peak being the main visitor attractions. The population in Shasta County grew at an annual average rate of 0.2 percent between 2010 and 2015. This growth was largely due to net migration, as the county gained an average of 220 net migrants per year. Due to an aging population, the natural increase (new births) has been relatively low, which has prevented faster rates of population growth (Caltrans 2016). Based on recent population growth data, annual population growth in Shasta County during the 2016-2021 period will average 0.1 percent per year. During this period, it is also expected that an average of 280 net migrants will enter the county each year. This will account for all expected population growth, as the county will experience a natural decrease (deaths will outnumber births).

The total number of staff needed for LSNFH is four and occasionally, during periods of increased workload, additional staff are temporarily transferred from Coleman NFH. A portion of the annual funding provided by BOR for operations and maintenance of the Coleman NFH Complex are used to fund programs that support hatchery operations. Approximately \$700,000 annually is transferred to the RBFWO to conduct evaluations, monitoring, research, and permitting related to hatchery operations. The Hatchery Evaluation Program at the RBFWO consists of eight to ten employees. Another portion of the total annual funding from the BOR is transferred to the California-Nevada Fish Health Center (CA-NV FHC) for technical expertise associated with fish health, including the prevention, diagnosis, and treatment of disease.

3.4 Commercial and Recreational Fisheries

Winter-run Chinook salmon propagated at 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. By providing a source of coded-wire tagged winter-run Chinook salmon, the Winter Chinook Integrated-Recovery Supplementation Program 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 Sacramento River winter-run Chinook salmon.

3.4.1 Ocean Harvest

Sacramento River winter-run Chinook salmon have a more southerly ocean distribution relative to other California Chinook salmon stocks, and are primarily impacted by fisheries south of Point Arena, California. Winter-run Chinook salmon age-3 ocean fishery impact rate estimates for the region south of Point Arena are currently available for 2000–2013, and have remained relatively stable over this time period, averaging 16 percent. There have been several layers of ocean salmon fishery regulations implemented to protect Sacramento River winter-run Chinook salmon beginning in the early 1990s. For example, a substantial portion of the winter-run Chinook salmon ocean harvest impacts used to occur in February and March recreational fisheries south of Point Arena, but fisheries at that time of the year have been closed since the early 2000s.

In 2010, NMFS completed formal consultation under section 7(a)(2) of the ESA and issued a biological opinion on the Authorization of Ocean Salmon Fisheries Pursuant to the Pacific Coast Salmon Fishery Management Plan and Additional Protective Measures as it affects Sacramento River Winter Chinook Salmon (NMFS 2010a). NMFS concluded that the proposed operation of the fishery with impacts at a level that would be expected without any consideration for additional action based on the current status of winter-run Chinook salmon has not ensured that the fishery is not likely to appreciably reduce the likelihood of survival and recovery. As a result, the 2010 biological opinion concluded the proposed action was likely to jeopardize the Sacramento River winter-run Chinook salmon ESU.

The ESA requires that NMFS identify Reasonable and Prudent Alternatives (RPAs) to a proposed Federal action that has not ensured against the likelihood of jeopardizing a listed species. One component of the RPA from the 2010 Biological Opinion (NMFS 2010a) specified that new fishery management objectives must be established. The implementation of the RPA resulted in the development of a harvest control rule which was first used for ocean fishery management in 2012. Specifically, the framework provides an explicit mechanism for NMFS and the Pacific Fishery Management Council (PFMC) to consider the status of winter-run Chinook salmon in the preseason ocean salmon fishery management process and adjust impacts accordingly to reflect that status, especially during times when the population is at low

levels. This framework contains clearly defined abundance thresholds, prescribed fishery objectives, and the tools required for implementation and integration into the ocean salmon fishery management process.

Under this RPA, the implementation of maximum allowable impact rates, also known as the Sacramento River Winter Chinook Control Rule, will likely affect fishing opportunity (through either spatial or temporal closures), although the majority of time (about 70 percent) NMFS expects that the original conditions and measures will be the standard for the fishery in any given fishing season.

3.4.2 Freshwater (Inland) Harvest

CDFW has established specific in-river fishing regulations and no-retention prohibitions designed to protect winter-run Chinook salmon during their freshwater life stages. Based on data from 1968-73 and 1975, Hallock and Fisher (1985) reported that the freshwater sport fishery harvested an average of 8.5 percent of the in-river run of Sacramento River winter-run Chinook salmon. Any Sacramento River winter-run Chinook salmon freshwater harvest that existed historically was essentially eliminated beginning in 2002, when the Sacramento Basin Chinook salmon fishery season openings were adjusted so that there would be little temporal overlap with the winter-run Chinook salmon spawning migration and spawning period. However, impacts to winter-run Chinook salmon may still occur; early arriving fish may be harvested prior to January 1, and late spawning winter-run Chinook salmon may be taken after August 1. Higher densities of fish in this portion of the river may also lead to higher harvest rates.

The upper Sacramento River supports substantial angling pressure for rainbow trout (*O. mykiss*). Rainbow trout anglers tend to concentrate in locations and at times where winter-run Chinook salmon are actively spawning (and therefore concentrated and more susceptible to impacts). By law, any winter-run Chinook salmon inadvertently hooked in this section of river must be released without removing it from the water. However, winter-run Chinook salmon may be impacted as a result of disturbance and the process of hook-and-release, especially during drought conditions.

Understanding that these potential adverse impacts can be exacerbated during periods of extended drought, like the one experienced by much of California over the last several years, CDFW adopted “enhanced protective measures” during 2015 and 2016 in order to protect critical spawning habitat in the upper Sacramento River and eliminate any incidental stress or hooking mortality of winter-run Chinook salmon by anglers. These temporary emergency regulations closed all fishing on the 5.5 mile stretch of the Sacramento River from the Highway 44 Bridge where it crosses the Sacramento River upstream to Keswick Dam (*i.e.*, the primary area used by adult winter-run Chinook salmon for spawning).

4 ENVIRONMENTAL CONSEQUENCES

This section provides the scientific and analytic basis for comparing the two proposed alternatives. It includes a discussion of the probable consequences of the two proposed alternatives on environmental resources. The Proposed Action potentially can affect the physical or biological resources within the action area. The following is an analysis of the potential environmental consequences on the major components of the environment based on the current affected environment conditions described in Section 3 (Affected Environment), above, organized by the alternatives considered in Section 2 (Alternatives Including the Proposed Action). Differences between the No-action and Proposed Action alternatives are primarily related to incremental biological improvements as a result of full implementation of the HGMP over the next ten years. As discussed previously, the environmental impacts from both alternatives are not expected to extend beyond 10 years.

4.1 Effects from Alternative 1 (No-action Alternative)

Under a No-action Alternative, NMFS concludes that the permit application does not meet the ESA section 10(a)(1)(A) permit issuance criteria and approval of the associated HGMPs is not warranted. NMFS would not issue the ESA section 10(a)(1)(A) permit to USFWS authorizing take of ESA-listed species associated with the requested hatchery propagation activities. For the purpose of this analysis, this alternative would not allow the activities necessary for successful hatchery supplementation program, nor would it allow for continued operation of a captive broodstock program. Consequently, any directed take of winter-run Chinook salmon for the purpose of artificial propagation would result in a violation of section 9 of the ESA. Therefore, it is unclear at this point how USFWS would continue hatchery operations at LSNFH.

4.1.1 Water Resources

Under the No-action alternative, BOR and USFWS would have to decide how to proceed in implementing the winter-run Chinook salmon programs at LSNFH in a manner to avoid violating take prohibitions in 50 CFR § 223.203. Therefore, as described in Section 2.1, it is unclear at this point how all of the elements of such a program would be implemented. Regardless of whether elements of the winter-run Chinook salmon programs would continue, other ongoing hatchery operations for Delta Smelt that may affect water quality, hydrology, and other resource areas would continue to occur.

4.1.1.1 Hydrology

The source of water for 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 LSNFH 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. Total flow available to the facility is approximately 3,000 gallons per minute (gpm) or 6.68 cubic feet per second (cfs).

During daily operations, flows pass through the LSNFH facilities and discharge into the Sacramento River (Keswick Reservoir). Under Alternative 1 (No-action), this level of water use would likely continue for other ongoing hatchery operations. This level of continued water use is not expected to have a significant effect on hydrologic conditions and resources. No appreciable consumption of water will occur under Alternative 1 since water diverted to LSNFH from Shasta Lake is returned to the Sacramento River. Also, the amount diverted is small relative to the total river flow (less than 1 percent), and causes no effects on other water uses in the short reach of the Sacramento River between the LSNFH water intake in Shasta Lake and the return discharge from LSNFH in Keswick Reservoir.

4.1.1.2 Water Quality

Under Alternative 1 (No-action), the characteristics of the LSNFH discharge with regard to other water quality constituents also would likely be unchanged from current conditions. Water discharged from LSNFH is regulated by a National Pollution Discharge Elimination System (NPDES) Permit issued by the California Regional Water Quality Control Board (CRWQCB). Negative impacts to ESA-listed populations and their habitats associated 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 CRWQCB 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. The facility discharges domestic wastes to a septic tank/leach field system. 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 CRWQCB.

USFWS would continue to operate LSNFH pursuant to the NPDES permit issued by the CRWQCB. The standards outlined in the NPDES Permit were developed to be protective of designated beneficial uses (including preservation and enhancement of fish, wildlife, and other aquatic resources), so it is expected that the hatchery effluent will have a negligible impact on Sacramento River water temperatures, pH, and

dissolved oxygen (DO) under Alternative 1. In addition, the NPDES permit requires a chemical pollutant scan under the California Toxics Rule every five years. However, staff at LSNFH conduct monthly self-monitoring of the hatchery's water supply and effluent to ensure that water quality parameters are maintained to be compliant with the General Order of the CRWQCB. Therefore, Alternative 1 is not expected to result in significant impacts to other water quality constituents in the Sacramento River.

4.1.2 Biological Resources

4.1.2.1 Salmon and Steelhead

Sacramento River winter-run Chinook salmon

Under Alternative 1 (No-action) as described in Section 2.1, if NMFS does not issue the ESA section 10(a)(1)(A) permit, BOR and USFWS would have to decide how to proceed in implementing the Winter Chinook Integrated-Recovery Supplementation Program and the Winter Chinook Captive Broodstock Program at LSNFH. It is unclear at this point whether and how all of the elements of the program would be implemented. Under Alternative 1, there would be no authorized take of listed Sacramento River winter-run Chinook salmon at LSNFH. Without a take authorization, collection and handling of winter-run Chinook salmon may cease, and other sources of hatchery broodstock would need to be identified. However, it is unclear whether collection and handling of listed winter-run Chinook salmon would cease, and, if it does cease, what other sources of hatchery broodstock might be identified. Elimination of the Sacramento River winter-run Chinook salmon hatchery program at LSNFH could have significant adverse conservation consequences. If the winter-run Chinook salmon hatchery program at LSNFH were eliminated, all potential negative impacts of the program to biological resources including anadromous salmonid species would be eliminated. However, the associated reduction in population size likely to occur would increase the extinction risk of the population in the near term.

Given the adverse conservation consequences of eliminating the LSNFH winter-run Chinook salmon programs, the history of the programs operating similar to current hatchery practices, and the uncertainty regarding whether elements of the program would continue or not, NMFS believes it is appropriate to also analyze the effects of continuing current operations at LSNFH under the No-action alternative, even though such operations may change without the issuance of a section 10(a)(1)(A) permit. Under such circumstances, production levels are limited to a maximum of 180 adult broodstock annually (60 females and up to 120 males). Juvenile production levels increase and decrease with the number of broodstock spawned, with an average of approximately 200,000 – 250,000 pre-smolts being released during a standard production year and up to 750,000 released during drought-related program expansion or for the purpose of initiating reintroduction efforts in Battle Creek. The low number of winter-run Chinook

salmon juveniles produced at LSNFH, relative to most propagation programs in the Central Valley, limits the potential for negative ecological impacts to ESA-listed fish stocks.

Inbreeding: One of the potential impacts of hatchery propagation at LSNFH is the genetic and demographic consequences of inbreeding. Inbreeding results when closely related adults are spawned at the hatchery. When inbreeding occurs, survival of progeny is decreased. This potential issue is significantly reduced by the broodstock selection techniques currently employed by staff at LSNFH. Selection of winter-run Chinook salmon broodstock is accomplished by screening collected adults using several diagnostic criteria developed to reliably discriminate 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 that significantly reduces the likelihood of genetic introgression and inbreeding.

The potential for indirect impacts to naturally-spawned juvenile salmonids may result from competitive and predatory interactions, disease transfer, and interbreeding between hatchery-origin and natural-origin individuals in the upper Sacramento River Basin. These interactions are an indirect impact of the winter-run Chinook salmon program at LSNFH and result in both positive and negative effects on salmonid populations.

Predation: The average size of hatchery-origin winter-run Chinook salmon smolts at the time of release in late January or early February is 88 mm FL (range 46-123 mm, standard deviation = 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 Increment Chart, CDWR). Because hatchery- 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.

Competition: An objective of the winter-run Chinook salmon Integrated-Recovery Supplementation Program 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-run Chinook salmon are approximately equal in size or smaller than other co-occurring ESA-listed salmonids; (2) hatchery-origin winter-run Chinook salmon are released after the vast majority of naturally produced winter- and spring-run Chinook salmon juveniles have left the upper Sacramento River Basin and those that remain have established home territories; (3) the number of winter-run Chinook salmon released from LSNFH is small compared to the number of juveniles produced annually in the upper Sacramento River Basin and the number of juvenile Chinook salmon produced in other hatchery programs; and (4) rearing habitats in the upper Sacramento River are generally not considered to be limiting the abundance of winter-run Chinook salmon.

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 LSNFH is attributed to effective prophylactic treatments, good fish culture practices, and supply “clean” source of water from deep in Shasta Lake. Additionally, The 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 Blue Book and USFWS Aquatic Animal Health Handbook. The hatchery receives an inspection report that lists the pathogens present, if any.

Interbreeding: Spawning by hatchery-origin winter-run Chinook salmon is not controlled on the spawning grounds of the Sacramento River. If the winter-run Chinook salmon programs at LSNFH were to continue under Alternative 1 as they do currently, interbreeding between hatchery-origin winter-run Chinook salmon from LSNFH and natural-origin winter-run Chinook salmon in the upper Sacramento River is likely to continue. When hatchery-origin salmonids stray into natural populations, they transfer genes from the hatchery population into the naturally spawning populations (Pearse et al. 2007). This is thought to be problematic because hatchery programs alter the genetic composition (Reisenbichler and Rubin 1999, Ford 2002), phenotypic traits (Hard et al. 2000, Kostow 2004), and behavior (Berejikian et al. 1996, Jonsson 1997) of natural populations. These genetic interactions between hatchery and naturally produced stocks may decrease the amount of genetic and phenotypic diversity of a species by homogenizing once disparate traits of hatchery and natural fish. The result has been progeny with lower survival (McGinnity et al. 2003, Kostow 2004) and ultimately, a reduction in the fitness of the natural

stock (Reisenbichler and McIntyre 1977, Chilcote 2003, Araki et al. 2007) and outbreeding depression (Reisenbichler and Rubin 1999, HSRG 2009).

Although risks from hatchery interbreeding would be expected, there could also be benefits from maintaining hatchery production. The conservation-oriented practices employed by USFWS staff at LSNFH, such as incorporation of natural-origin adults into the broodstock, and the high extinction risk of the Sacramento River winter-run Chinook salmon ESU, outweigh many of the concerns associated with interbreeding. It is also important to note that hatchery propagated winter-run Chinook salmon from LSNFH are managed to be integrated with the natural population of winter-run Chinook 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 Basin, spawn in the wild, and become reproductively and genetically assimilated into the natural spawning population.

Central Valley spring-run Chinook salmon and California Central Valley Steelhead

ESA-listed natural-origin CV spring-run Chinook salmon and CCV steelhead co-exist in the upper Sacramento River Basin with winter-run Chinook salmon, and may be incidentally trapped in the KDFT during broodstock collection. All salmonids captured at the KDFT are transported to LSNFH where they are identified and sorted. Non-target fishes are separated and released near suitable spawning habitats in the upper Sacramento River near Redding, California.

Several methods are used to reduce any incidental impacts of trapping for winter-run Chinook salmon broodstock at Keswick Dam. First, incidental impacts to non-target stocks of Chinook salmon are reduced by installing a fish counter at the entrance of the fish trap. 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 fish trap 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 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 preying 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.

As previously mentioned, NMFS believes it is appropriate to analyze the effects of continuing current operations at LSNFH under the No-action alternative, due to uncertainties regarding how hatchery

operations would proceed without ESA authorization. Injury and incidental mortality could possibly result from trapping, handling, or transport of non-target salmonids; however, total time in captivity is approximately two to four hours and both CV spring-run Chinook salmon and CCV steelhead are generally in good physical condition at the time of year when winter-run Chinook salmon broodstock are being collected. Incidental mortality of CV spring-run Chinook salmon and CCV steelhead is expected to be less than 1 percent of the total number handled annually.

Under a No-action Alternative where hatchery production at LSNFH has been eliminated, broodstock collection activities for winter-run Chinook salmon would cease. However, the KDFT would still be operated from late-December through February for the collection of late-fall run Chinook salmon broodstock to be spawned at Coleman NFH. CV spring-run Chinook salmon and CCV steelhead would likely still be incidentally collected during trapping for late-fall Chinook salmon broodstock. Therefore, under the No-action Alternative (for both continuation of current operations and eliminated production), significant impacts to other ESA-listed salmonids are not likely to occur.

Juvenile releases timed to coincide with high flow events are also believed to encourage emigration and decrease ecological interactions in the upper river. Hatchery-origin winter-run Chinook salmon are believed to exhibit a short-term residency in the lower Sacramento River or Delta prior to entering saltwater in the late spring. Releasing hatchery-origin winter-run Chinook salmon in January-March reduces concurrent residence (and thus reduce ecological interactions) with naturally produced salmonids in the upper Sacramento River Basin, while encouraging smoltification and emigration. Releases will occur at dusk and be timed to coincide with storm events resulting in increased flow and turbidity, to the extent possible, to reduce the likelihood of predation soon after release. Given the small number of winter-run Chinook salmon propagated at LSNFH annually (200,000-250,000) and the seasonal timing of releases, concerns of ecological effects resulting from the release of hatchery-origin juveniles are minimal. Therefore, if the LSNFH winter-run Chinook salmon programs were to continue under the No-action Alternative as it does currently, predation on and competition with CV spring-run Chinook salmon and CCV steelhead by hatchery-origin winter-run Chinook salmon is unlikely to occur and it is not expected to result in significant impacts. For the same reasons described above, a No-action Alternative where hatchery production has been eliminated is also unlikely to result in significant impacts to other ESA-listed salmonids in the upper Sacramento River.

Because LSNFH is located upstream of the critical habitat designated for both CV spring-run Chinook salmon and CCV steelhead, and the No-action Alternative is not likely to adversely affect any prey

resources or migration corridors utilized by ESA-listed salmonids in the upper Sacramento River Basin, NMFS does not anticipate that the No-action Alternative will have any effect on essential features of critical habitat for CV spring-run Chinook salmon and CCV steelhead. Therefore, the No-action Alternative is not likely to adversely affect critical habitat for CV spring-run Chinook salmon and CCV steelhead.

Central Valley fall-run Chinook salmon and Central Valley late-fall Chinook salmon

Fall-run Chinook salmon are the most widely distributed run of Chinook salmon in the Central Valley. The abundance of Central Valley fall-run Chinook salmon has varied significantly in recent years, but the run is widespread and the number of spawners typically exceeds 100,000 fish. The late-fall portion of the Central Valley fall/late-fall run Chinook salmon ESU continues to have low, but perhaps stable numbers.

Under the No-action Alternative (Alternative 1), detrimental impacts to other races of Chinook salmon resulting from the hatchery programs at LSNFH are unlikely due to the low number of winter-run Chinook salmon juveniles released annually from LSNFH and differences in the timing of spawning, rearing and juvenile emigration.

4.1.2.2 Other Fish Species

Southern Distinct Population Segment of North American Green Sturgeon

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 impacts to 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. Therefore, the No-action Alternative is not likely to adversely affect SDPS green sturgeon or their critical habitat.

Pacific Lamprey

The No-action Alternative is not expected to affect the physical, chemical, or biological conditions for Pacific lamprey spawners within the Sacramento River. However, winter-run Chinook salmon juveniles produced by LSNFH under the No-action Alternative could prey on larval lamprey, which hatch within several weeks of spawning activity and drift downstream to backwater areas where they burrow into the substrate and commence feeding as ammocoetes (Kostow 2002). However, due to the small number of hatchery smolts released (200,000-250,000) if the hatchery operations at LSNFH were to continue under the No-action alternative as they do currently, predation by winter-run Chinook salmon under the No-

action alternative is not likely to significantly affect juvenile Pacific lamprey due to the diversity of other prey items utilized by Chinook salmon juveniles and the relatively high fecundity of larvae produced by Pacific lamprey spawners.

In addition, Chinook salmon are prey for adult Pacific lamprey. The winter-run Chinook salmon adults produced by LSNFH provide a food source for Pacific lamprey in both the marine and freshwater periods of their life-cycle. Therefore, Alternative 1 (No-action) is not likely to negatively affect Pacific lamprey adults, unless hatchery production of winter-run Chinook salmon is eliminated. However, even if that occurred, due to the small number of hatchery-origin adult winter-run Chinook salmon that return to the upper Sacramento River Basin (generally less than 1,000) and the availability of other more abundant and desirable food sources, elimination of winter-run Chinook salmon hatchery production at LSNFH is not expected to result in significant impacts to Pacific lamprey adults.

4.1.2.3 Fish Eating Birds

If the LSNFH winter-run Chinook salmon programs were to continue under the No-action Alternative as it does currently, LSNFH production likely would continue to benefit overall foraging opportunities for fish-eating birds by increasing the numbers of Chinook salmon in the upper Sacramento River. However, if production of winter-run Chinook salmon were eliminated under the No-action Alternative, significant impacts to fish-eating birds are not likely to occur due to the small number of hatchery-origin smolts currently released (200,000-250,000) and the availability of other food sources in the upper Sacramento River.

4.1.3 Socioeconomics

Under Alternative 1 (No-action), no significant effects on the population or employment are expected. As discussed above in Section 3.3, the total number of staff needed for LSNFH is four and occasionally, during periods of increased workload, additional staff are temporarily transferred from Coleman NFH. BOR would continue funding 100 percent of hatchery operations and maintenance costs for the Coleman Complex (Coleman NFH and LSNFH) pursuant to the mitigation requirements associated with the construction of Shasta Dam. Therefore, the impact of Alternative 1 (No-action) on regional employment and income is likely insignificant.

4.1.4 Commercial and Recreational Fisheries

4.1.4.1 Ocean Harvest

As described in Section 3.4.1, ocean 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-run Chinook salmon released from LSNFH is the source of empirical data used to monitor impact fishery rates. Available information indicates that, with the exception of 2008-2010 when the ocean salmon fishery was closed or heavily restricted due to the severe decline in fall-run Chinook salmon escapement, the level of winter-run Chinook salmon fishery impacts has not changed appreciably since the 2010 NMFS Viability Assessment (Williams et al. 2011), yet there have been additional ocean fishery regulations implemented with the purpose of reducing exploitation of winter-run Chinook salmon when the average population size is reduced.

If the winter-run Chinook salmon programs at LSNFH were to continue under the No-action Alternative as it does currently, ocean harvest (although constrained by protections for winter-run Chinook salmon), would likely benefit from more conservative regulations which promote the longevity and resilience of the targeted stocks. It is possible that existing recreational fisheries, in spite of being highly regulated and managed, may harvest natural-origin fish at unsustainable rates (Williams 2006). Fisheries may also affect Chinook salmon populations through continual removal of larger and older individuals. By providing a source of coded wire tagged winter-run Chinook salmon, the programs at LSNFH may indirectly benefit 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.

If hatchery production at LSNFH were to cease under Alternative 1 (No-action), fishery managers would be unable to determine the level of impact to winter-run Chinook salmon resulting from commercial and recreational fisheries. The lack of hatchery production would likely result in reduced escapement, subsequently lowering the 3-year geometric mean which drives the Sacramento River Winter Chinook Control Rule, as described in Section 3.4.1. This could result in fishery closures along the West Coast, south of Point Arena. A reduction in harvest when the targeted stock's population levels are steady and hatchery production is constant could result in unintended adverse impacts through increased levels of hatchery-origin adult escapement to natural spawning areas.

4.1.4.2 Freshwater (Inland) Harvest

Winter-run Chinook salmon propagated at LSNFH are not intended for harvest, although some are incidentally harvested in fisheries targeting non-listed salmonids. As previously mentioned in Section 3.4.2, the upper Sacramento River is closed for salmon fishing during winter-run Chinook salmon spawning, however angling for rainbow trout is permitted.

Under the No-action Alternative (Alternative 1) with hatchery operations at LSNFH continuing as they do currently, significant impacts to freshwater harvest are not anticipated. Occasional fishery closures may occur in response to unfavorable conditions in the upper Sacramento River that are likely to adversely impact ESA-listed species and their habitat, such as the prolonged drought conditions that resulted in closures during 2015 and 2016. However, these closures only limit angling in the upper 5.5 miles of the Sacramento River, resulting in little to no impact to freshwater harvest in the Sacramento River Basin.

If hatchery production at LSNFH were to cease under Alternative 1 (No-action), overall abundance including adult escapement of winter-run Chinook salmon to the upper Sacramento River would be reduced. Given the ESU's endangered status, fishing closures and increased protective measures for winter-run Chinook salmon are likely to be implemented to help safeguard critical spawning habitat and reduce the extinction risk to the species.

4.2 Effects from Alternative 2 (Proposed Action)

Under Alternative 2, NMFS would issue a permit under section 10(a)(1)(A) of the ESA to USFWS, for a period of ten years authorizing the implementation of the Winter Chinook Integrated-Recovery Supplementation Program and the Winter Chinook Captive Broodstock Program at LSNFH, as described in two HGMPs. As a result of permit issuance, an exception to the take prohibitions described in 50 CFR § 223.203 would apply to the authorized activities. These activities are outlined in the permit application and associated HGMPs and include actions related to propagation of winter-run Chinook salmon at LSNFH (as described in Section 2.1.2.1) and monitoring of winter-run Chinook salmon in the Sacramento River (as described in Section 2.1.2.3). Through implementation of the HGMPs, the Winter Chinook Integrated-Recovery Supplementation Program and Winter Chinook Captive Broodstock Program will be operated to conserve ESA-listed species.

4.2.1 Water Resources

4.2.1.1 Hydrology

No significant effects on hydrologic conditions and resources are expected under Alternative 2 (Proposed Action). The potential hydrology effects under Alternative 2 (Proposed Action) would be the same as described for Alternative 1 (No-action) in Section 4.1.1.1 because there is no appreciable difference in terms of water use between the two alternatives. The current level of water use at LSNFH would likely continue. No appreciable consumption of water will occur under Alternative 2 (Proposed Action) since water diverted to LSNFH from Shasta Lake would be returned to the Sacramento River. Also, the amount diverted would be small relative to the total river flow (less than 1 percent), and cause no effects on other water uses in the short reach of the Sacramento River between the LSNFH water intake and the return discharge in Keswick Reservoir.

4.2.1.2 Water Quality

No significant effects on water quality are expected under Alternative 2 (Proposed Action). The potential water quality effects under Alternative 2 (Proposed Action) would be the same as described for Alternative 1 (No-action) in Section 4.1.1.2 because there is no appreciable difference between the two alternatives in terms of activities that can affect water quality. Under Alternative 2 (Proposed Action), water discharged from LSNFH into the Sacramento River would continue to contribute minor amounts of nutrient and organic matter loading to the river due to LSNFH operations, but these small loads are not expected to result in significant impacts to nutrients and algae in the Sacramento River. The characteristics of the LSNFH discharge with regard to other water quality constituents also would likely be unchanged from current conditions. USFWS would continue to operate LSNFH pursuant to an NPDES Permit that establishes conditions for the LSNFH discharge to maintain compliance with the Clean Water Act. Therefore, Alternative 2 (Proposed Action) is not expected to result in significant impacts to other water quality constituents in the Sacramento River for the same reasons as described for Alternative 1 (No-action) in Section 4.1.1.2.

4.2.2 Biological Resources

4.2.2.1 Salmon and Steelhead

Sacramento River winter-run Chinook salmon

Under Alternative 2 (Proposed Action), effects on winter-run Chinook salmon would occur from continued operation of the hatchery programs at LSNFH and implementation of the submitted HGMPs. Hatchery propagation of winter-run Chinook salmon under Alternative 2 would require the lethal take of adult winter-run Chinook salmon for broodstock and the loss of individuals during incubation, rearing, and marking. Activities authorized under Alternative 2 would include collection of adult broodstock

targeting up to 60 females and at least 60 males (up to 120 males may be used to increase the effective population size) in order to release approximately 200,000–250,000 juvenile winter-run Chinook salmon each year. Releases of up to 750,000 are possible during a year of expanded production due to drought-related program expansion or for initial contribution to reintroduction efforts in Battle Creek.

Up to 1,000 juveniles from the Integrated-Recovery Supplementation Program may be withheld annually from release, maintained, and reared to maturity as Captive Broodstock at LSNFH. Captive Broodstock and their progeny may potentially be available to fulfill multiple purposes to advance the preservation and conservation of the winter-run Chinook salmon ESU, including: 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; 2) to be a source of winter-run Chinook salmon to contribute to multi-agency reintroduction efforts upstream of Shasta Dam and into restored habitats of Battle Creek; and 3) to be a source of winter-run Chinook salmon to fulfill the needs of approved research projects. During years when Captive Broodstock adults are in excess of the needs described above and are deemed unnecessary, they may be experimentally released into North Fork Battle Creek rather than allowing all unused fish to intentionally senesce in the hatchery.

USFWS will target 100 percent natural-origin adult winter-run Chinook salmon for use as broodstock. This practice is intended to achieve a high level of fitness by decreasing the perpetuation of domestication selection. Although this approach is preferred, USFWS anticipates that it will not be possible to achieve this target in some years. Therefore, hatchery-origin adults may be used as broodstock, as necessary, to meet broodstock collection targets. Adults may enter the facility and not be used for broodstock. Excess adult fish collected as broodstock for the Integrated-Recovery Supplementation Program will be transported and returned back to the upper Sacramento River. The handling and release of these adult winter-run Chinook salmon back to the river may result in injury or mortality. However, based on recent acoustic tracking work, it is expected that a small percentage of the fish collected and released will suffer injury sufficient to result in mortality (See Section 2.1.2.2 for a description of proposed RM&E). Thus, impacts to winter-run Chinook salmon from LSNFH activities would be reduced under Alternative 2. The “best management practices” utilized by LSNFH (*i.e.*, limited annual production, incorporation of natural-origin fish into broodstock, marking and tagging of all fish released, *etc.*) and the associated research, monitoring, and evaluation conducted to allow for adaptive management under Alternative 2 would be expected to result in an overall beneficial effect on anadromous salmonid species and would not be expected to result in significant adverse effects to anadromous salmonid species.

As described in Section 4.1.2.1, the potential for indirect impacts to naturally-spawned salmonids may result from inbreeding, competitive and predatory interactions, disease transfer, and interbreeding between hatchery-origin and natural-origin individuals in the upper Sacramento River Basin. These interactions are an indirect impact of the winter-run Chinook salmon program at LSNFH and result in both positive and negative effects on salmonid populations.

Inbreeding: Certain components of the current management scheme (*i.e.*, small program size, increases in the number of hatchery-origin adults returning to the river due to increased hatchery production during 2014 and 2015) are anticipated to result in minor impacts over the next several years. Alternative 2 would be expected to decrease the degree of inbreeding and divergence in the hatchery population based on HGMP activities, such as the incorporation of jacks into the broodstock, the incorporation of natural-origin adults into the broodstock (up to 100 percent of total broodstock), the avoidance of hatchery-origin individuals, and the implementation of a genetically based spawning matrix which allows for the exclusion of sibling crosses (*i.e.*, mating of related individuals) and non-target Chinook salmon runs from the broodstock. Therefore under Alternative 2 (Proposed Action), inbreeding is not likely to result in significant impacts.

Similar to the discussion under Alternative 1 (No-action Alternative), if the winter-run Chinook salmon programs at LSNFH were to continue under the No-action alternative as it does currently, under Alternative 2 the potential for indirect impacts to naturally-spawned juvenile salmon could result from competitive and predatory interactions, disease transfer, and interbreeding between hatchery-origin and natural-origin individuals in the upper Sacramento River. However, the small number of juveniles produced by LSNFH, relative to other propagation programs in the Central Valley, limits the potential for negative ecological impacts to other ESA-listed fish stocks. Further, winter-run Chinook salmon produced at 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.

Predation: Due to the small number of winter-run Chinook salmon propagated at LSNFH and the seasonal timing of releases, concerns of ecological effects resulting from the release of hatchery-origin juveniles are minimal. ESA-listed juvenile salmonids present in the upper Sacramento River Basin at the time when juvenile winter-run Chinook salmon are released from LSNFH are expected to be equal in size or larger than hatchery-origin winter-run Chinook salmon, making predation very unlikely. Also, 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.

Under Alternative 2, the impacts of predation on natural-origin winter-run Chinook salmon are expected to be relatively minor given: (1) the small number of juveniles present in the mainstem Sacramento River at the time when juvenile hatchery-origin winter-run Chinook salmon would be migrating; (2) the relatively low number of hatchery-origin winter-run Chinook salmon released from LSNFH; and (3) releases that are timed to coincide with high flow events which are thought to encourage emigration and decrease ecological interactions in the upper Sacramento River. The impacts on other naturally produced ESA-listed salmonids in the upper Sacramento River Basin are expected to be similarly minor due to larger populations, increased abundance and differences in both size and timing when present together. In sum, NMFS does not anticipate any significant effect on predatory interactions under Alternative 2, through implementation of the HGMP.

Competition: Similar to the impacts of predation, there is potential under Alternative 2 for impacts related to competition between hatchery-origin winter-run Chinook salmon and natural-origin salmonids for space in refugia and rearing habitat in the upper Sacramento River Basin. However, hatchery-origin winter-run Chinook salmon from LSNFH are managed to integrate with naturally produced winter-run Chinook salmon. Therefore, under Alternative 2 (Proposed Action), potential negative effects of competition/displacement are not expected to result in significant impacts for the following reasons: (1) juvenile hatchery-origin winter-run Chinook salmon are approximately equal in size or smaller than co-occurring ESA-listed salmonids; (2) hatchery-origin winter-run Chinook salmon are released after the vast majority of naturally produced 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 LSNFH is small compared to the number of juveniles produced annually in the upper Sacramento River Basin and the number of juvenile Chinook salmon produced in other hatchery programs; (4) rearing habitats in the upper Sacramento River Basin are generally not considered to be limiting the abundance of winter-run Chinook salmon; and (5) competition between adult hatchery-origin winter-run Chinook salmon for spawning habitat is not expected because the level of adult escapement on the spawning grounds in the upper Sacramento River Basin is expected to remain below the capacity of the available spawning habitat.

Disease: Currently, USFWS certifies the health and disease status of winter-run Chinook salmon prior to their release in the upper Sacramento River. Juvenile winter-run Chinook salmon released from LSNFH have been notably healthy and free of disease problems. Lack of disease outbreaks at LSNFH is attributed to effective prophylactic treatments, good fish culture practices, and supply “clean” source of water from

deep in Shasta Lake. This would not significantly change under Alternative 2, so there are not expected to be significant disease effects associated with the implementation of the HGMP.

Interbreeding: Under Alternative 2 (Proposed Action), 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. Although there are risks from hatchery-origin fish interbreeding with natural-origin winter-run Chinook salmon, there can also be benefits. If natural populations are too small without the input of hatchery-origin individuals, they can experience depensation, or the negative genetic impacts of small population size (*e.g.*, inability to find mates, inbreeding). Hatchery propagated winter-run Chinook salmon are managed to be integrated with the natural population of winter-run Chinook salmon in the upper Sacramento River Basin and are intended to provide a demographic enhancement to aid in the resilience, rebuilding and recovery of that population. Therefore under Alternative 2, adverse impacts associated with interbreeding are not anticipated.

Central Valley spring-run Chinook salmon and California Central Valley Steelhead

ESA-listed natural-origin CV spring-run Chinook salmon and CCV steelhead co-exist in the upper Sacramento River Basin with winter-run Chinook salmon, and may be incidentally impacted by the proposed hatchery activities at LSNFH. Potential impacts associated with juvenile interactions between hatchery-origin winter-run Chinook salmon and naturally produced CV spring-run Chinook salmon and CCV steelhead are described in the sections above (see *Predation* and *Competition*). During broodstock collection at the KDFT, injury or incidental mortality may result from trapping, handling, and transport of non-target salmonids; however, total time in captivity is approximately two to four hours and both CV spring-run Chinook salmon and CCV steelhead are generally in good physical condition at the time of year when winter-run Chinook salmon broodstock are being collected.

Under Alternative 2, the CV spring-run Chinook salmon ESU may experience beneficial effects as a result of broodstock collection activities at the KDFT. Hatchery-origin spring-run Chinook salmon released from FRH may stray when released off-site. Adult hatchery-origin spring-run Chinook salmon from FRH that stray to the upper Sacramento River and are captured in the KDFT will be culled and removed from the population. CV spring-run Chinook salmon in the upper Sacramento River Basin are genetically distinct from hatchery propagated spring-run Chinook salmon from FRH. Because of these differences, there are concerns over possible introgression with natural-origin spring-run Chinook salmon in Sacramento River tributaries, such as Mill and Deer creeks.

Therefore under Alternative 2, the removal of stray FRH spring-run Chinook salmon from the upper Sacramento River basin and the handling, transport, and release of natural-origin, non-target salmonids during broodstock collection activities at the KDFT, is not likely to adversely impact the CV spring-run Chinook salmon ESU, the CCV steelhead DPS, or their critical habitat.

Central Valley fall-run Chinook salmon and Central Valley late-fall Chinook salmon

The potential effects on non-listed stocks of Chinook salmon under Alternative 2 (Proposed Action) would be the same as described for Alternative 1 (No-action) in Section 4.1.2.2 if the winter-run Chinook salmon programs at LSNFH were to continue under the No-action alternative as it does currently, because there is no appreciable difference between the two alternatives in terms of activities that can affect Central Valley fall-run Chinook salmon ESU. Additionally, under Alternative 2, no significant adverse effects are expected on anadromous salmonid habitat in the upper Sacramento River Basin. Given the differences in spawn timing among the different Chinook salmon runs and the small number of winter-run Chinook salmon released from LSNFH annually, the available spawning habitat is expected to be adequate to support the various runs of Chinook salmon in the upper Sacramento River Basin.

4.2.2.2 Other Fish Species

Southern Distinct Population Segment of North American 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. Therefore, the Proposed Action (Alternative 2) is not likely to adversely affect SDPS green sturgeon or their critical habitat.

Pacific Lamprey

The potential effects on Pacific lamprey under Alternative 2 (Proposed Action) would be the same as described for Alternative 1 (No-action) in Section 4.1.2.2 if the LSNFH winter-run Chinook salmon program were to continue under the No-action alternative as it does currently, because there is no appreciable difference between the two alternatives in terms of activities that can affect Pacific lamprey.

4.2.2.3 Fish Eating Birds

Under Alternative 2 (Proposed Action), LSNFH production likely would continue to benefit overall foraging opportunities for fish-eating birds by increasing the numbers of salmon present in the upper Sacramento River. However, this benefit is likely minor due to the small number of winter-run Chinook salmon juveniles released from LSNFH annually.

4.2.3 Socioeconomics

Under Alternative 2 (Proposed Action), no significant effects on regional population and employment are expected. As discussed above in Section 3.3.2, LSNFH employs up to four permanent positions.

Alternative 2 has the potential to result in the employment of more people in order to carry out activities required by the HGMP (such as escapement surveys, emigration monitoring, broodstock genetic analysis, juvenile tagging *etc.*) as compared to Alternative 1. However, the impact of Alternative 2 (Proposed Action) on regional employment is expected to remain relatively small.

4.2.4 Commercial and Recreational Fisheries

4.2.4.1 Ocean Harvest

Because winter-run Chinook salmon are protected as an endangered species, fishing regulations are implemented to avoid or minimize their harvest in ocean and freshwater commercial or recreational fisheries. Under Alternative 2 (Proposed Action), the hatchery programs at LSNFH indirectly benefit harvest management by providing a source of tagged (CWT) winter-run Chinook salmon; 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.

As described in Sections 3.4.1 and 4.1.4, the Sacramento River Winter Chinook Control Rule specifies the maximum forecast age-3 impact rate for the area south of Point Arena, California, as a function of the geometric mean of escapement from the most recent three years. Under Alternative 2 (Proposed Action), hatchery production from LSNFH is likely to benefit ocean harvest, by increasing adult escapement to the upper Sacramento River and allowing for an assessment of the impact rate of the fishery through recovery of CWTs.

4.2.4.2 Freshwater (Inland) Harvest

CDFW has established specific in-river fishing regulations and no-retention prohibitions designed to protect winter-run Chinook salmon during their freshwater life stages. Based on data from 1968-73 and 1975, Hallock and Fisher (1985) reported that the freshwater sport fishery harvested an average of 8.5 percent of the in-river run of Sacramento River winter-run Chinook salmon.

Under the Proposed Action (Alternative 2), inland fisheries are likely to benefit from the increased abundance of winter-run Chinook salmon in the upper Sacramento River resulting from hatchery production at LSNFH. Winter-run Chinook salmon propagated at LSNFH are managed to supplement natural production, thereby providing a demographic enhancement to aid in the rebuilding and recovery

of that population. This demographic enhancement should reduce of the likelihood of fishery closures aimed at protecting adult winter-run Chinook salmon spawners and their habitat in the upper Sacramento River. During some years, environmental conditions such as drought may result in the need for fishery closures, however the increased resiliency of the population resulting from hatchery supplementation may help to reduce adverse impacts from inland fisheries.

5 CUMULATIVE EFFECTS Introduction

The National Environmental Policy Act defines cumulative effects as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions” (40 CFR 1508.7). Council on Environmental Quality (CEQ) guidelines recognize that it is not practical to analyze the cumulative effects of an action from every conceivable perspective, but rather, the intent is to focus on those effects that are truly meaningful. In other words, if several separate actions have been taken or are intended to be taken within the same geographic area, all of the relevant actions together (cumulatively) need to be reviewed, to determine whether the actions together could have a significant impact on the human environment. Past, present, and reasonably foreseeable future actions include those that are Federal and non-Federal. For this EA analysis, they also include those that are hatchery related (*e.g.*, hatchery production levels) and non-hatchery related (*e.g.*, human development).

5.2 Geographic and Temporal Scales

The cumulative effects analysis area is the upper Sacramento River Basin, from RBDD upstream to Keswick Dam, including tributaries such as Battle Creek (Section 1.4, Action Area). NMFS considered whether the ocean should be included in the broad analysis area, but the effects analysis was unable to detect or measure effects of the Proposed Action beyond the Sacramento River. Available knowledge and research abilities are insufficient to discern the role and contribution of the Proposed Action to density dependent interactions affecting salmon and steelhead growth and survival in the Pacific Ocean. NMFS’ general conclusion is that the influence of density dependent interactions on growth and survival is likely small compared with the effects of large scale and regional environmental conditions. While there is evidence that hatchery production, on a scale many times larger than the Proposed Action, can impact salmon survival at sea, the degree of impact or level of influence is not yet understood or predictable, nor is there any evidence that programs of this size have effects in the ocean. Thus, direct, indirect, and cumulative impacts of the programs on the human environment outside of the Sacramento River are not expected.

The scope of the action considered here includes the rearing and release of hatchery-origin winter-run Chinook salmon in the upper Sacramento River Basin. Adult collection, rearing, and release activities would occur in localized areas only; associated direct and indirect effects of these activities are analyzed in Section 4, Environmental Consequences. The HGMPs would be in effect after the associated ESA section 10(a)(1)(A) permit is signed, and would remain in effect for up to ten years when the permit

expires, or until NMFS determines that that the plans are no longer effective. Cumulative effects within the analysis area are analyzed below.

5.3 Climate Change

Under either Alternative 1 (No-action) or Alternative 2 (Proposed Action), no significant effects to climate change are expected. No activities would occur under either alternative that would result in changes to greenhouse gas emissions or other pollutants that are likely to significantly contribute to environmental conditions associated with climate change.

Climate change poses a high threat to salmonids within the Action Area, particularly to winter-run Chinook salmon. Temperatures in California's Central Valley are predicted to increase between 2°C and 7°C by 2100 (Dettinger et al. 2004, Hayhoe et al. 2004, Van Rheezen 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 persist 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.*, winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead) that must hold below the dam over the summer and fall periods.

Overall, the range and degree of variability in ambient temperature and precipitation are likely to increase in all populations, creating long term threats to the persistence of Sacramento River winter-run Chinook salmon. Although long-term trends in climate change are likely to place additional stress on the conservation and recovery of the Sacramento River winter-run Chinook salmon ESU, NMFS does not expect that climate change will be significant enough to have an appreciable effect on winter-run Chinook salmon in the Sacramento River basin during the 10-year permit period.

5.4 Habitat Restoration

Urban and agriculture development along with levee construction and channelization for flood control, and water delivery operations have resulted in reduced rearing habitat, migration corridors, and food web production for juvenile winter-run Chinook salmon in the Sacramento River Basin. The CVPIA has

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

Rehabilitation of habitat in the cumulative effects analysis area will improve salmon and steelhead habitat under all alternatives, with particular benefits to freshwater and estuarine environments considered to be important for the survival and reproduction of fish. However, the low beneficial effects from watershed and habitat rehabilitation will not substantially increase survival and abundance of salmon and steelhead without other improvements. In addition, rehabilitation is dependent on continued funding, which is difficult to predict over time. Benefits from watershed and habitat rehabilitation are expected to affect salmon and steelhead survival similarly under all alternatives.

In summary, the management actions may maintain or continue to improve salmon and steelhead habitat over time under all alternatives, which may have a negligible or low beneficial cumulative effect on the abundance and productivity of natural-origin salmon and steelhead and hatchery-origin populations. Although none of the alternatives would affect the overall trend in cumulative effects on salmon and steelhead, the Proposed Action could help mitigate some adverse effects and reduce the extinction risk of natural-origin populations resulting from cumulative effects such as habitat degradation.

5.5 Cumulative Effects by Resource

5.5.1 Water Resources

Flows in the Sacramento River in the 65 mile reach between Shasta Dam and RBDD are regulated by Shasta Dam and reregulated downstream at Keswick Dam. Water stored in upstream 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 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. As described in Section 3.1.1, the OCAP BO requires BOR to conserve water in Shasta Reservoir during the spring in order to provide sufficient water to reduce adverse effects of high water temperature in the summer months to benefit winter-run Chinook salmon, without sacrificing carryover storage in the fall.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout California's Central Valley. A substantial number of small and medium-size water diversions exist along the Sacramento River, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions may entrain and kill many life stages of aquatic species, including juvenile listed anadromous species (Mussen et al. 2014a, Mussen et al. 2014b). 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).

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).

As described above in Sections 4.1.1 and 4.2.1, neither Alternative 1 (No-action) nor Alternative 2 (Proposed Action) are expected to have significant effects on hydrology and water use in the Sacramento River. As such, neither Alternative 1 (No-action) nor Alternative 2 (Proposed Action) would contribute to any significant adverse cumulative impacts to hydrology and water use in the upper Sacramento River. The Sacramento River's hydrology would continue to be dominated by the basin's natural hydrologic character and upstream management of flow volumes from Shasta Lake and releases from both Shasta and Keswick dams.

5.5.2 Biological Resources

5.5.2.1 Salmon and Steelhead

Salmon and steelhead abundance naturally alternates between high and low levels on large temporal and spatial patterns that may last centuries and on more complex ecological scales than can be easily observed (Rogers et al. 2013). The effects of climate change on salmon and steelhead are described in general in ISAB (2007), and would vary among species and among species' life history stages. Climate change,

particularly changes in streamflow and water temperatures, would likely impact hatchery- and natural-origin salmon and steelhead life stages in various ways as summarized in Table 5-2.

Table 5-2. Examples of potential impacts of climate change by salmon and steelhead life stage under all alternatives

Life Stage	Effects
Egg	<ul style="list-style-type: none"> • Increased water temperatures and decreased flows during spawning migrations would increase pre-spawn mortality and reduce egg deposition for some species. • Increased maintenance metabolism would lead to smaller fry. • Faster embryonic development would lead to earlier hatching. • Increased mortality for some species because of more frequent winter flood flows. • Lower flows would decrease access to or availability of spawning areas.
Spring and Summer Rearing	<ul style="list-style-type: none"> • Faster yolk utilization may lead to early emergence. • Smaller fry are expected to have lower survival rates. • Growth rates would be slower if food is limited or temperature increases exceed optimal levels. • Growth could increase where food is available, and temperatures are below stressful levels. • Lower flows would decrease habitat capacity. • Sea level rise would eliminate or diminish the tidal wetland capacity.
Overwinter Rearing	<ul style="list-style-type: none"> • Smaller size at start of winter is expected to result in lower winter survival. • Mortality would increase because of more frequent floods. • Warmer winter temperatures would lead to higher metabolic demands, which may decrease winter survival if food is limited, or increase winter survival if growth and size are enhanced. • Warmer winters may increase predator activity/hunger, which can decrease winter survival.
Out-Migration	<ul style="list-style-type: none"> • Earlier snowmelt and warmer temperatures may cause earlier emigration to the estuary and ocean either during favorable upwelling conditions, or prior to the period of favorable ocean upwelling. • Increased predation risk in the mainstem because of higher consumption rates by predators at the elevated spring water temperatures.

Adult	<ul style="list-style-type: none"> • Increased water temperatures may delay fish migration. • Increased water temperature may also lead to more frequent disease outbreaks as fish become stressed and crowded.
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Sources: (Glick et al. 2007, ISAB 2007, Beamish et al. 2009, Beechie et al. 2013)

Alternative 1 (No-action) could cause an increased risk of extinction for the Sacramento River winter-run Chinook salmon ESU when added to other past, present, and reasonably forecast future actions if measures identified in the HGMP are not fully implemented. With implementation of the HMGP, biologically-based hatchery management strategies would be implemented that are expected to contribute to the conservation and recovery of the species. As described above in Section 4.2.2, full implementation of the HGMP under Alternative 2 (Proposed Action) would decrease the genetic and demographic risks of inbreeding (at the hatchery) and hatchery and natural interbreeding (on the spawning grounds) further aiding recovery of the Sacramento River winter-run Chinook salmon ESU. Accordingly, although there are still risks from predation, competitive interactions, and interbreeding, the conservation benefits of Alternative 2 outweigh the risks associated with Alternative 2. Implementation of the HGMPs under Alternative 2 (Proposed Action) would support recovery of the population in the upper Sacramento River that might otherwise continue to decline irreversibly. Based on these factors, Alternative 2 is not expected to contribute to any significant adverse cumulative impacts on fish species.

5.5.2.2 Other Fish Species

Similar to salmon and steelhead, other fish species such as green sturgeon and lamprey require and use a diversity of habitats. Other fish species may also be affected by climate change and development because of the potential for loss or degradation of aquatic habitat or the inability to adapt to changing conditions. In addition, climate change and development may attract non-native aquatic plants that can out-compete native aquatic plants that provide important habitat to native fish (Patrick et al. 2012). However, habitat restoration actions may help mitigate impacts from climate change and development, and the hatchery programs will provide a prey source for some fish species. Thus, the proposed action has no change compared to current conditions on other fish species when added to the other cumulative effects in the analysis area.

5.5.2.3 Fish-Eating Birds

Bald eagles and osprey have made a strong comeback from the mid-1960s and '70s when they were severely impacted by the use of Dichlorodiphenyltrichloroethane (DDT), a widely used pesticide now banned in the United States. DDT caused significant declines in fish-eating birds as the chemical was

accumulated by prey and resulted in reproductive failures of the birds. Populations of these species are considered stable and expanding, and in 2007 the bald eagle was removed from the list of endangered and threatened species in the United States. In the Sacramento River basin it is believed bald eagles are expanding their numbers and breeding and foraging ranges. Similar trends are observed with the osprey.

As described above in Sections 4.1.2.4 and 4.2.2.4, Alternative 1 (No-action) would maintain the current or similar contribution that LSNFH production has on forage for fish-eating birds, and Alternative 2 (Proposed Action) may slightly increase the contribution that LSNFH production currently has on forage for fish-eating birds. The contribution of LSNFH production to forage for fish-eating birds, when added to other past, present, and foreseeable future actions, will result in beneficial cumulative effects on these birds.

5.5.3 Socioeconomics

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and storm water runoff patterns. 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 waterbodies, will not require Federal permits and/or authorizations. 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 and green sturgeon moving through the system. Increased recreational boat operation is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the associated water bodies.

As described above in sections 4.1.3 and 4.2.3, neither Alternative 1 (No-action) nor Alternative 2 (Proposed Action) are likely to impact socioeconomics in the action area. As such, neither Alternative 1 (No-action) nor Alternative 2 (Proposed Action) would contribute to any significant cumulative impacts to these resources.

5.5.4 Commercial and Recreational Fisheries

It is likely that the salmon and steelhead fisheries in the analysis area will change over time. These changes are likely to reduce effects to natural-origin salmon and steelhead listed under the ESA. For example, effects to natural-origin salmon and steelhead would be expected to decrease over time to the extent that fisheries management programs continue to be reviewed and approved by NMFS under the ESA, as evidenced by the beneficial changes to programs that have thus far undergone ESA review. Fisheries management program compliance with conservation provisions of the ESA will ensure that listed species are not jeopardized and that “take” under the ESA from salmon and steelhead fisheries is minimized or avoided. Where needed, reductions in effects on listed salmon and steelhead may occur through changes in areas or timing of fisheries, or changes in types of harvest methods used.

5.5.4.1 Ocean Fisheries

When the winter-run Chinook salmon ESU was being evaluated by NMFS for listing under the ESA in the late 1980s, overutilization was not considered to be an important factor in the species decline. In the years following the ESA listing of winter-run Chinook salmon, more information on the impacts of the ocean fisheries on the ESU became available, and it was recognized that the fisheries may play a greater role in the viability of the ESU than previously thought. In 1996 and 1997 NMFS issued a biological opinion and amendment which considered the effects of ocean salmon fisheries on winter-run Chinook salmon. Those documents determined that the ocean fisheries jeopardize winter-run Chinook salmon and, as part of the RPA, fishery restrictions were adopted to protect the ESU.

There have been five biological opinions issued for the ocean salmon fishery's effects on winter-run Chinook salmon (1991, 1996/1997, 2002, 2004, and 2010). Similar to the 1996/1997 biological opinion, the 2010 biological opinion determined that the fisheries jeopardized the species. To avoid jeopardy, the action agency (NMFS Sustainable Fisheries Division) continues to implement the RPA, which: (1) specifies that the previous consultation standards for winter-run Chinook salmon regarding minimum size limits and seasonal windows south of Point Arena for both the commercial and recreational fisheries will continue to remain in effect at all times regardless of abundance estimates or impact rate limit; and (2) establishes an abundance-based management framework where, during periods of relatively low abundance, the fisheries are restricted in order to lower the impact rate on winter-run Chinook salmon.

Seasonal time/area restrictions and minimum size limits for the sport and commercial ocean salmon fisheries are in place for the protection of winter-run Chinook salmon. Additionally, there is a regulatory management framework to further reduce ocean fishery impacts when the status of winter-run is declining

or unfavorable (NMFS 2012). Production from LSNFH may be incidentally encountered in commercial and recreational fisheries in the Sacramento River Basin and the Pacific Ocean. Under Alternative 1 (No-action), commercial and recreational fishing would continue to benefit from operation of the salmon production program at LSNFH because 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. However, it is uncertain whether the Winter Chinook Integrated-Recovery Supplementation Program could continue in its current form under Alternative 1. Under Alternative 2 (Proposed Action), further increases in winter-run Chinook salmon abundance and productivity are more likely to occur, contributing to the conservation and recovery of the species, and subsequent resumption of directed fisheries.

5.5.4.2 Inland (Freshwater) Fisheries

The current ESA-listing status of winter-run Chinook salmon limits the ability of the region to fully benefit from freshwater salmon fisheries by limiting the opportunity to harvest other non-listed runs of Chinook salmon intermingled with listed winter-run Chinook salmon during certain times of the year. Freshwater harvest of winter-run Chinook salmon was largely eliminated in 2002 when the opening of the Sacramento River recreational fishing season was adjusted so that the fishery would have only limited overlap with the adult immigration and spawning life stages. Higher densities of fish, particularly below dams such as Keswick Dam, likely create opportunities for both illegal poaching of salmon and the inadvertent or intentional snagging of fish.

Occasional fishery closures may occur in response to unfavorable conditions in the upper Sacramento River that are likely to adversely impact ESA-listed species and their habitat (*e.g.*, prolonged drought conditions that result in low flows and high temperatures). However, the demographic enhancement resulting from the release of hatchery-origin winter-run Chinook salmon from LSNFH should reduce of the likelihood of fishery closures aimed at protecting adult winter-run Chinook salmon spawners and their habitat in the upper Sacramento River. Improvements in the prospects for the recovery of winter-run Chinook salmon through hatchery operations and monitoring and evaluation activities as described in the approved HGMP, in addition to complementary habitat restoration and reintroduction actions, are expected to provide benefits to the regional salmon fisheries.

SECTION 6 PERSONS AND AGENCIES CONSULTED

The following parties were consulted during the development of this EA:

United States Fish and Wildlife Service

Bureau of Indian Affairs

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