HATCHERY AND GENETIC MANAGEMENT PLAN

Hatchery Program:	Livingston Stone National Fish Hatchery - Integrated-Recovery Supplementation Program
Species or Hatchery Stock:	Sacramento River Winter Chinook Salmon (*Oncorhynchus tshawytscha*)
Agency/Operator:	U.S. Fish and Wildlife Service
Watershed and Region:	Sacramento River
Date Submitted:	January 20, 2016
Date Last Updated:	Initial Submission

SECTION 1. GENERAL PROGRAM DESCRIPTION

1.1) Name of hatchery or program

The Livingston Stone National Fish Hatchery (NFH) houses the Winter Chinook Conservation Hatchery, which consists of an integrated-recovery supplementation program and a captive broodstock program. The Livingston Stone NFH, together with the Coleman NFH, comprise the Coleman NFH Complex.

1.2) Species and population (or stock) under propagation, and ESA status

The Evolutionary Significant Unit (ESU) of Sacramento River Winter-run Chinook salmon (*Oncorhynchus tshawytscha*) are listed as endangered under the Endangered Species Act (ESA) of 1973. Winter Chinook were first listed as threatened (August 4, 1989, 54 FR 32085), reclassified as endangered (January 4, 1994, 59 FR 440), reaffirmed as endangered (June 28, 2005, 70 FR 37160 and August 15, 2011, 76 FR 50447)

1.3) Responsible organization and individuals

Indicate lead contact and on-site operations staff lead.

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Additional responsible agencies:
Coleman and Livingston Stone NFH are mitigation features to partially offset habitat and fish losses resulting from the construction of Shasta and Keswick dams, part of the Central Valley Project (CVP). Both facilities are operated by the U.S. Fish and Wildlife Service (Service) and funded by the U.S. Bureau of Reclamation (Reclamation).

Reclamation Contact

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1.4) Funding source, staffing level, and annual hatchery program operational costs

Reclamation provides to the Service an annual budget of approximately $5.6 million for operations and maintenance of the Coleman National Fish Hatchery Complex. Additional dedicated funding, such as for construction, facility rehabilitation, research and monitoring, or other projects, may be secured from other sources (e.g., CVPIA [CVPIA] and State funding).

The Coleman NFH has approximately 20 employees, including seasonal staff. A portion (approx. $250,000) of the budget provided to the Service is allocated to the Livingston Stone NFH for the winter Chinook propagation program. Total staff for the Livingston Stone NFH is four and occasionally, during periods of increased workload, additional staff are temporarily transferred from the Coleman NFH. The Livingston Stone NFH is also used to house a refugial population of delta smelt. Delta smelt reared at the Livingston Stone NFH are a genetically redundant secondary population of the primary delta smelt refugial population housed at Byron, California. Funding for the delta smelt refugial hatchery program is provided through the Service's Fisheries Program.

A portion of the annual funding provided by Reclamation 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 Red Bluff Fish and Wildlife Office (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 Reclamation 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.

1.5) Location(s) of hatchery and associated facilities

Livingston Stone NFH is located in the upper Sacramento River basin in the northern Central Valley of northern California. The hatchery is located at the base of Shasta Dam (Keswick Reservoir) on the west side of the Sacramento River approximately 12 river miles (RM) upstream of the limit of anadromy at Keswick Dam. The stock location code recognized by the Pacific States Marine Fisheries Commission (PSMFC) Regional Mark Processing Center for Livingston Stone NFH is 6FCSASAF LVNH. The Coleman NFH, which combines with the Livingston Stone NFH to form the Coleman NFH Complex, is located on Battle Creek, an eastside tributary that enters the Sacramento River 32.5 river miles (RM) downstream of the Keswick Dam.

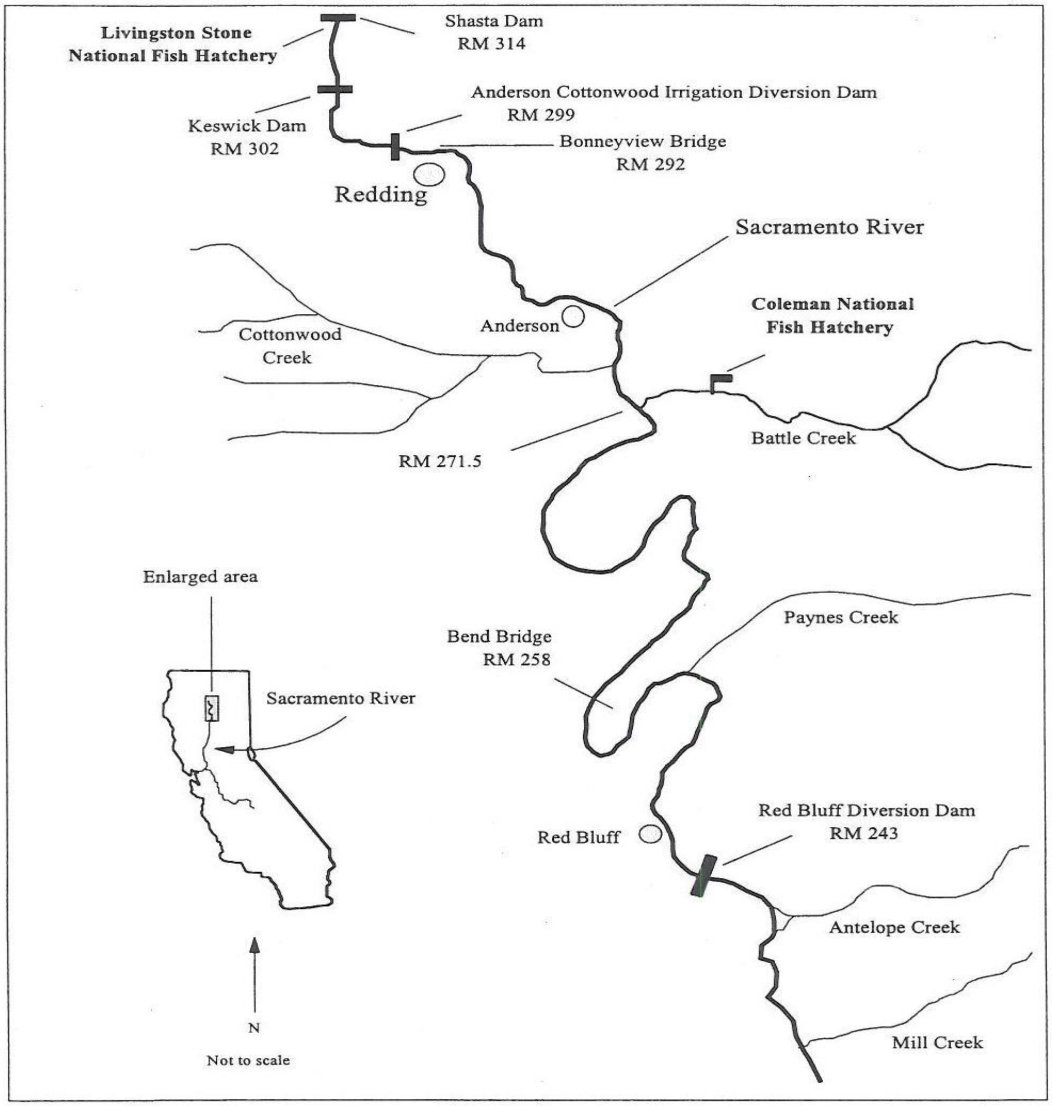

Figure 1.5.1. Locations of the Coleman and Livingston Stone National Fish Hatcheries

1.6) Type of program

The Winter Chinook Conservation Hatchery consists of two interrelated programs; 1) the Winter Chinook Integrated-Recovery Supplementation Program and the Winter Chinook Captive Broodstock Program. In the Winter Chinook Integrated-Recovery Supplementation Program, hatchery propagated winter Chinook are managed to be *integrated* with the natural population of winter 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 Chinook produced at the Livingston Stone NFH are intended to return as adults to the upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated into the natural spawning population. The Winter Chinook Captive

Broodstock Program is conducted by withholding from release a portion of the juveniles produced annually in the integrated-recovery supplementation program and rearing them to maturity at the Livingston Stone NFH.

1.7) Purpose (Goal) of program

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

1.8) Justification for the program

Livingston Stone NFH was constructed by Reclamation in 1997 for the explicit purpose of propagating ESA-listed winter Chinook salmon. Hatchery propagated winter Chinook are managed to be *integrated* with the natural population of winter Chinook in the upper Sacramento River and are intended to provide a demographic enhancement to aid in the resilience, rebuilding and *recovery* of that population. The Winter Chinook Integrated-recovery supplementation program is supported in NMFS' Final Recovery Plan for Central Valley Chinook Salmon and Steelhead (NMFS 2014). The Final Recovery Plan states that the program "…*is expected to play a continuing role as a conservation hatchery to help recover winter-run Chinook salmon* (NMFS 2014).

1.9) List of program "Performance Standards"

The following performance standards have been designed to evaluate the benefits and risks of the Winter Chinook Integrated-recovery supplementation program conducted at the Livingston Stone NFH. Performance standards have been classified as either "benefits" or "risks." Performance standards categorized as "benefits" measure the benefits resulting from an artificial propagation program (e.g., contribution to recovery, restoration, conservation/preservation, and/or research). Performance standards categorized as "benefits" (B) indicate possible benefits to winter Chinook. Performance standards categorized as "risks" (R) indicate possible risks the artificial propagation program may pose to winter Chinook.

Performance Standards to Evaluate Benefits

Benefit Number	Standard / Guideline
B1.	Provide a demographic benefit to the abundance of winter Chinook
B2.	Maintain stock integrity and conserve genetic and life history diversity
B3.	Provide fish for experimental purposes

B4.	Conduct research to monitor and evaluate hatchery operations and practices
B5.	Improve survival using appropriate incubation, rearing, and release strategies
B6.	Improve survival by preventing disease introduction, spread, or amplification
B7.	Provide a source of winter Chinook to be coded-wire tagged for purpose of informing decisions related to harvest management
B8.	Provide a source of fish for the winter Chinook Captive Broodstock Program, which can be used to prevent extinction and support reintroduction efforts

Performance Standards to Evaluate Risks

Risk Number	Standard / Guideline
R1.	Reduce potentially harmful genetic and ecological interactions between hatchery- and natural-origin fish
R2.	Do not introduce, spread, or amplify pathogens
R3.	Minimize harmful effects of program operations on winter Chinook

1.10) List of program "Performance Indicators", designated by "benefits" and "risks"

The following performance indicators can be used to monitor and evaluate the aforementioned benefits and risks of the Winter Chinook Integrated-recovery supplementation program at the Livingston Stone NFH. Performance indicators have been separated into two categories: benefits (B) that the hatchery program will provide to the population by meeting program objectives; and risks (R) that the hatchery program may be pose to the population.

1.10.1) "Performance Indicators" addressing benefits

Performance Standard B1: Provide a demographic benefit to the abundance of winter Chinook

Restoration and recovery of native fish and aquatic ecosystems are priorities for the National Fish Hatchery System. Hatchery propagation of winter Chinook salmon at Livingston Stone NFH is conducted primarily to supplement the natural population in the Sacramento River. The basis for the winter Chinook Integrated-recovery supplementation program is that hatchery production can provide higher rates of survival from egg-to-smolt life stages than can be achieved in the natural environment.

Relevant fish culture practices:

- Rear fish using the water where the fish are intended to imprint to enhance homing abilities and promote integration with naturally produced winter Chinook in the upper Sacramento River

- Developed a hatchery facility designed specifically for supplementing Sacramento River winter Chinook salmon
- Constrain the collection of broodstock (maximum of 15% of estimated total run) to lower the demographic and genetic risks to the naturally spawning population
- Use only natural-origin winter Chinook as broodstock to lower the degree of fitness reduction caused by domestication
- Implement strategies to effectively identify and spawn only target broodstock
- Use factorial-type mating strategy to avoid decreasing the effective population size
- Mark and tag 100% of hatchery production

Performance Indicators:
- Continue to conduct field surveys to generate adult run-size estimates and evaluate survival, spawning success, and integration of hatchery propagated winter Chinook salmon with the natural population
- Continue to monitor and evaluate genetic risks of the winter Chinook propagation program to measure potential genetic effects on the natural population
- Conducted a genetic grand parentage analysis to verify reproductive success of the winter Chinook salmon from the propagation program at Livingston Stone NFH

Performance Standard B2: Maintain stock integrity and conserve genetic and life history diversity

Fish culture practices at the Livingston Stone NFH are designed to maintain stock integrity, conserve genetic and life history diversity, and reduce divergence from naturally reproducing stocks. Adult broodstock are collected across a range of phenotypic characteristics, including run timing and age. In addition, under typical conditions the hatchery uses only natural-origin winter Chinook as broodstock. However, under extreme circumstances, such as prolonged drought, the inclusion of adult hatchery-origin winter-run Chinook salmon in the broodstock may be warranted. These practices of broodstock selection are believed to help maintain the fitness of the hatchery stock by reducing the risks of domestication selection and decreasing the potential for divergence between hatchery and natural stocks.

Relevant fish culture practices:
- Use locally-collected, natural-origin adults for broodstock
- Conduct spawning in a manner that minimizes genetic drift and conserves genetic variability of the stock
- Collect adults throughout the duration of run timing, modeling the collection schedule upon historic run timing of naturally produced winter Chinook past the Red Bluff Diversion Dam (RBDD)
- Employ a factorial type mating strategy, using at least two males (if possible) to fertilize a separate portion of eggs from each female. Spawn each male with preferably two but no more than four females
- Use phenotypic and genetic techniques to effectively identify and spawn only winter Chinook
- Use mark status to identify hatchery-origin winter Chinook

- Use natal stream water at the hatchery to reinforce genetic compatibility with local environments and promote homing

Performance Indicators:

- Monitor population trends in fecundity, return rates, return timing, spawn timing, adult size and age composition, survival for different life stages, effective population size, and other parameters

Performance Standard B3: Provide fish for approved experiments

Investigators from government agencies, academic institutions, and the private sector request fish or fish tissues to study a variety of issues. In these investigations, fishes propagated at Coleman and Livingston Stone NFHs can be used as surrogates for natural-origin fish, which may not be available for research purposes. Additionally, some research projects involving winter Chinook may seek to improve the performance and cost-effectiveness of artificial production and provide a means for improving the program through adaptive management. All winter Chinook provided for experimental purposes must be approved by the National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife (CDFW).

Relevant fish culture practices:

- Spawn and rear fish in a manner that will support the needs of NMFS-CDFW approved research projects
- Mark and CWT experimental fish prior to release

Performance Indicators:

- As appropriate for specific experimental design

Constraints:

- The size and configuration of rearing units limits total hatchery production and flexibility of lot sizes
- The endangered status of Sacramento River winter Chinook and the potential for reduced survival in some experiments constrains the use of ESA-listed fish for experimental purposes

Performance Standard B4: Conduct research, monitoring and evaluations of hatchery operations and practices

Standard and proven fish culture practices are used at the Livingston Stone NFH to produce fish necessary to accomplish program goals, while reducing the potential for negative effects resulting from the program. Research and monitoring are conducted on- and off-site. Knowledge gained through experimentation and research is used to modify fish culture practices, when appropriate, to better accomplish program goals.

Relevant fish culture practices:

- All existing fish culture practices at the Livingston Stone NFH
- The existing Monitoring and Evaluation Program conducted from the Red Bluff FWO

Performance Indicators:

- Marking and tagging of 100% hatchery-origin winter Chinook
- Periodically review and summarize ocean harvest data
- Analyze and summarize information collected during mainstem Sacramento River carcass surveys to evaluate program operations
- Livingston Stone NFH has served as the source of winter Chinook for acoustic tracking studies to assess survival during emigration
- Broodstock trapping efforts at the Keswick Dam Fish Trap (KDFT) have been the source of studies to assess survival of adult winter Chinook released back into the Sacramento River (i.e., not used as broodstock at the Livingston Stone NFH).

Constraints:

- The endangered status of Sacramento River winter Chinook and the potential for reduced survival in some studies constrains the use of ESA-listed fish for experimental purposes

Performance Standard B5: Improve survival of propagated species/stock using appropriate incubation, rearing, and release strategies

The Service will continue to work to achieve a high level of survival of fish produced at the Livingston Stone NFH, to ensure that the program is producing a demographic benefit to increase escapement and supplement natural production, while reducing the risks to naturally produced salmonids

Relevant fish culture practices:

- Release fish at a time and size that attempts to achieve a balance between high rates of survival and a low level of risk to naturally produced salmonids
- Incubate eggs and rear fish at densities favorable for reducing stress, disease, and mortality
- Use proper disease prevention and control techniques to achieve a high level of survival

- Conduct studies to investigate effects of fish culture practices, such as: food types; rearing densities; ponding strategies; natural-type rearing elements; and size, time, and location of release. Apply knowledge gained through investigations to modify hatchery practices, when appropriate, to achieve a balance between high rates of survival and low potential for detrimental impacts

Performance Indicators:

- Analyze trends in survival for different life stages at the hatchery
- Analyze trends in rates of ocean harvest, freshwater harvest, and escapement

Performance Standard B6: Improve survival by preventing disease introduction, spread, or amplification

The primary goal of fish health management programs at the Livingston Stone NFH is to produce healthy fish that will contribute to program's conservation goals. This goal is accomplished, with assistance and technical guidance from the Service's CA-NV FHC, using state-of-the art technologies in disease prevention and treatment. Fish culture practices at the Livingston Stone NFH are designed to produce healthy smolts. Propagation of healthy juveniles will maximize survival and contribution of hatchery fish, both before and after release, and reduce the potential to negatively impact naturally produced salmonids. The following list details specific projects or activities undertaken at the Livingston Stone NFH to prevent the introduction, spread, or amplification of fish pathogens.

Relevant fish culture practices:

- Maintain sanitary conditions for fish rearing
- Monitor fish behaviors and mortality during incubation and rearing for issues potentially related to fish heath
- Use fencing and/or bird netting to reduce predation and disease transmission into or out of the hatchery
- Prescribe appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) to alleviate disease-contributing factors using approved methods and chemicals
- Conduct applied research leading to improved control of disease epizootics
- Develop and conduct propagation strategies to reduce opportunities for transferring disease from the hatchery to natural fish (e.g., water filtration for embryos and emergent fry)
- Routinely perform examinations of live fish to assess health status and detect problems before they progress into clinical disease or mortality
- Remove dead and moribund fish from rearing containers. In cases of increased mortality, perform necropsies of diseased and dead fish to diagnose the cause of death
- Examine hatchery broodstock for disease organisms (viral, bacterial and parasites)

Performance Indicators:

- Analyze survival trends for different life stages at the hatcheries

Constraints:

- It is difficult to control all pathways of disease transmission
- Fish health can be compromised by poor water quality

<u>Performance Standard B7:</u> Provide a source of winter Chinook salmon to be coded-wire tagged for purpose of informing decisions related to harvest management

Because winter Chinook are protected as an endangered species, harvest regulations are implemented to avoid or minimize their harvest in ocean and freshwater commercial or recreational fisheries. Harvest constraints may be implemented, if necessary, to reduce impacts to winter Chinook. Winter Chinook originating at the Livingston Stone NFH are the only source of coded-wire-tagged winter Chinook, which are used to gauge the success of harvest regulations.

<u>Relevant fish culture practices:</u>

- All hatchery produced winter Chinook salmon are marked and coded-wire tagged prior to release. Releases and recoveries of CWT winter Chinook are reported to the coast-wide CWT database (RMIS; maintained by the PSMFC), where the data are available to evaluate impacts of harvest.

<u>Performance Indicators:</u>

- Report coded-wire tag releases and recoveries
- Coded-wire tag 100% of the winter Chinook produced at the Livingston Stone NFH

<u>Performance Standard B8:</u> Provide a source of fish for the winter Chinook Captive Broodstock Program, which can be used to prevent extinction and support reintroduction efforts

The abundance of winter Chinook is low, and the fact that there is only one population places the species at a high risk of extinction. The Winter Chinook Captive Broodstock Program was reinstituted in 2014 to increase the security of the winter Chinook ESU by rearing a captive population in a safe and secure environment, to be available for use as hatchery brood stock in the event of a catastrophic decline in the abundance of winter Chinook spawners in the Sacramento River. Furthermore, the Captive Broodstock Program will potentially will be used to re-establish winter Chinook to native habitats upstream of Shasta Dam and to Battle Creek.

<u>Relevant fish culture practices:</u>

- Developed a hatchery facility designed specifically for propagating Sacramento River winter Chinook salmon
- Select captive broodstock in a manner that represents the genetic diversity of the parent stock
- Implement proactive strategies of fish health monitoring and treatment achieve high rates of survival
- Implement proactive strategies of fish health monitoring and treatment to achieve high rates of survival

<u>Performance Indicators:</u>

- Report survival across all life-stages of captive broodstock
- Report reproductive success of winter Chinook captive broodstock

Constraints:

- The size and configuration of rearing units at the Livingston Stone NFH limits flexibility of lot sizes and necessitates trade-offs between the size of the winter Chinook Integrated-recovery supplementation program and the Captive Broodstock Program

1.10.2) "Performance Indicators" addressing risks

Performance Standard R1: Reduce potentially harmful genetic and ecological interactions between hatchery- and natural-origin stocks

Hatchery propagation of winter Chinook at the Livingston Stone NFH is designed primarily to aid in the recovery, conservation and/or reintroduction of the natural winter-run Chinook salmon population, and fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population while reducing the potential for negative effects resulting from the propagation program.

Relevant fish culture practices:

- Propagate only genetically-identified winter Chinook collected from the upper Sacramento River
- Release fish at the area intended for supplementation to promote imprinting and reduce straying
- Use natal stream water to reinforce genetic compatibility with local environments
- Use primarily natural-origin winter Chinook from the upper Sacramento River as hatchery broodstock
- Spawn numbers of adults necessary to minimize genetic drift and to conserve genetic variability
- Collect and spawn adults throughout the duration of run timing
- Use a factorial-type mating (e.g., 1 male to fertilize half eggs from two females) to increase effective population size relative to single pair matings
- Select and pair broodstock randomly from collected broodstock
- Incorporate jacks into the spawning plan.

Performance Indicators:

- Monitor and assess characteristics of hatchery-origin winter Chinook in comparison to naturally produced winter Chinook

Constraints:

- Limited funding and endangered status limit field monitoring capabilities

Performance Standard R2: Do not introduce, spread, or amplify pathogens

The primary goal of fish health management programs at the Livingston Stone NFH is to produce healthy fish that will contribute to program goals conservation, and preservation, while minimizing the potential for negatively impacting natural stocks. Propagation of healthy juveniles will maximize survival and contribution of hatchery fish, both before and after release. This goal is accomplished using state-of-the art technologies in disease prevention along with assistance and technical advice from the CA-NV FHC. It is equally important to reduce potential negative effects that releasing diseased fish may have on natural salmonid populations. The following list identifies specific projects or activities undertaken at the Livingston Stone NFH to prevent the introduction, spread, or amplification of fish pathogens from hatchery stocks into natural populations.

Relevant fish culture practices:

- Employ strategies of propagation, rearing, tagging, and release that minimize occurrence of disease in hatchery fish and decrease the potential for transmission of diseases to natural fish
- Maintain sanitary conditions for fish rearing including: 1) disinfecting all equipment (e.g., nets, tanks, rain gear, boots, brooms) with iodophor between uses with different fish/egg lots, 2) disinfecting (with iodophor) the surface of all eggs spawned at the facility and 3) when practicable, disinfect outside rearing units between use with a portable ozone sprayer
- Prescribe appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) to alleviate disease-contributing factors using approved methods and chemicals
- Conduct applied research through the U. S. Food and Drug Administration Investigational New Animal Drug process to control disease epizootics
- Routinely remove dead and moribund fish from rearing containers. Perform necropsies of diseased and dead fish to diagnose the cause of death
- Perform examinations of collected broodstock for disease organisms (bacterial, viral and parasitic)
- Routinely observe juveniles to assess for abnormal appearance and behaviors that could indicate health problems before they progress into clinical disease or mortality

Performance Indicators:

- Routinely monitor on-station mortality of Chinook salmon and conduct examinations when dictated by abnormal appearance, behaviors, or mortality levels

Performance Standard R3: Minimize harmful effects of program operations on the ESA-listed population

Hatchery propagation of winter Chinook could impose negative effects upon the winter Chinook population. For example, trapping of winter Chinook for use as hatchery broodstock could result in mortality, injury or behavioral effects, resulting in decreased natural spawning success. Minimizing such effects is necessary to promote achievement of program objectives

Relevant fish culture practices:.

- Broodstock collection activities at the Livingston Stone NFH

Performance Indicators:

- Conduct floy/dart tagging of fishes released from trapping activities to gain insights into the fate of released fish
- Conducted a study to monitor the movements of winter Chinook released during the course of broodstock collection activities. A final report of this study is being prepared and will be provided to NMFS upon completion.

1.11) Expected size of program

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. The broodstock collection target is limited to a maximum of 15% of the estimated upriver escapement, with an upper limit of 120 broodstock per brood year (i.e., when run sizes >800). To maintain genetic diversity in the event of very low abundance, no less than 20 winter Chinook adults will be collected for broodstock regardless of run size (i.e., when run sizes <135).

In emergency situations, such as the extreme drought that was experienced during the summer of 2014 and 2015, production of winter Chinook may be increased above the standard production levels indicated above to partially mitigate for extremely poor conditions faced by naturally spawning winter Chinook in the Sacramento River. This temporary expansion of winter Chinook propagation activities is intended to partially mitigate for the effects of drought, and is based on the anticipation of temperatures unfavorable for successful natural spawning of winter Chinook in the Sacramento River. In these situations, potential expansion of program goals will be determined collaboratively by the Service, NMFS, and CDFW.

1.11.1) Proposed annual broodstock collection level (maximum number of adult fish)

The standard collection target for winter Chinook is 15% of the estimated upriver escapement, with a minimum of 20 and a maximum of 120. These collection targets include any mortality to potential broodstock while being held captive. In some years, these numbers may be increased to address drought emergencies by mitigating for high levels of in-river mortality due to low flows and lethal water temperatures. In these situations, potential expansion of broodstock collection targets will be determined collaboratively by the Service, NMFS, and CDFW.

1.11.2) Proposed annual fish release levels (maximum number) by life stage and location

Annual targets for the Winter Chinook Integrated-Recovery Supplementation Program are not fixed in terms of numbers of juveniles produced, but rather, the program goal is to maximize production from the adults collected and used as hatchery broodstock (as explained above). The typical annual production level anticipated when operating under normal broodstock collection limits (i.e., n=120 spawners comprised of 60 females and 60 males) is approximately 250,000 smolts. During years when the program is expanded to mitigate for poor in-river conditions, hatchery production may increase, perhaps substantially. For example, during the drought-related expansion of 2014 total hatchery releases exceeded 600,000 juvenile winter Chinook.

Table 1.11.2 Proposed release location and maximum release level of winter Chinook from the Livingston Stone National Fish Hatchery

Life Stage	Release Location	Annual Release Level
Eyed Eggs	N/A	0
Unfed Fry	N/A	0
Fry	N/A	0
Fingerling (Smolt)	Sacramento River – RM 298.5[1]	Maximum annual production at standard program level is approx. 250,000 Maximum annual production during a drought-related program expansion may exceed 700,000
Yearling	N/A	0

1 Release levels, life stages, and locations may vary with approval by NMFS and CDFW, depending on drought contingencies, reintroduction efforts, recovery goals, etc.

1.12) Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data

For brood years 2000 through 2011, the average estimated rate of total contribution (i.e., ocean harvest plus spawning escapement) for winter Chinook salmon from the Livingston Stone NFH was approximately 0.62% (95% CI, 0.23% - 1.01%) of the total number of juveniles released per brood year. The total contribution includes an average of approximately 759 (95% CI, 309 – 1,210) adults returning to the upper Sacramento River.

Table 1.12. Estimated number and proportion of juvenile winter Chinook salmon produced at the Livingston Stone NFH from 2000 through 2011 contributing to fisheries and returning to spawning areas of the upper Sacramento River. Data presented include progeny produced from cryopreserved semen, which is a standard back-up propagation strategy occasionally used at Livingston Stone NFH. Captive broodstock progeny were excluded from tabulated information as these releases may not be representative of general performance of the Integrated-recovery supplementation program. Data are complete only through 2014.

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

1. Return data for hatchery origin winter Chinook from the Service's Hatchery Evaluation Program, Red Bluff, California and the RMPC database (http://www.rmpc.org).

1.13) Date program started (years in operation), or is expected to start

The Service initially propagated winter Chinook salmon at Coleman NFH in 1955. This initial attempt, as well as several subsequent efforts from 1958 through 1967, was generally unsuccessful. Similarly, from 1978 through 1985, several additional attempts to propagate winter Chinook salmon at Coleman NFH were met with limited success as high water temperatures at the Coleman NFH on Battle Creek resulted in substantial mortality of broodstock, eggs, and juveniles.

With a decline in the natural-origin winter Chinook salmon population and a pending petition to list winter Chinook salmon under the ESA, the Service re-committed to developing a successful propagation program for winter Chinook in 1988. The goal of the resurrected Winter Chinook Integrated-Recovery Supplementation Program would be to supplement natural production and assist in recovery of winter Chinook salmon in the upper Sacramento River. Winter Chinook salmon were propagated at the Coleman NFH, located on Battle Creek, from 1989 through 1995. However, despite attempts to imprint juveniles to the Sacramento River, hatchery-origin adults instead returned to the site of the hatchery on Battle Creek, where suitable spawning habitats were not available. Because of this failure to imprint juveniles to the Sacramento River and additional concerns about possible hybridization with spring Chinook, the Service temporarily discontinued collecting winter Chinook broodstock during 1996 and 1997. During these years, hatchery spawning of winter Chinook was limited to very low numbers of fish from a Captive

Broodstock Program that was conducted cooperatively with the Bodega Marine Laboratory of the University of California at Davis and the Steinhart Aquarium of the California Academy of Sciences, San Francisco, California. The collection of winter Chinook broodstock from the Sacramento River was re-initiated in 1998 after refined broodstock selection methods and a new rearing facility on the Sacramento River (Livingston Stone NFH) alleviated concerns of hybridization and imprinting. Since that time the winter Chinook propagation program has operated continuously, including the annual collection and spawning of broodstock from the upper Sacramento River.

1.14) Expected duration of program

The Winter Chinook Integrated-Recovery Supplementation Program is a temporary measure to assist in the recovery of the winter-run Chinook ESU, which currently includes only one population in the upper Sacramento River. Hatchery propagation of winter Chinook is expected to cease when the ESU has been recovered and the program is no longer needed to support reintroduction efforts. The Final Recovery Plan calls for the development of criteria and a process for phasing out the Livingston Stone winter-run Chinook salmon hatchery program as recovery criteria are reached.

1.15) Watersheds targeted by program

The Winter Chinook salmon Integrated-Recovery Supplementation Program at Livingston Stone NFH is operated to supplement natural production in the upper Sacramento River. All natural spawning of Sacramento River Winter Chinook Salmon occurs in the Sacramento River upstream of the city of Red Bluff, California (Pacific States Marine Fisheries Commission [PSMFC] Recovery Location code: 6FCSASAF ABRB). This same recovery location code is used in CalFish to identify spawning locations for winter Chinook, which are primarily within the city limits of Redding, California.

1.16) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed

Several alternative/complementary actions have been implemented to improve environmental conditions and population status of winter Chinook salmon, including habitat restoration activities (including a large-scale restoration project on Battle Creek), establishment of criteria for managing flow and water temperature in the upper Sacramento River, harvest restrictions, removal of migration impediments, and a myriad of actions to improve survival through the Delta.

Processes are underway to introduce winter Chinook to areas where they have been extirpated, such as upstream of Shasta Dam and Battle Creek; these actions could be considered either alternative or complementary actions to the conservation hatchery program. Both of these actions have been proposed and are in process of being implemented through separate (but linked) planning processes, and will likely involve participation by the Winter Chinook Conservation Hatchery.

SECTION 2. PROGRAM EFFECTS ON NMFS ESA-LISTED SALMONID POPULATIONS

2.1) List all ESA permits or authorizations in hand for the hatchery program

Section 7 Permitting History:

Programs:	Artificial propagation of non-listed hatchery-origin fall and late-fall Chinook salmon and ESA-listed steelhead
Current Permit:	Section 7 Biological Opinion covering propagation of non-listed Chinook salmon and ESA-listed steelhead at Coleman NFH
Issue Date:	February 06, 2014

Section 10 Permitting History:

Program:	Artificial propagation of ESA-listed winter Chinook salmon
Current Permit:	Section 10 Enhancement Permit (No. 1027) authorizing the winter Chinook salmon propagation and Captive Broodstock Programs, and associated monitoring projects. Application for renewal of Permit 1027 (Permit 16477) was submitted July 2013 and is currently being processed by NMFS
Issue Date:	January 31, 1997
Expiration Date:	July 31, 2001

Program:	Monitoring projects targeting winter Chinook salmon conducted from the Red Bluff Fish and Wildlife Office
Current Permit:	Section 10 Permit (No. 1415) authorizing the take of winter Chinook salmon for various monitoring projects
Issue Date:	February 6, 2014
Expiration Date:	December 31, 2018

2.2) Provide descriptions, status, and projected take actions and levels for NMFS ESA-listed natural populations in the target area

2.2.1) <u>Description of NMFS ESA-listed salmonid population(s) affected by the program</u>

Both hatchery and naturally produced winter Chinook salmon are included in the ESU of Sacramento River winter Chinook salmon and are provided protections under section 9 of the Endangered Species Act. Information presented below briefly summarizes biological information and life history characteristics of Sacramento River Winter Chinook Salmon and Central Valley Spring Chinook Salmon and Central Valley Steelhead, which could be affected by the Winter Chinook Integrated-Recovery Conservation Hatchery Program at the Livingston Stone NFH. Below, general information is presented on geographic distribution and life history characteristics of ESA-listed salmonids potentially affected by the integrated hatchery program.

Sacramento River Winter Chinook Salmon

Spawning habitat for winter Chinook salmon is restricted to downstream of the Keswick Dam, primarily within the city limits of Redding, California. Prior to 2012 spawning migrations of winter Chinook were partially blocked or delayed by the RBDD and limited spawning occurred downstream as far as the city of Red Bluff, California. The RBDD was deactivated in 2012, and is no longer a migration impediment. Winter Chinook salmon generally migrate past the RBDD between mid-December and early August, with most fish passing that point between January and May and numbers peaking in March. Winter Chinook spawning occurs from mid-April through mid-August, with most spawning activity occurring in May and June. Based on data collected in the Sacramento River carcass survey from 2001 through 2010, age structure of hatchery-origin winter Chinook salmon was 6.2% age-2, 91.4% age-3, and 2.4% age-4, with a rare age-5 fish returning. Detailed information on the age structure of natural-origin winter Chinook salmon is not readily available, but proportion of jacks (age-2) and adults (age 3+) from 2001 to 2010 were 5.1% and 94.9%, respectively based on length-frequency distributions. Fisher (1994) reported that most winter Chinook females mature at age-3 (1% age-2, 91% age-3, and 8% age-4).

Size and sex ratio data for spawning winter Chinook salmon are available for adults captured during 1998 through 2011 at the Battle Creek barrier weir, RBDD fish trap, and KDFT. Adult males ranged between 240 and 1,151 millimeter (mm) fork length (FL), and females ranged between 500 and 1,000 mm FL. Average male-to-female sex ratio was approximately 0.9:1. Winter Chinook eggs incubate and hatch in about two months, depending on water temperatures. Juveniles emerge between the end of June and mid-October. Juvenile winter Chinook salmon generally emigrate between August and April, with peak emigration rates at RBDD in September to early October. Studies involving acoustic tagging of juvenile hatchery-origin winter Chinook provide information on survival and travel speeds during their emigration to the Delta. In studies conducted in 2013 and 2014, survival and travel speeds of acoustically tagged hatchery-origin winter Chinook was shown to be highly variable and largely dependent on environmental conditions in the Sacramento River. Acoustic tagged winter Chinook emigrating coincident with precipitation events, associated with increased river flow and turbidity, travel downstream faster and survive at higher rates as compared to winter Chinook emigrating during conditions of low flow and clear water. For example, survival of acoustic tagged winter Chinook in 2014 (0.42), which were associated with a rainfall event in the upper Sacramento River Basin, exceeded nearly three-fold those conducted in 2013 (0.16), which was not associated with a precipitation event (A. Amman, NMFS, personal communication). Juvenile winter Chinook salmon enter saltwater at approximately 120 mm FL.

Table 2.2.1 Size ranges, means, and sex ratios of winter Chinook salmon captured during broodstock collection activities at the Coleman NFH barrier weir, Red Bluff Diversion Dam, and Keswick Dam Fish Trap for years 1998-2014[a,b].

Return Year	Males				Females				Sex Ratio (♂ to ♀)
		Fork Length (mm)				Fork Length (mm)			
	Number	Min	Max	Mean	Number	Min	Max	Mean	
1998	38	621	833	735	76	523	815	675	0.5 to 1
1999	14	488	818	569	10	617	718	672	1.4 to 1
2000	50	391	958	674	59	673	886	767	0.8 to 1
2001	117	445	1,151	686	89	584	845	737	1.3 to 1
2002	87	450	1,000	693	101	665	828	750	0.9 to 1
2003	106	412	1,000	671	121	538	880	749	0.9 to 1
2004	252	420	935	586	68	600	881	755	3.7 to 1
2005	163	475	1,000	785	211	620	910	779	0.8 to 1
2006	151	490	1,000	829	163	620	1,000	780	0.9 to 1
2007	56	430	1,000	836	98	680	990	787	0.6 to 1
2008	96	450	930	763	98	500	890	778	1.0 to 1
2009	107	550	990	852	162	520	900	775	0.7 to 1
2010	191	240	1,010	819	228	560	980	737	0.8 to 1
2011	185	480	1,000	641	193	500	980	655	1.0 to 1
2012	313	520	930	804	490	580	880	731	0.6 to 1
2013	132	440	1,000	733	182	550	820	733	0.7 to 1
2014	178	440	1,041	701	247	540	1,000	760	0.7 to 1
Overall	2,236	240	1,151	728	2,596	500	1,000	742	0.9 to 1

a. Source: U.S. Fish and Wildlife Service unpublished data.
b. Winter Chinook salmon were identified through genetic analyses. Genetic analyses for 1998 to 2003 were conducted by Bodega Marine Laboratory, University of California-Davis, Bodega, California. Genetic analyses for 2004 to present were conducted by the Abernathy Fish Technology Center, USFWS, Longview, Washington.

Central Valley Spring Chinook Salmon
Current spawning habitats in the upper Sacramento River include the mainstem Sacramento River downstream of Keswick Dam and Clear, Beegum, Battle, Antelope, Mill, Deer, and Butte creeks. Central Valley Spring Chinook also occur in Feather and Yuba Rivers, and spring Chinook are currently being reintroduced as an experimental population into the San Joaquin River. Migration of adult spring Chinook salmon in the upper Sacramento River begins in late-March. Historical accounts suggest that spring Chinook salmon migration continued until October, peaking July through September. However, recent data for spring Chinook populations in Mill and Deer creeks show adult migrations occurring primarily from March through June, peaking during the month of May. Changes in timing of migration apparently occurred after the construction of Shasta Dam, and indicate possible hybridization with fall Chinook salmon.

Spring Chinook spawning occurs from mid-August through October and peaks in late September. Data on age and sex ratios of upper Sacramento River spring Chinook spawners are not currently available.

Age at emigration varies; spring Chinook salmon have been captured emigrating past the RBDD as fry, fingerlings, and yearlings. Newly-emerged spring Chinook fry begin migrating past RBDD in November. Emigration continues through April, with the largest numbers of juveniles passing RBDD as fry in December and January. Spring Chinook salmon undergo physiological changes that enable transition to saltwater at about 80 mm FL.

Central Valley Steelhead
Life history characteristics for steelhead are highly variable. Adult steelhead migrate past RBDD throughout the year. Most of the migrating adults arrive between the end of August and the end of November, with peak numbers passing in late September and early October. Spawning occurs between late December and early May, peaking in February (Hallock 1989, Busby et al. 1996).

Hallock (1989) reports age structure of naturally-spawning steelhead as follows: 17% age-2, 41% age-3, 33% age-4, 6% age-5, and 2% age-6. Most steelhead spawn once then die, but repeat spawning does occur, mostly among females. Analysis of scale data indicated 83% were first-time spawners, 14% were second-time spawners, 2% were spawning for the third time, and 1% spawned for the fourth time (Hallock 1989). Sex ratios for naturally-spawning populations of steelhead in the Sacramento River are not available, but overall sex ratio of steelhead along the west coast of the US is thought to be 1 to 1 (Pauley et al. 1986).

Steelhead eggs generally hatch in four to seven weeks, and fry emerge one to two weeks after hatching (Pauley et al. 1986). Juvenile steelhead may emigrate soon after emergence, or spend one to two years in freshwater before their seaward migration. Hallock (1989) reported a small percentage of steelhead rear for three years in freshwater before smolting. Most steelhead fry disperse downstream past the RBDD shortly after emergence from the gravels (USFWS 2002). Newly-emerged steelhead fry emigrate from the upper Sacramento River in two temporal peaks annually. Steelhead fry (≈50 mm) typically begin to pass RBDD in February and downstream movement continues through August. A second, distinct peak of steelhead fry typically begins to pass RBDD in early-July and continues through November (Johnson and Martin 1997, USFWS 2002).

Southern Distinct Population Segment (DPS) of North American Green Sturgeon, Southern Resident Killer Whale, and Delta Smelt
The Southern DPS of North American Green Sturgeon, Southern Resident Killer Whale, and Delta Smelt are ESA-listed species that overlap in time and space with a portion of the life cycle of winter Chinook salmon that are not expected to be negatively affected by the propagation program at the Livingston Stone NFH. Southern Resident Killer Whale could benefit slightly from hatchery production of winter Chinook due to increased forage base of salmon, which is their principle prey item.

Identify the NMFS ESA-listed population(s) that will be directly affected by the program
The Sacramento River winter Chinook salmon ESU will be directly affected by Winter Chinook

Integrated-Recovery Supplementation Program. Winter Chinook are trapped from the upper Sacramento River for use as hatchery broodstock. Returning hatchery-origin adults are intended to spawn in the upper Sacramento River and integrate into the naturally spawning population.

Identify the NMFS ESA-listed population(s) that may be incidentally affected by the program

Central Valley Spring Chinook, Central Valley steelhead, the Southern DPS of North American Green Sturgeon, and Southern Resident Killer Whale may be incidentally affected by the Winter Chinook Integrated-Recovery Supplementation Program.

2.2.2) Status of NMFS ESA-listed salmonid population(s) affected by the program

Describe the status of the listed natural population(s) relative to "critical" and "viable" population thresholds

Sacramento River Winter Chinook Salmon

Sacramento River Winter Chinook Salmon were historically abundant and comprised of populations in the McCloud, Pit, Little Sacramento, and Calaveras rivers. Evidence also indicates winter Chinook 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 the Keswick Dam and the city of Red Bluff.

Estimates of winter Chinook abundance have been derived using a combination of methods. From 1967 to 2008, estimates for winter Chinook abundance were derived by counting passage through the fish ladders at the RBDD. However, the ability to estimate winter Chinook passage at the RBDD was decreased after 2012 when dam gates were raised for a longer portion of the migration season and passage-based estimates were ended after 2012 with the completion of construction of a pumping plant, which enabled year-round diversion of water without lowering the dam gates. Beginning in 1996, estimates of winter Chinook spawner abundance have been derived by employing daily surveys of winter Chinook spawning areas and a combination of carcass mark-and-recapture estimators, including the Peterson, Schaefer, Jolly-Seber, and Cormack Jolly-Seber.

Abundance of winter Chinook have fluctuated greatly, exhibiting multi-year trends of either increase or decrease. From 1967 through the early 1990s, the Sacramento River winter Chinook salmon population declined at an average rate of 18% per year, or roughly 50% per generation. Based on passage estimates at RBDD, the Sacramento River winter Chinook salmon population reached a low abundance in 1994 when an estimated 189 adults passed above RBDD. From the mid-1990s until 2006 the winter Chinook salmon population steadily increased in abundance, reaching a high of 17,296. From 2006 to 2011 the abundance of winter Chinook spawners declined to an estimate of only 827, and rebounded somewhat to approximately 2600, 6000, and 3,000 in 2012, 2013, and 2014, respectively. The cohort replacement rate for winter Chinook salmon was less than one for six consecutive years between 2007 and 2012, indicating a sustained period of declining abundance. Cohort replacement rates for winter Chinook returns of 2013 and 2014 were greater than one.

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 Chinook salmon to achieve the recovery criteria, three viable populations must exist at low risk of extinction (NMFS 2014).

Central Valley Spring Chinook Salmon

Spring Chinook salmon were once the predominant run in the Central Valley. Present day abundance of spring Chinook has declined dramatically from historical levels. Commercial harvest data comparing average catch from 1916 through 1949 and 1950 through 1957 showed a 90% reduction in spring 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. Estimated spawner escapement for the Sacramento River basin population of spring Chinook salmon, based on run-timing, averaged 11,155 over the last 13 years, but yearly estimates ranged widely from just over 3,000 spawners to over 31,000. There are only a few isolated, naturally-spawning populations remaining and these generally exist at relatively low levels of abundance (typically <1000) (NMFS 2014). The National Marine Fisheries Service (2014) classifies watersheds based on their known ability or potential to support viable populations of Spring Chinook. Core 1 watersheds have the highest potential to support viable populations (low risk of extinction) of spring Chinook. Core 2 populations have the potential to support populations at a moderate risk of extinction, and likely increase diversity within the ESU and provide a buffering effect against local catastrophic occurrences to Core 1 populations. Core 3 populations are present on an intermittent basis and require straying from nearby populations. Recovery Criteria for spring Chinook include (NMFS 2014) core 1 populations in Battle Creek, Clear Creek, Deer Creek, Mill Creek, and Butte Creek along with reintroduction into Core 1 populations in historic habitat above Shasta Dam, in the upper Yuba River, and the San Joaquin River. Hybridization with fall Chinook salmon is a primary concern for naturally-spawning spring Chinook salmon in the mainstem Sacramento River, Feather River, and elsewhere, because of similar spawn timing and lack of spatial separation in limited geographic distribution.

Central Valley Steelhead

Run size estimates are not available for the Central Valley 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. Following construction of Shasta Dam, steelhead abundance in the upper Sacramento River was believed to initially increase appreciably (Azevedo and Parkhurst 1958, Moffett 1949). Between 1953 and 1959, steelhead run-size estimates for the Sacramento River system (above Feather River) ranged from over 14,000 to over 28,000 (Hallock et al. 1961). Hallock et al. (1961) estimated a total run size of 40,000 in the Sacramento River system in the early 1960s. 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% 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 Central Valley steelhead.

The NMFS (2014) uses a similar system of classifying steelhead habitats as Core 1, Core 2, and Core 3, based on their suitability of supporting viable populations. Core 1 watersheds have the highest potential to support viable populations of steelhead. Core 2 populations have a lower potential to support viable populations, and likely increase diversity within the DPS and provide a buffering effect against local catastrophic occurrences to Core 1 populations. Core 3 populations are present on an intermittent basis and require straying from nearby populations. Based on this classification system, NMFS (2014) has identified the following populations as belonging to the Core 1 Classification: Battle Creek, Clear Creek, Deer Creek, Mill Creek, Antelope Creek, and the Calaveras River, as well as reintroductions upstream of Shasta Dam, and the upper Yuba River.

Southern DPS of North American Green Sturgeon

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. In North America, spawning populations of green sturgeon are currently found in only three river systems: the Sacramento and Klamath rivers in California and the Rogue River in southern Oregon. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (Erickson and Hightower 2007). During the late summer and early fall, sub-adults and non-spawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific Coast (Emmett *et al.* 1991, Moser and Lindley 2007). Particularly large concentrations of green sturgeon from both the northern and southern populations occur in the Columbia River estuary, Willapa Bay, Grays Harbor and Winchester Bay, with smaller aggregations in Humboldt Bay, Tillamook Bay, Nehalem Bay, and San Francisco and San Pablo bays (Emmett *et al* 1991, Moyle *et al.* 1992, and Beamesderfer *et al.* 2007). Data indicate that North American green sturgeon migrate from the Sacramento-San Joaquin Estuary considerable distances up the Pacific Coast and sometimes migrate into other estuaries, particularly the Columbia River estuary. Green sturgeon tagging studies (CDFG 2002) confirm this life-history characteristic; the CDFG tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of the Oregon and Washington coasts. Eight of the 12 recoveries in the commercial fishery occurred in the estuary of the Columbia River (CDFG 2002). Interestingly, Lindley et al (2011) found that green sturgeon of the northern and southern DPSs do not appear to enter the freshwater of each other’s natal rivers.

Abundance of the Southern DPS of green sturgeon is described in the NMFS status reviews (http://www.nmfs.noaa.go/pr/listing/reviews.htm). Israel (2006) estimated the abundance of green sturgeon spawners using sibling-based genetics, which indicated spawning populations upstream of the RBDD of 32 spawner pairs in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006. Limited information of population abundance comes from incidental captures of North American green sturgeon while monitoring white sturgeon during the CDFG's sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish in 1993 to more than 8,421 in 2001, and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these estimates, and CDFG does not consider these estimates reliable because they are based on small sample sizes, intermittent reporting, and are drawn from inferences made from incidental catches while monitoring catch of white sturgeon.

Collections of juvenile green sturgeon at the John E. Skinner Fish Collection Facility between 1968 and 2006 can also be used to make inferences on the abundance of the Southern DPS of green sturgeon. The average number of Southern DPS of green sturgeon entrained per year at the State Facility prior to 1986 was 732. From 1986 to 2006, the average per year was 47 (April 5, 2005, 70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (April 5, 2005, 70 FR 17386). However, because these incidental catches at the State and Federal pumping plants are likely to be highly influenced by pumping volumes, these data have uncertain reliability for making inferences about green sturgeon abundance.

The Southern DPS of green sturgeon spawn in the Sacramento, Feather, and possibly the Yuba rivers. Most spawning occurs in the upper Sacramento River in deep pools between Dry Creek and just downstream of the Glen-Colusa Irrigation District (GCID) diversion (Antelope Creek). Larval and juvenile green sturgeon have been caught in traps at two sites in the upper Sacramento River: the RBDD (RM 342; Poytress 2011, 2013) and the GCID pumping plant (RM 205; CDFG 2002). Salmonid monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 larvae and juvenile green sturgeon per year (Adams *et al*. 2002). Larvae captured at the RBDD site are typically only a few days to a few weeks old, with lengths ranging from 24 to 31 mm. This body length is equivalent to 15 to 28 days post hatch as determined by Deng *et al.* (2002). Recent data indicate that very little production took place in 2007 and 2008 (13 and 3 larval green sturgeon captured in the RST monitoring sites at RBDD, respectively; Poytress 2008, Poytress *et al*. 2009).

Southern Resident Killer Whales

The historical abundance of Southern Residents is estimated from 140 to 200 whales. The minimum estimate (≈140) is the number of whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time of the captures. The maximum estimate (≈200) is based on a recent genetic analysis of microsatellite DNA (May 29, 2003, 68 FR 31980). At present, the Southern Resident population has declined to essentially the same size that was estimated during the early 1960s, when it was likely depleted (figure 4-13 in Olesiuk *et al*. 1990). Since censuses began in 1974, J and K pods steadily increased; however, the population suffered an almost 20 percent decline from 1996-2001, largely driven by lower survival rates in L pod. There were increases in the overall population from 2002-2007, however, the population declined in 2008 with 85 Southern Residents counted, 25 in J pod, 19 in K pod and 41 in L pod. Two additional whales have been reported missing since the 2008 census count.

Provide the most recent 12 year (e.g. 1988-present) progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for the listed population. Indicate the source of these data.

For brood years 1999 through 2012, the median estimated cohort replacement rate (CRR) was 0.80 for Sacramento River Winter Chinook salmon. The winter Chinook CRR was less than one for seven of the recent twelve years.

Table 2.2.2.1 Estimated run sizes and cohort replacement rates for Sacramento River winter Chinook salmon, 1999-2014

Return Year	Estimated Run Size[1]	Cohort Replacement Rate[2]
1999	1,352	
2001	8,224	-
2002	7,441	-
2003	8,218	6.08
2004	7,869	0.96
2005	15,839	2.13
2006	17,296	2.10
2007	2,541	0.32
2008	2,830	0.18
2009	4,537	0.26
2010	1,596	0.63
2011	827	0.29
2012	2674	0.59
2013	6123	3.84
2014	3015	3.65
Median		0.80

[1] Estimated Run Size from CDFG GRANDTAB file dated April 22, 2014 (http://www.calfish.org/portals/0/Programs/AdditionalPrograms/CDFGFisheriesBranch/tabid/104/Default.aspx).

[2] Cohort Replacement Rate (CRR) calculated by dividing the run size in year "x+3" by the run size in year "x". The predominant age at return for winter Chinook salmon is three years.

- Provide the most recent 12 year (e.g. 1988-1999) annual spawning abundance estimates, or any other abundance information. Indicate the source of these data.

Table 2.2.2.2 Estimated run size of Sacramento River Winter Chinook, 2000-2014

Return Year	Estimated Run Size[1]
2000	1,352
2001	8,224
2002	7,441
2003	8,218
2004	7,869
2005	15,839
2006	17,296
2007	2,541
2008	2,830
2009	4,537
2010	1,596
2011	827
2012	2,674
2013	6,123
2014	3,015

[1] Estimated Run Size from CDFG GRANDTAB file dated April 22, 2014 (http://www.calfish.org/portals/0/Programs/AdditionalPrograms/CDFGFisheriesBranch/tabid/104/Default.aspx).

- Provide the most recent 12 year (e.g. 1988-1999) estimates of annual proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known.

Table 2.2.2.3 Sacramento River winter Chinook salmon estimated run size, hatchery-origin run component, carcasses observed, and river miles surveyed for return years 2001 – 2010.

Return Year	Total Estimated Run-size[1]	Hatchery Origin Run-size[2]	% of Run Hatchery Origin
2000	1,352		-
2001	8,224	513	6.2
2002	7,441	570	7.7
2003	8,218	423	5.1
2004	7,869	636	8.1
2005	15,839	3,056	19.3
2006	17,296	2,380	13.8
2007	2,541	140	5.5
2008	2,830	170	6
2009	4,537	467	10.3
2010	1,596	199	12.5
2011	827	80	9.7
2012	2,674	809	30.3
2013	6,123	400	6.5
2014	3,015	705	23.4
Median	4,537	490	8.9

[1] Estimated Run Size for 2000-2010 from CDFW GRANDTAB file dated February 1, 2011 (http://www.calfish.org/portals/0/Programs/AdditionalPrograms/CDFGFisheriesBranch/tabid/104/Default.aspx). Estimated run size from 2011 from Doug Killam, CDFG Red Bluff (pers. com.).

[2] Hatchery-origin run size from SERVICE annual reports of Winter Chinook Spawning Grounds Survey (http://www.fws.gov/redbluff/he_reports.aspx). Methodology for estimating hatchery run-size changed beginning 2002.

2.2.3) Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of NMFS listed fish in the target area, and provide estimated annual levels of take

Describe hatchery activities that may lead to the take of listed salmonid populations in the target area, including how, where, and when the takes may occur, the risk potential for their occurrence, and the likely effects of the take.

Activities associated with the Winter Chinook Integrated-Recovery Supplementation Program will result in take of ESA-listed winter Chinook, spring Chinook, and steelhead. Estimates of direct take of ESA-listed salmonids resulting from the Service's integrated-recovery supplementaion program are described in the Service's section 10 permit application and summarized below. Take of resulting from program operations at the Livingston Stone NFH is expected to be limited to activities associated with broodstock collection.

Broodstock Collection

Winter Chinook broodstock are collected using a the Keswick Dam Fish Trap (KDFT), located at the base of Keswick Dam. Collection of winter Chinook broodstock begins in mid-February and extends through July. The entrance to the KDFT is generally opened during hours of daylight and closed prior to sunset. The trap entrance is closed during hours of darkness to prevent harassment and predation upon trapped fishes by river otters. The KDFT is generally emptied twice a week during the period of collecting winter Chinook broodstock, Tuesdays and Fridays, thus fishes may spend up to four days in the fish trap prior to initial sorting.

All fishes captured at the KDFT are transported to the Livingston Stone NFH for initial sorting. Chinook salmon collected at the KDFT are initially identified and sorted as either winter Chinook or non-winter Chinook based on phenotypic characteristics. Phenotypic natural-origin winter Chinook that are needed to meet monthly collection targets are retained for genetic verification of run assignment prior to use as hatchery broodstock. Phenotypic non-winter Chinook and hatchery-origin winter Chinook collected incidental to broodstock trapping activities are tissue sampled, tagged with two anchor-type tags, and released into the Sacramento River at Redding, CA. Steelhead are enumerated and released into the Sacramento River as Redding, CA. Non-retained fishes may spend two to five hours in the transport truck before they are released.

Phenotypically identified natural-origin winter Chinook are tissue sampled and placed in quarantine while a genetically-based run assignment is determined. Genetic run assignment is performed using single nucleotide polymorphism (SNP) markers which provide a high degree of accuracy in differentiating winter Chinook from other co-occurring runs of salmon. Genetic analysis may require three to five days. Quarantined fish that are identified by genetics as non-winter Chinook are transported back to the Sacramento River at Redding, CA where they are released. Quarantined fish that are genetically-identified as winter Chinook are retained as broodstock. All winter Chinook salmon trapped at the KDFT are considered direct take. Take may occur as capture, handling, transport, tissue sample, captivity, stress, injury, and intentional or unintentional lethal take.

The Service has recently installed a new fish trap at the north fish ladder of the ACID to supplement collections of winter Chinook salmon at the KDFT. The ACID Trap will serve as a secondary trapping facility for collecting winter Chinook broodstock. The location of this facility benefits from being centrally located to the natural spawning population in the upper Sacramento River. Additionally, the ACID Trap benefits in that it has been designed to be staffed continuously during operation, which will potentially reduce effects of confinement and handling compared to the KDFT. Collection of broodstock at the ACID are expected to begin in 2016.

Incidental impacts resulting from salmon and steelhead propagation programs at the Coleman NFH Complex to ESA-listed Sacramento River Winter Chinook, Central Valley Spring Chinook, Central Valley Steelhead, Southern DPS of North American Green Sturgeon, and the

Southern Resident Killer Whale were evaluated in a section 7 biological assessment submitted to NMFS in July 2011. In February 2014 the Service received a biological opinion authorizing incidental take of listed species associated with hatchery operations.

Research and monitoring activities associated with the Service's ongoing evaluations of anadromous salmonid populations in the Upper Sacramento River basin, including activities associated with evaluating the propagation programs at the Coleman NFH Complex, may also result in take of the following ESA-listed fishes; Sacramento River Winter Chinook, Central Valley Spring Chinook, Central Valley Steelhead, and the Southern DPS of North American Green Sturgeon. The Service's RBFWO submitted to NMFS an application for a section 10 Permit and in February 2014 received section 10 Permit 1415 authorizing take of listed fish species associated with these research and monitoring projects.

Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish.

Winter Chinook

Chinook salmon are semelparous and female broodstock at the Livingston Stone NFH are therefore killed at the time of spawning. Male broodstock are used in multiple matings, and spawning events of an individual male may occur over several days, thus males are kept alive until after they are spawned for the final time.

Some of the fish encountered during the collection of hatchery broodstock may be incidentally injured or killed during the process of trapping, transportation, anaesthetization, handling, or during their detention at hatchery prior to spawning. Lethal take of this type, occurring while fish are held captive, is characterized as "pre-spawn mortality" in hatchery records. Pre-spawn mortality of winter Chinook is expected to be less than 15% of the number of adults retained as broodstock. Pre-spawn mortality results in losses of genetic information and causes lost productivity. Prespawn mortality resulting from winter Chinook trapping, transportation, handling, sampling, and anaesthetization during years of standard production levels (i.e., >120 broodstock) ranged from 4 to 19 annually from 2000 to 2013. Additional mortality should be expected when the program size is increased, such as was conducted in 2014 and is again being implemented in 2015 to mitigate for effects of prolonged severe drought. For example, in 2014 a total of 64 winter Chinook, nearly 16.5% of the number retained, died prior to spawning at the Livingston Stone NFH. Incidental mortality of unmarked ESA-listed spring Chinook ranged from 0 to 2 annually between 2000 and 2014. Adipose-clipped spring Chinook from the Feather River Fish Hatchery, which are sacrificed when captured at the KDFT, are not included in these totals. Only one steelhead-rainbow trout mortality has been documented at the KDFT Fish trap since 2000; an adipose-clipped hatchery-origin steelhead was sacrificed in 2005 to inspect for the presence of a coded-wire tag. No mortality of sturgeon has been documented as a result of the Winter Chinook Conservation Hatchery Program.

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

Information are not available to confidently estimate levels of take to fish that are trapped at the Keswick Dam but not retained for use as hatchery broodstock. Lethal take of fishes trapped and released from the KDFT has previously been estimated at 5% the number released; however, data are not available to confidently support or refute this estimate. Fishes not meeting phenotypic and genetic criteria, winter Chinook in excess of monthly collection targets, and all hatchery-origin winter Chinook, are released into the Sacramento River at Redding, California. The intent of releasing these fish is that they integrate and spawn with the naturally reproducing population. Prior to their release, non-retained winter Chinook are tagged with two dart-type tags. Tagging enables these fish to be identified if they are subsequently recaptured at the KDFT or encountered as carcasses on the winter Chinook escapement survey (i.e, carcass survey). It is not uncommon for dart tagged winter Chinook to re-enter the KDFT multiple times during a collection season. Some fish have been trapped at the KDFT as many as six times, with capture dates extending more than four months after the initial collection (SERVICE, Red Bluff FWO, unpublished data). This information suggests that trapping and handling of fishes is not necessarily detrimental to survival, at least for some fishes. However, few anchor tagged winter Chinook are observed on the carcass survey. Observations of anchor-tagged fish on the winter Chinook carcass survey occur far less frequently than would be expected given the numbers of tagged fish released and recent estimates of winter Chinook abundance. The lack of observations of anchor tagged winter Chinook on the carcass survey suggests that released fish may not be successfully contributing to the natural spawning population. Considered together, these data are confounding and do not provide the resolution necessary to characterize the effects of broodstock collection activities on the reproductive success of winter Chinook that are not retained as broodstock. The Service is currently studying movements of winter Chinook after they have been trapped at the KDFT and released into the Sacramento River using acoustic telemetry (see Section 12). It is anticipated that these studies will help to elucidate delayed effects of trapping and handling upon released fishes, which can then be used to better quantify estimates of this manner of take.

The new fish trap being constructed at ACID has not been previously operated, thus, there are no past take of ESA-listed salmonids at that location. When installation of the ACID fish trap is completed, the Service will develop and submit operational protocols and estimates of take at the ACID fish trap to NMFS and CDFW for review, input, and necessary take authorizations.

Table 2.2.3 Total trapping mortalities and pre-spawn mortalities of winter Chinook salmon collected at the Keswick Dam Fish Trap during winter Chinook broodstock collection (March 1 through July), return years 2000-2014.

Return Year	Number of Mortalities			Total number retained	Total number collected
	Male	Female	Total		
2000	5	4	9	82	102
2001	3	2	5	99	205
2002	6	2	8	96	193
2003	4	2	6	85	236
2004	7	5	12	85	346
2005	9	5	14	109	391
2006	3	1	4	93	312
2007	6	5	11	55	157
2008	7	5	12	105	198
2009	4	2	6	121	279
2010	5	3	8	63	422
2011	4	4	8	86	379
2012	7	2	9	93	807
2013	9	10	19	117	314
2014	20	44	64	388	429
Median	6	4	9	93	312

Table 2.2.4 Total incidental spring Chinook mortalities resulting from the Winter Chinook Integrated-recovery supplementation program, return years 2000-2014.

Return	Mortality Counts			Total number
Year	Male	Female	Total	collected
2000	0	0	0	52
2001	0	2	2	21
2002	0	0	0	40
2003	2	0	2	41
2004	0	0	0	87
2005	0	0	0	6
2006	0	0	0	61
2007	0	0	0	21
2008	1	0	1	151
2009	1	0	1	20
2010	1	0	1	24
2011	0	0	0	83
2012	0	0	0	39
2013	0	0	0	317
2014	1	0	1	174
Median	0	0	0	41

Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).

*Complete the appended "take table" (**Table 1**) for this purpose. Provide a range of potential take numbers to account for alternate or "worst case" scenarios.*

Table 2.2.5. Projected levels and types of take of winter Chinook salmon resulting from artificial propagation programs at the Livingston Stone National Fish Hatchery. Where a fish may be affected by more than one type of take it is included in the category that would have the greatest detrimental impact; such that the total number of potentially affected individuals of can be estimated by the sum of each column. Numbers in parentheses ( ) indicate elevated take levels resulting from expanded production levels due to implementation of drought contingency program expansion.

Listed species affected: __Winter Chinook Salmon____ ESU/Population:____Sacramento River____ Activity:_Winter Chinook Propagation				
Location of hatchery activity:_Sacramento River____ Dates of activity:_February through August__ Hatchery program operator:__SERVICE_______				
Type of Take	**Annual Take of Listed Fish By Life Stage *(Number of Fish)***			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass	0	0	0	18,000
Collect for transport	0	0	0	0
Capture, handle, and release	0	0	0	
Capture, transport, handle, tag/mark/tissue sample, and release a)	0	250,000 (750,000)	824	10,000
Removal (e.g. broodstock) b)	0	0	102 (400)	0
Intentional lethal take	0	0	0	0
Unintentional lethal take c)	0	0	62 (100)	0
Other Take (specify) d)	0	500	50	0

a. Estimate of direct take of winter Chinook salmon include the following: Juveniles – number of juvenile winter Chinook marked with a fin clip an d coded-wire tagged; Adult - maximum numbers of winter Chinook trapped (2012) while collecting broodstock at the KDFT; and Carcass – Maximum number carcasses observed on the Winter Chinook Carcass Survey. Authorization for the Carcass Survey is covered under section 10 Permit #1415.

b. Includes intentional mortality of winter Chinook as a result of spawning as broodstock The project take level is the maximum retention number (i.e., 120) minus the maximum level of prespawn mortality (i.e., 15% of 120 = 18).

c. Unintentional mortality of winter Chinook, including loss of fish during transport or holding prior to spawning or prior to release into the wild. The projected take level represents 15% of the maximum adult collection target and does not include juvenile mortalities during incubation and rearing.

d. Other take includes the following: juvenile – acoustic tagging of up to 500 juveniles to assess survival and emigration patterns, adult - additional handling, gastric tagging, and possible mortality from acoustic telemetry of up to 50 adults

Table 2.2.6. Projected levels and types of take of spring Chinook salmon resulting from artificial propagation programs at the Livingston Stone National Fish Hatchery. For these take estimates all genetic non-winter Chinook are presumed to be spring Chinook. Where a fish may be affected by more than one type of take it is included in the category that would have the greatest detrimental impact; such that the total number of potentially affected individuals can be estimated by the sum of each column.

Listed species affected: __Spring Chinook Salmon____ ESU/Population:____Central Valley___ Activity:_Winter Chinook Supplementation				
Location of hatchery activity:_Sacramento River______ Dates of activity:___ February through June _ Hatchery program operator:_SERVICE_____				
Type of Take	**Annual Take of Listed Fish By Life Stage *(Number of Fish)***			
	Egg/Fry	Juvenile/Smolt	Adult	Carcass
Observe or harass	0	0	0	0
Collect for transport	0	0	0	0
Capture, handle, and release	0	0	0	0
Capture, handle, tag/mark/tissue sample, and release a)	0	0	133	0
Removal (e.g. broodstock)	0	0	0	0
Intentional lethal take b)	0	0	20	0
Unintentional lethal take c)	0	0	9	0
Other Take (specify)	0	0	0	0

a. Request for incidental take of spring Chinook salmon from the Sacramento River are estimated to be equivalent to the maximum annual number of genetic non-winter Chinook trapped at the KDFT while collecting winter Chinook broodstock. Requested take of 171represents maximum observed non-winter Chinook collected during the 2008 broodstock collection season. Collections of spring Chinook at the KDFT may also occur while trapping for late-fall Chinook broodstock; however, collections of spring Chinook during late-fall broodstock collection season are not included in this table.
b. Maximum intentional mortality of listed Central Valley Spring Chinook Salmon captured at the KDFT and culled. Requested take of 28 represents maximum number of spring Chinook from the Feather River Fish Hatchery captured and culled during the course of winter Chinook broodstock collection activities (from the 2010 broodstock collection season).
c. Unintentional mortality of spring Chinook, including loss of fish during transport, handle, mark/tag/tissue sample, and release, prior to release into the wild. The projected take level of one represents does not include juvenile mortalities during incubation and rearing.

Table 2.2.7. Projected levels and types of take of steelhead/rainbow trout resulting from the winter Chinook propagation program at the Livingston Stone National Fish Hatchery. For these take estimates all life history types of the species Oncorhynchus mykiss are indicated. Where a fish may be affected by more than one type of take it is included in the category that would have the greatest detrimental impact; such that the total number of potentially affected individuals can be estimated by the sum of each column.

Listed species affected: __Steelhead____ ESU/Population:____Central Valley____ Activity:_Winter Chinook Supplementation				
Location of hatchery activity:_Sacramento River______ Dates of activity:___February through June_ Hatchery program operator:__SERVICE_____				
Type of Take	**Annual Take of Listed Fish By Life Stage *(Number of Fish)***			
	Egg/Fry	Juvenile/Smolt	Adult[a]	Carcass
Observe or harass	0	0	0	0
Collect for transport	0	0	0	0
Capture, handle, and release	0	0	0	0
Capture, transport, handle, tag/mark/tissue sample, and release a)	0	0	102	0
Removal (e.g. broodstock)	0	0	0	0
Intentional lethal take	0	0	0	0
Unintentional lethal take b)	0	0	2	0
Other Take (specify)	0	0	0	0

a. Request for incidental take of steelhead/rainbow trout from the Sacramento River has been estimated to be equivalent to the maximum annual number of steelhead/rainbow trout trapped at the KDFT while collecting winter Chinook broodstock. Requested take of 104represents maximum observed steelhead/rainbow trout collected at the KDFT (during the 2004 broodstock collection season). Collections of steelhead/rainbow trout at the KDFT may also occur while trapping for late-fall Chinook broodstock; however, collections of steelhead/rainbow trout during late-fall broodstock collection season are not included in this table but are counted within the Service's biological assessment for the Coleman NFH (2011).
b. Unintentional mortality of steelhead/rainbow trout, including loss of fish during trapping, transport, handle, mark/tag/tissue sample, and release, prior to release into the wild.

Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program

NMFS will be notified within 48-hours if take levels resulting from the Winter Chinook Integrated-recovery Supplementation Program exceed authorized levels. Discussions will include the reasons authorized take level was exceeded and possible alternative operating strategies to reduce take levels.

SECTION 3. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

3.1) Describe alignment of the hatchery program with any ESU-wide hatchery plan or other regionally accepted policies. Explain any proposed deviations from the plan or policies.

The Winter Chinook Conservation Hatchery will be operated in coordination with the NMFS and CDFW and will strive to comply with the plans being developed to introduce winter Chinook upstream of Shasta Dam and the ongoing planning process to introduce winter Chinook to Battle Creek. Additionally, operational strategies employed at the Livingston Stone NFH will be reviewed for alignment with the recommendations provided by the California Hatchery Scientific Review Group.

3.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates

The Coleman NFH complex is operated to mitigate for the loss of spawning habitat caused by the construction and operation of Shasta Dam. The Coleman NFH complex is operated by the *U.S. Fish and Wildlife Service* through an interagency agreement with the *Bureau of Reclamation,* which funds the maintenance and operation of the Coleman NFH as a mitigation feature of the CVP. The agreement stipulates that the Service will operate, maintain, and evaluate the facility for the salvage, protection, and preservation of fish which spawned in the upper Sacramento River Basin prior to the construction of Shasta and Keswick dams, while the Reclamation will reassume all financial responsibility for the facility and arrange for recovery costs from project beneficiaries in accordance with Federal reclamation law.

3.3) Relationship to harvest objectives

Winter Chinook salmon propagated at the Livingston Stone NFH are not intended for harvest, although some are incidentally harvested in fisheries targeting non-listed salmon. Most incidental harvest occurs in the ocean recreational fishery south of San Francisco Bay. The primary goal of the Service's Winter Chinook Integrated-Recovery Supplementation Program is to provide a demographic enhancement to the natural spawning population in the upper Sacramento River, assisting in the *recovery* of that population. As a source of coded-wire tagged winter Chinook, the Winter Chinook Integrated-Recovery Supplementation Program also indirectly benefits harvest management; recovery of coded-wire tags from winter Chinook originating at the Livingston Stone NFH 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 winter Chinook.

3.3.1) Describe fisheries benefitting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years, if available

The purpose of the Winter Chinook Integrated-Recovery Supplementation Program at the Livingston Stone NFH is to supplement the naturally spawning, ESA-listed population. Harvest regulations have been enacted to reduce impacts to winter Chinook, including time-area restrictions of fisheries and minimum size limits. Recovery of coded-wire tags applied to juvenile winter Chinook salmon released from Livingston Stone NFH is the source of empirical data used to monitor impact fishery rates. Estimates of ocean harvest hatchery-origin winter Chinook from brood year 1998 to 2011 are shown below.

Table 3.3.1. Estimated ocean harvest of winter Chinook from Livingston Stone National Fish Hatchery, 1998-2011. Data Source: http://www.rmpc.org.

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

3.4) Relationship to habitat protection and recovery strategies

Several programs are in place to restore anadromous fish habitats and recover salmonid populations in California's Central Valley. The two largest such programs are the CVPIA, along with its associated Anadromous Fish Restoration Program (AFRP), and the Bay-Delta Conservation Plan (BDCP). These programs are designed to address the complex biological, economic, social, and technological issues necessary to support populations of naturally reproducing anadromous salmonids and their Central Valley habitats. Following is a discussion of the relationships between artificial propagation programs conducted at the Livingston Stone NFH and the CVPIA-AFRP, and the BDCP. Additionally, the winter Chinook integrated-hatchery program is supported in the recovery plan for Central Valley Salmonids (NMFS 2014).

The Central Valley Project Improvement Act

Program Overview - The CVPIA of October 1992 (Public Law 102-575, Title 34) is intended to remedy habitat and other problems associated with the Reclamation's CVP. The CVPIA amends the authority of the CVP to include fish and wildlife protection, restoration, and mitigation as equal priorities with other CVP functions such as navigation, flood control, irrigation, and municipal water supply. The CVPIA has two key features to benefit anadromous salmonids: Firstly, Section 3406(b)(1) of the CVPIA directs the Department of the Interior to "develop...and implement a program which makes all reasonable efforts to ensure that, by the year 2002, *natural production* of anadromous fishes in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967 - 1991...." [Emphasis added]. Secondly, Section 3406(b)(2) authorizes the use of 800,000 acre- feet of CVP water rights for fish, wildlife, and habitat restoration purposes. The Central Valley Project Restoration Fund was established to contribute to the goals of the CVPIA. The CVPIA provides the Secretary of the Interior the authority to use the fund to carry out the habitat restoration, improvement, and acquisition (from willing sellers) provisions necessary to fulfill the requirements of the CVPIA.

The Anadromous Fish Restoration Program

Program Overview - The AFRP was developed by the Secretary of the Department of the Interior to accomplish the fish population restoration goals identified in the CVPIA. Within the AFRP, watersheds have been prioritized for restoration actions based on a combination of biological and non-biological factors. Specific numeric population recovery goals have been determined for each watershed or watershed portion, including the Sacramento River and Battle Creek. A total of 172 actions and 117 evaluations are identified in the AFRP that, when implemented, are intended to increase anadromous fish populations throughout the Central Valley to twice the average levels from 1967 through 1991 as specified by the CVPIA (Service 2001a). Because the Secretary does not have direct authority to implement restoration actions in all streams, implementation of the AFRP relies heavily upon cooperation through partnerships, including state and federal agencies, watershed workgroups, conservation groups, water districts, and property owners.

The California Bay-Delta Authority

The California Bay-Delta Authority (CBDA) oversees the implementation of the CALFED Bay-Delta Program for the 25 state and federal agencies working cooperatively to improve the quality and reliability of California's water supplies while restoring the Bay-Delta ecosystem. The Authority is comprised of state and federal agency representatives, public members, a member of the Bay-Delta Public Advisory Board, ex-officio legislative members and members at large. The department acts as consortium, coordinating the activities and interests of the state government of California and the U.S. federal government to focus on interrelated water problems in the state's Sacramento-San Joaquin River Delta. CALFED's priorities for the Sacramento-San Joaquin River Delta include:

- **Improve Ecosystem Quality**. Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta system to support sustainable populations of diverse and valuable plant and animal species.

- **Improve Water Supply Reliability**. Reduce the mismatch between Bay-Delta system water supplies and current and projected beneficial uses that depend on the Bay-Delta system ecosystems.
- **Improve Water Quality**. Provide good water quality for all beneficial uses.
- **Improve Levee System Integrity**. Reduce the risk to land use and associated economic activities, water supply, infrastructure, and ecosystem from catastrophic failure of Delta levees.

A major element of the CALFED program is the Ecosystem Restoration Program (ERP). The ERP is designed to improve and increase aquatic and terrestrial habitats and improve ecological functions to support sustainable populations of diverse and valuable plant and animal species. Major elements of the ERP are directed at recovering endangered species, eliminating the need for additional listings on the ESA, and providing increased abundance of valuable sport and commercial fisheries. Benefits of the ERP will be achieved by working with local conservancies and watershed groups to restore the ecological processes associated with stream flow, stream channels, watersheds, and floodplains.

Bay-Delta Conservation Program
Program Overview - The BDCP is a department within the government of California, administered under the California Natural Resources Agency. The BDCP is guided by the 2009 Delta Reform Act, which made it state policy to manage the Delta in support of the co-equal goals of water supply reliability and ecosystem restoration in a manner that acknowledges the evolving nature of the Delta as a place for people and communities. The Bay Delta Conservation Plan (BDCP) is being prepared by a group of local water agencies, environmental and conservation organizations, state and federal agencies, and other interest groups. The BDCP is being developed in compliance with the Federal Endangered Species Act (ESA) and the California Natural Communities Conservation Planning Act (NCCPA). When complete, the BDCP will provide the basis for the issuance of endangered species permits for the operation of the state and federal water projects. The heart of the BDCP is a long-term conservation strategy that sets forth actions needed for a healthy Delta. Implementation of the Plan will occur over a 50-year time frame by a number of agencies and organizations with specific roles and responsibilities as prescribed by the Plan. A major part of implementation will be monitoring conservation measures to evaluate effectiveness, and revising actions through the adaptive management decision process.

Recovery Plan for Central Valley Salmon and Steelhead
The Winter Chinook Integrated-Recovery Supplementation Program is described in the Final Recovery Plan for Central Valley Salmonids (NMFS 2014) as a conservation measure for the protection and enhancement of the existing winter Chinook population downstream of Keswick and Shasta dams. Furthermore, the winter Chinook integrated-recovery supplementation program will likely play a role in re-establishing winter-run salmon habitats upstream of Shasta Dam and Battle Creek.

3.5) Ecological interactions

Potential ecological effects of releasing juvenile hatchery-origin winter Chinook from the Livingston Stone NFH include predation, competition/displacement, and disease. Deleterious ecological impacts to winter Chinook or other listed salmonids are not anticipated, primarily due to the small size of the winter Chinook program. Production levels in the winter Chinook program are dictated by spawner escapement levels and, under typical production levels, limited to a maximum of 120 spawners annually. Numbers of broodstock may be increased up to 400 in the winter Chinook program when the operating under a drought-related program expansion. Juvenile production levels increase and decrease with the number of broodstock spawned, with an average of approximately 250,000 smolts being released during a standard production year and up to 750,000 possible during a year of expanded production due to drought-related program expansion. The low number of juveniles produced in the winter Chinook program, relative to most propagation programs in the Central Valley, limits the potential for negative ecological impacts to listed fish stocks. More detailed explanations of potential ecological interactions resulting from hatchery-propagated winter Chinook are provided below:

Predation

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

Competition/Displacement

An objective of the winter Chinook propagation program is that hatchery-origin fish integrate with naturally produced winter Chinook. Potential negative effects of competition/displacement are not expected to result in deleterious effects for the following reasons: 1) juvenile hatchery-origin winter Chinook are approximately equal in size or smaller than co-occurring listed salmonids; 2) hatchery-origin winter Chinook are released after the vast majority of naturally produced winter and spring Chinook juveniles have left the upper river system and those that remain have established home territories; 3) the number of winter Chinook released from the Livingston Stone NFH is small compared to the number of juveniles produced annually in the upper Sacramento River 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 Chinook salmon.

Disease

Increased transmission or amplification of disease is not expected to result from releasing juvenile winter Chinook from the Livingston Stone NFH. Juvenile winter Chinook released from the Livingston Stone NFH have been notably healthy and free of disease problems. Lack of disease outbreaks at the Livingston Stone NFH is attributed to effective prophylactic treatments, good fish culture practices, and supply “clean” source of water from deep in Shasta Lake.

Ecological interactions are also possible upon hatchery-origin winter Chinook by other listed and non-listed salmonid species. Risk factors similar as those discussed above (e.g., predation, competition/displacement, and disease) could potentially affect hatchery-origin winter Chinook. The extent that these factors affect hatchery origin winter Chinook is highly uncertain, as scant empirical evidence exists regarding the effects of ecological interactions in natural environments.

SECTION 4. WATER SOURCE

4.1) Provide a quantitative and narrative description of the water source (spring, well, surface), water quality profile, and natural limitations to production attributable to the water source.

The source of water for the Livingston Stone NFH is Shasta Lake, which is also the source of water for the only population of naturally reproducing winter Chinook in the upper Sacramento River. Water is delivered to the hatchery by a pipe tapped directly into the penstocks of Shasta Dam. To ensure water availability in the event one or more penstocks become inoperable, the facility has the option to draw water off of alternate penstocks. Water from the penstocks is delivered to two gas equilibration columns atop an 18,000-gallon head tank. This head tank supplies the entire facility through a PVC manifold system. Total flow available to the facility is approximately 3,000 gpm.

The water delivery system at the Livingston Stone NFH is completely automated (e.g., employing computer controlled electronic valves); however, manual overrides, redundancies, and fault securities have been built into the system. In the event of a power outage, a solenoid will trip thus allowing free flow (i.e., approximately 5,000 gpm) to the head tank. The head tank will overflow in this situation, however, the water supply will be uninterrupted and fish production will not be at risk. Any power outages at the Shasta Dam facilities are expected to be of short duration. Since Shasta Dam is the primary electricity generating facility in Northern California electrical grids at the facility are generally restored as a high priority.

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

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

Water used for winter Chinook production at Livingston Stone NFH is returned to Keswick Reservoir just below Shasta Dam. Water discharged from the Livingston Stone NFH is regulated by a National Pollution Discharge Elimination System permit issued by the California Regional California Regional Water Quality Control Board (WQCB; (http://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/general_orders/r5-2014-0161.pdf).

4.2) Indicate risk aversion measures that will be applied to minimize the likelihood for the take of listed natural fish as a result of hatchery water withdrawal, screening, or effluent discharge.

The Service anticipates no take of ESA-listed or non-listed salmonids through Livingston Stone NFH water intakes. Livingston Stone NFH obtains its water through the penstocks of Shasta Dam, an area inaccessible to ESA-listed fishes.

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

SECTION 5. FACILITIES

Construction of the Livingston Stone NFH was completed in 1998. The Livingston Stone NFH is constructed on a 0.4 acre Reclamation-owned site located approximately 0.5 miles downstream of Shasta Dam on the Keswick Reservoir. The hatchery is situated on the west bank of the Sacramento River, outside the flood plain.

5.1) Broodstock collection facilities

Adult winter Chinook salmon broodstock are collected from the Sacramento River at a fish trap constructed onto the face of the Keswick Dam and a supplemental collection facility at the Anderson-Cottonwood Irrigation District (ACID) Dam.

The KDFT and associated structures are located in the center of the dam between the powerhouse and the spillway. Broodstock collection facilities consist of a twelve-step fish ladder, a brail-lift, and a 1,000-gallon fish-tank elevator. Salmon and steelhead are attracted to the fish ladder with a 340 cfs jet pump. Additional flow for attracting fish is supplied through diffusers within the ladder floor. The fish ladder is approximately 170- feet long by 38- feet wide, and contains weirs which create pools. The top of the ladder leads to a fyke weir. After passing through the fyke weir, adult fish are contained in a large fiberglass brail enclosure.

When the brail is raised, fish are directed into a 1,000-gallon elevator which transports them up the face of the dam to a fish distribution vehicle. Several modifications to the KDFT and associated structures occurred prior to 2001 and resulted in improved operation and maintenance of the structure and are described in Service 2001b. Modifications to these structures since 2001 include replacement of the hoist motor and brake system and installation of cameras and an automatic gate, which enable the trap to be monitored and operated to eliminate otter predation.

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

5.2) Fish transportation equipment (description of pen, tank truck, or container used)

Adults collected in the KDFT and the ACID fish trap are transported to Livingston Stone NFH in a fish distribution vehicle carrying an aerated 250-gallon insulated transport tank, or one of the two larger distribution vehicles from Coleman NFH. These vehicles are also used for transporting juvenile winter Chinook salmon to the release location. Transportation of adult salmon and steelhead from the KDFT and ACID Fish Trap requires approximately 25 minutes. Transportation of juvenile and adult salmon to the release location covers approximately 11 miles and requires about 30 minutes. The total duration that adult salmon from the KDFT are held in fish transport vehicles ranges from about two to four hours, depending on whether the fish are retained for broodstock or released back into the Sacramento River.

5.3) Broodstock holding and spawning facilities

Following transport to Livingston Stone NFH, phenotypically identified winter Chinook are placed in a 20-foot circular quarantine tank while awaiting the results of genetic analyses. Results of genetic analysis may require up to three days. Adult salmon genetically identified as winter Chinook salmon are then transferred into another 20-foot circular tank for longer-term holding until they are mature and ready to spawn. The holding tanks are connected to a carbon filter for removal of malachite green following prophylactic and therapeutic antifungal treatments of broodstock.

5.4 – 5.6) Facilities for incubation, rearing, and acclimation/release

Facilities for incubation, rearing, and release are located in close proximity to each other at the Livingston Stone NFH, and are described here together. The spawning and rearing building at the Livingston Stone NFH is a 2,700-square feet insulated steel building containing egg and fry incubation units, sixty 30-inch diameter circular tanks for early-rearing, a 100 square-feet walk-in freezer, and an office. The incubation building also contains a large 120 gpm chiller and a 75 kilowatt back-up generator. Larger outdoor tanks are used for juvenile rearing, including Twenty-four 3-feet x 16-feet rectangular tanks and ten 12-feet diameter circular tanks.

The release location for winter Chinook salmon is the upper Sacramento River at Redding, California (RM 299). Juvenile winter Chinook are transported to the release site in two 2,000 gallon insulated fish hauling trucks. The source of water for the Livingston Stone NFH is the same as used by the natural-spawning population in the upper Sacramento River and has similar physical and chemical characteristics; therefore, no acclimation facilities are used.

5.7) Describe operational difficulties or disasters that led to significant fish mortality

Near the end of the brood year 2004 broodstock collection season the Service discovered that river otters were likely predating on salmonids that were captured in the KDFT. Based on these findings, broodstock collection operations at the KDFT were subsequently modified at the end of the 2004 winter Chinook broodstock collection season to reduce the potential for otter predation. Trapping operations were modified in the following manner:

1) the KDFT is "opened" in mornings to allow broodstock to enter and “closed” at the end of the regular workday (approximately 4:00-5:00) by blocking the entrance with the trap’s brail structure. Because otters are primarily nocturnal hunters, closing the trap at night substantially reduces the potential for otter predation upon captured fishes.

2) video monitoring was employed to monitor for otter predation inside the fish trap. Video monitoring has been used both inside of the trap (during periods the trap was "open" to capture fishes) and just outside of the trap at the entrance (during periods the trap was "closed"). Video recordings are then reviewed to observe for incidents of otter harassment and/or predation.

Based on video surveillance and direct observations, the strategies put in place during 2004 broodstock collection season were effective at preventing predation by river otters upon fishes within the KDFT. River otters have not been observed to enter the trap since these protective measures were implemented.

Poor water quality has also led to mortality of winter Chinook at the Livingston Stone NFH. Under normal circumstances water quality at Livingston Stone NFH is favorable for propagating winter-run Chinook salmon. Suitable water temperature is achieved by choosing amongst multiple intakes which draw water through multiple penstocks and the use of the Temperature Control Device (TCD) at Shasta Dam. Turbidity in the hatchery water supply is generally low because suspended solids tend to settle out of the water column in Shasta Lake. Suspended sediments are further reduced by filtering water that is delivered to eggs and alevins. No water disinfection system is currently used to treat water prior to use at the Livingston Stone NFH, but may be necessary in the near future to allay concerns of transmitting disease into the hatchery if anadromous adult salmon are to be introduced to the watershed upstream of Shasta Dam.

During conditions of severe drought, the quality of water available for use at the Livingston Stone NFH can be compromised in regard to its ability to support winter Chinook. For example, brood year 2014 winter Chinook at the Livingston Stone NFH were exposed to high loads of very fine suspended sediments and unusually warm and highly variable water temperatures. These conditions contributed to elevated mortality of juvenile Chinook salmon at the hatchery. Ultimately, it became necessary to bring portable water chillers on-station to reduce water temperature and variability.

5.8) Indicate available back-up systems, and risk aversion measures that will be applied, that minimize the likelihood for the take of listed natural fish that may result from equipment failure, water loss, flooding, disease transmission, or other events that could lead to injury or mortality

The water delivery system for Livingston Stone NFH is equipped with a low-water alarm and a telephone call-out system. In the event of an emergency (e.g., power outage), the penstock supplying Livingston Stone NFH defaults to open, which ensures continued supply of water for fish propagation. The facility receives water from three of the five Shasta Dam penstocks (penstocks 2, 3, and 4); a redundancy which promotes an uninterrupted water supply. Additionally, the capability to supply water from penstock 5 is currently being sought. A 75 kilowatt back-up generator is enabled in the event of a power outage. Additional chillers can be brought on station, if necessary, to ensure that water delivered to the hatchery is suitable for Chinook salmon at the life stages present at the hatchery. For example, during the extreme drought of 2014 two large diesel powered chillers were used to bring the water down to suitable temperature for winter Chinook.

Disinfection of incoming water is not currently necessary at the Livingston Stone NFH, but will become necessary in the near future to assuage concerns of transmitting disease into the hatchery after anadromous salmonids are introduced to the watershed upstream of Shasta Dam. The Service is currently investigating water treatment options, and expects to have a water treatment system installed prior to the release of anadromous salmon upstream of Shasta Dam.

SECTION 6. BROODSTOCK ORIGIN AND IDENTITY

Describe the origin and identity of broodstock used in the program, its ESA-listing status, annual collection goals, and relationship to wild fish of the same species/population.

6.1) Source

Broodstock for the Winter Chinook Integrated-Recovery Supplementation Program are obtained from the main stem Sacramento River, primarily at the KDFT. The Service has recently completed the construction of a secondary trapping facility for winter Chinook at the ACID Dam. This trapping facility will benefit from being situated near the center of the distribution of winter Chinook spawning in the City of Redding, CA. Prior to 2008, an alternate trapping facility at the RBDD was occasionally used to collect winter Chinook broodstock; however, use of that facility was discontinued due to ineffectiveness of that collection location. All trapping facilities used to collect broodstock for the Livingston Stone NFH, both past and present, obtain fish from the single extant population in the upper Sacramento River, which is listed as endangered under the ESA.

6.2) Supporting information

6.2.1) History

Winter Chinook salmon presently spawn only in the Sacramento River near to and upstream of Redding, California, and all broodstock for the Livingston Stone NFH are collected from that area. The KDFT is located at the upstream limit of anadromy in the Sacramento River and is the primary location for collecting broodstock. Beginning in 2016, collections of winter Chinook broodstock from the KDFT are expected to be supplemented using a new fish trap that has recently been installed at the ACID Dam, Redding, CA, which is located nearer to the center of the winter Chinook spawning distribution.

6.2.2) Annual size

Broodstock collection targets of the Winter Chinook Integrated-Recovery Supplementation Program are limited to the lesser of 15% of the estimated total run-size or 120 fish. A minimum of 20 winter Chinook adults will be targeted for capture during any year regardless of run size (e.g., run size <133). Equal numbers of males and females will be targeted for collection in attempt to equalize sexes for a 1:1 spawning ratio.

In situations where the natural spawning population of winter Chinook faces severe threat from drought, such as the extreme drought experienced in 2014 and 2015, the winter Chinook program may be increased in size to mitigate for poor success in natural spawning areas. Such a situation existed in 2014, when production of the Winter Chinook Integrated-recovery supplementation program was increased approximately three-fold in anticipation that temperatures in the Sacramento River would become unfavorable for natural spawning. Any future decisions to expand the size of the program above the standard production level will be made jointly by the SERVICE, NMFS, and CDFW.

6.2.3) Past and proposed level of natural fish in broodstock

Since the inception of the Winter Chinook Integrated-Recovery Supplementation Program in the early-1990s, most broodstock have been natural-origin. Prior to 2010, broodstock collection targets allowed up to 10% of the broodstock to be of hatchery-origin. Beginning in 2011, a decision was made to use only naturally produced winter Chinook as broodstock to reduce the potential for harmful genetic effects due to domestication. From 2011 to 2013 only natural-origin fish were used as broodstock and this will be standard protocol at the Livingston Stone NFH in normal operating conditions.

Since the inception of the Winter Chinook Conservation Hatchery, the majority of hatchery broodstock have been of natural origin (Table 6.2.3.). Prior to 2010, hatchery broodstock included up to 10% hatchery-origin winter Chinook. Beginning in 2010, the Service discontinued spawning hatchery-origin winter broodstock to limit the effects of domestication. This practice was temporarily modified in 2014 and 2015, when the integrated-recovery supplementation program was substantially increased in size (i.e., approx. 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 spawn hatchery-origin winter Chinook for broodstock. In the future, when the program is operated at standard production levels, the integrated-recovery program will again strive to exclude hatchery origin fish from being used as hatchery broodstock, however; we anticipate that we may need to consider exceptions to this strategy during some years. For example, we expect that the spawning escapement of 2017 will be comprised of a majority of hatchery-origin fish as a result of increased hatchery production and poor in-river spawning success in 2014. Therefore, it may be necessary to either reduce program size or otherwise compensate for the increased proportion of hatchery-origin broodstock in 2017. The course of action for this situation, which will be made collectively with the Service, NMFS, and CDFW, has not yet been determined.

In the future, when the program is operated at standard production levels, the integrated-recovery supplementation program will again strive to exclude hatchery origin fish from being used as hatchery broodstock, however; we anticipate that we may need to consider exceptions to this strategy during some years. For example, we expect that the spawning escapement of 2017 will be comprised of a majority of hatchery-origin fish as a result of increased hatchery production and poor in-river spawning success in 2014. Therefore, it may be necessary to either reduce program size or increase the limit of hatchery-origin broodstock when the progeny from the 2014 spawning season return as adults in 2017. This decision, which will be made collectively with the Service, NMFS, and CDFW, has not yet been made.

Table 6.2.3. Numbers of hatchery-and natural-origin winter Chinook salmon used as broodstock at the Livingston Stone National Fish Hatchery, by year. Data presented include fish used as brood stock and do not include pre-spawn mortalities or fish rescued from the Sacramento Refuge irrigation canals in 2013.

Year	Natural-Origin	Hatchery-Origin	% Hatchery-Origin
1998	91	5	5.2
1999	22	0	0.0
2000	66	12	15.4
2001	87	10	10.3
2002	79	9	10.2
2003	71	8	10.1
2004	65	8	11.0
2005	92	3	3.2
2006	87	2	2.2
2007	39	5	11.4
2008	86	7	7.5
2009	109	6	5.2
2010	55	0	0.0
2011	78	0	0.0
2012	84	0	0.0
2013	98	0	0.0
2014	107	217	67.0

6.2.4) Genetic or ecological differences

The Winter Chinook Integrated-Recovery Supplementation Program is designed to reduce the potential for genetic divergence of the hatchery and natural-origin fish and to manage the natural spawning aggregate in the Sacramento River downstream of Keswick Dam as a single integrated population. In most years, hatchery broodstock are comprised entirely of naturally produced winter Chinook from the upper Sacramento River and are intended to represent the genotypic, phenotypic, and behavioral characteristics of the natural spawning population. Selection of winter Chinook broodstock is accomplished by screening all collected adults using several diagnostic criteria developed to reliably identify winter Chinook salmon. To be selected as hatchery broodstock, adult salmon must satisfy both phenotypic criteria (run/spawn timing, collection location, intact adipose fin, and physical appearance) and genetic criteria (based on 96 single nucleotide polymorphism (SNP) markers) that provide effective discrimination between co-occurring runs in the Sacramento River. Because broodstock are often trapped prior to sexual dimorphism, a GHpsi marker is also used to identify sex of broodstock. In combination, the genetic and phenotypic criteria enable accurate and precise identification of winter Chinook salmon for use in the Integrated-Recovery Program at Livingston Stone NFH.

6.2.5) Reasons for choosing

Selection of winter Chinook broodstock is accomplished by screening collected adults using several diagnostic criteria developed to reliably discriminate winter 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 Chinook broodstock provide an accurate and precise discriminatory tool.

Some fishes may enter the trap with injuries or become injured during the stages of trapping, confinement, loading, transportation, or sorting. Fishes that are believed to have entered the trap seriously injured may be excluded from consideration as broodstock if it is believed that their survival would likely be compromised by the injury. However, if a fish is believed to have been injured during the course of trapping or transportation then it will be considered as “take” and will be retained as broodstock. Other than criteria to identify collected fishes as being winter Chinook, and exclusion of some badly injured winter Chinook, no additional other phenotypic criteria are used to select for broodstock. Jacks are incorporated as hatchery broodstock at their rate of collection.

6.3) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish that may occur as a result of broodstock selection practices

Considerable effort has been made to minimize any adverse genetic or ecological effects from broodstock selection practices. For example, winter Chinook are collected and spawned throughout the duration of run timing to maintain phenotypic and genetic variability. The program preferentially uses only natural-origin broodstock to reduce the perpetuation of traits associated with domestication selection; however, an exception to this strategy is made during years when the program is expanded to mitigate for effects caused by severe drought when natural reproduction of winter Chinook in the Sacramento River is believed to be jeopardized. A factorial-type spawning scheme is used to increase the effective population size of hatchery-produced winter Chinook. Phenotypic and genetic broodstock selection criteria are used to ensure that hybridization with other runs does not occur in the hatchery. Additionally, limits have been established for the collection of winter Chinook broodstock; the lower limit is set at 20 fish and the upper collection limit is the lesser of 120 fish or no more than 15% of estimated run-size. The lower limit is designed to ensure genetic variability while providing a demographic benefit to a population that exists at a very low level of abundance. The upper limit guards against removing too many fish from the naturally spawning population and places the primary emphasis on maintaining a healthy naturally-reproducing component of the population.

SECTION 7. BROODSTOCK COLLECTION

7.1) Life-history stage to be collected (adults, eggs, or juveniles)
Adult (age-3 and older) and "jack" (age-2) winter Chinook salmon are collected for broodstock. Age-2 winter Chinook are spawned at their rate of occurrence at the trapping facilities.

7.2) Collection or sampling design
Winter Chinook broodstock are collected at the KDFT, located at the upstream terminus of the area accessible to anadromous fish in the Sacramento River. Additionally, a supplemental trapping facility has been recently developed at the ACID dam. Winter Chinook broodstock are collected throughout the period of adult migration into spawning areas in the upper Sacramento River. Trapping for winter Chinook broodstock occurs from approximately mid-February through July. Monthly broodstock collection targets are established to ensure appropriate representation of the complete run timing of winter Chinook. A schedule of proposed monthly collection targets for winter Chinook broodstock is forecasted prior to the beginning of winter Chinook salmon broodstock collection (Table 7.2.1). The pre-season collection schedule is determined by allocating the total annual collection goal (which is determined from the estimated run size) throughout the total duration of winter Chinook salmon migration timing. The proportion of winter Chinook that historically migrated past the RBDD is multiplied by the total annual collection goal to calculate monthly collection targets. For example, if the estimated run size is 800 the total number of adults targeted for captured would be 800 x 15% = 120. Based on historical information, 8.89% of the winter Chinook migrated past RBDD during the month of May. In this example, the collection target for May is therefore 8.89% x 120 = 11 adults.

Table 7.2.1 Schedule of monthly winter Chinook broodstock collection targets. Monthly target number assumes the standard seasonal collection goal of 120 winter Chinook.

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

Winter Chinook are managed as a single interbreeding population comprised of hatchery and natural origin fish. The winter Chinook salmon Integrated-Recovery Supplementation Program at Livingston Stone NFH is designed to reduce the potential for hybridization to occur in the hatchery and reduce the potential for genetic divergence between fish of hatchery and natural origin. Indigenous winter Chinook salmon are the only source of hatchery broodstock. Selection of winter Chinook broodstock is accomplished by screening all collected adults using several diagnostic criteria developed to reliably discriminate winter Chinook salmon. To be selected as hatchery broodstock, adult salmon must satisfy both phenotypic criteria (run/spawn timing, collection location, and physical appearance) and genetic criteria (based on 96 single SNP markers that provide effective discrimination of winter Chinook plus another GHpsi marker to identify gender). In combination, the genetic and phenotypic criteria enable accurate and precise identification of winter Chinook salmon for use in the winter Chinook salmon artificial propagation program at Livingston Stone NFH.

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

Fin punch samples are collected from captured Chinook. Fin samples from putative broodstock are mailed to the Service's Conservation Genetics Laboratory within a day after the trap is emptied. A genetic run determination generally requires less than two days, and genetic results are then immediately sent to the Livingston Stone NFH. Confirmed winter Chinook broodstock are transferred from the quarantine tank to a holding tank and non-winter Chinook with an intact adipose fin are transferred to the Sacramento River in Redding where they are released. Non-winter Chinook with a missing adipose fin (i.e., either stray late-fall Chinook from the Coleman NFH or stray spring Chinook from the Feather River FH) are culled and their CWT recovered.

The Service desires that broodstock retained for the Winter Chinook Integrated-Recovery Supplementation Program be representative of the winter Chinook population, with a preference towards naturally produced winter Chinook to reduce the effects of domestication. However, due to the KDFT being located at the terminus of winter Chinook spawning habitat, a large component of the population may not reach the trapping location, and therefore, would not have the opportunity to be selected for broodstock. To lessen this concern, the Service has partnered with the CDFW and the Anderson-Cottonwood Irrigation District to develop an additional broodstock collection facility at the ACID Dam in Redding. The ACID Trap will serve as a secondary trapping facility for collecting winter Chinook broodstock. The location of this facility benefits from being centrally located to the natural spawning population in the upper Sacramento River. Additionally, the ACID Trap benefits in that it has been designed to be staffed continuously during operation, which will potentially reduce effects of confinement and handling compared to the KDFT. Collection of broodstock at the ACID are expected to begin in 2016.

7.3) Identity

All winter Chinook produced at in the integrated-recovery supplementation program are marked with an adipose-fin clip and coded-wire tagged. Hatchery-and natural-origin winter Chinook are differentiated based on this mark. Under standard operating conditions, only natural-origin winter fish are used as broodstock in the Winter Chinook Integrated-recovery supplementation program at Livingston Stone NFH. However, during conditions of severe drought, an exception may be made to spawn hatchery origin broodstock at the Livingston Stone NFH. For example, during the drought-emergency program expansion of 2014, hatchery-origin winter Chinook were spawned at the Livingston Stone NFH. Spawning of hatchery origin winter Chinook at the Livingston Stone NFH during 2014 was necessary to accomplish expanded production targets associated with conditions of extreme drought. With continuing conditions of severe drought in California's Central Valley, a drought-related program expansion, including the use of hatchery-origin winter Chinook as broodstock, is again being implemented again in 2015.

Chinook salmon collected at the KDFT and ACID Fish Trap are identified to run using a combination of phenotypic and genetic characteristics. Initial identification of winter Chinook is made using phenotypic characteristics, including color (e.g., darkness), degree of ripeness (e.g., firmness), body size, and amount of fungus. Physical characteristics that differentiate winter Chinook from non-target stocks vary throughout the season of broodstock collections. In late-February and March, early in the process of collecting winter Chinook broodstock, ripe, dark, and fungussed salmon are selected *against*; fish with these characteristics are more likely to be late-fall Chinook than winter Chinook. Conversely, winter Chinook at that time are characterized by firm muscle tone, bright coloration, and clean appearance (i.e., minimal fungus). As the winter Chinook broodstock collection season progresses into April and May, firm, bright, and very clean salmon are selected *against*; fish with these characteristics are likely to be spring Chinook salmon. Also during this time, salmon that are over-ripe, dark coloration, and with a large amount of fungus are selected *against,* as fish with these characteristics are likely to be late-fall Chinook salmon. Winter Chinook at that time tend to be moderately firm with dark coloration and generally clean in appearance. By the end of broodstock collection (late-May through mid-July), phenotypic selection criteria for winter Chinook broodstock include flaccid muscle tone, dark coloration, and very fungussed. Spring and fall Chinook are the only other adult salmon in the Sacramento River late in the broodstock collection period of winter Chinook, and they are characterized as having very firm muscle tone, bright silver coloration, and clean appearance. Unmarked Chinook that do not satisfy the phenotypic criteria of winter Chinook, and any winter Chinook not needed for the program (e.g., exceeding monthly collection target) are transported to the Sacramento River at Redding, CA and released.

All fish initially identified by phenotypic characteristics as a potentially being winter 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 Service's 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.

Computer simulations and "blind tests" show that the genetic discrimination techniques are capable of accurate and consistent identification of winter Chinook salmon. Broodstock selection criteria are intended to be conservative, in that some winter Chinook salmon may be rejected from the program to guard against spawning any non-winter Chinook salmon. Using past methodology, the probability of wrongly identifying winter Chinook salmon (false positives) was less than 0.2% and the probability of incorrectly excluding a winter Chinook salmon from the propagation program (false negatives) was less than 6.1%. Recent modifications to the procedure implemented in 2012, including changing from microsatellite markers to SNP markers, provide improved discrimination between winter Chinook and other runs, thus further reducing the rate of error in run assignments. Considered together, phenotypic and genetic criteria for identifying winter Chinook broodstock reduce the genetic risks of the artificial propagation program by preventing hybridization within the hatchery program.

7.4) Proposed number to be collected:

7.4.1) Program goal (assuming 1:1 sex ratio for adults):

In a typical production year the winter Chinook propagation program targets 15% of the estimated run size, with a minimum of 20 and a maximum of 120 winter Chinook to be collected for use as broodstock. Therefore, when the estimated winter Chinook run size is greater than 800, an attempt is made to collect the full allocation of up to 120 broodstock. The program attempts to secure equal ratios of males and females for broodstock to increase effective population size of hatchery-produced fish.

In emergency situations, such as the extreme drought that was experienced during the summer of 2014 and 2015, production of winter Chinook may be increased above the standard production levels. This expansion of winter Chinook propagation activities is intended to partially mitigate for extremely poor conditions faced by naturally spawning winter Chinook in the Sacramento River. In these situations, potential expansion of program goals will be determined collaboratively by the Service, NMFS, and CDFW. A decision to expand the scale of the program will necessitate an increase in the number of broodstock collected. Because of the inability to capture enough natural origin fish, broodstock collection targets may be expanded to include the retention of hatchery origin fish. For example, during the drought-related emergency program expansion conducted in 2014 a total of 428 winter Chinook salmon were collected at the KDFT. Retention of broodstock during that year included 136 natural origin and 249 hatchery origin winter Chinook.

7.4.2) Broodstock collection levels for the last twelve years (e.g. 1988-99), or for most recent years available

Table 7.4.2. Tabulated data include number of males and females collected from the Sacramento River including trap and pre-spawn motailty. Numbers of eggs and juveniles produced include all production, including, where applicable, a portion resulting from the use of captive broodstock and cryopreserved semen. Data source: SERVICE, Red Bluff FWO, unpublished data

Brood Year	Keswick Counts Female	Keswick Counts Male	Eggs	Juveniles	Percent Captive or Cryopreserved sperm
1998	67	36	205,668	153,908	0.3
1999	10	14	68,892	30,840	14.0
2000	48	41	216,075	166,206	1.1
2001	52	50	342,822	252,684	24.5
2002	50	46	355,200	233,613	29.5
2003	48	37	363,910	218,617	31.0
2004	42	43	241,516	168,261	11.8
2005	56	53	317,866	173,344	7.5
2006	53	40	361,667	196,288	17.9
2007	29	25	121,341	71,883	0.0
2008	53	52	260,370	146,211	0.0
2009	63	58	324,321	198,582	0.0
2010	30	33	139,349	123,859	2.0
2011	49	37	213,739	194,264	0.0
2012	49	44	204,145	181,857	0.0
2013[1]	60	57	229,784	175,947	0.0
2014	218	169	908,479	612,056	0.0

1. Excludes fish rescued from the Sacramento Refuge irrigation canals.

7.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs.
Trapping efforts for winter Chinook broodstock are frequently adjusted to stay within monthly collection targets. For example, trapping may occur anywhere from seven days a week to only a few hours a week, depending on broodstock needs and the number of fish observed to ender the trap. Winter Chinook collected in excess of year-to-date collection targets are released into the Sacramento River in Redding, CA, near to natural spawning areas.

7.6) Fish transportation and holding methods
Adult broodstock for the Winter Chinook Integrated-Recovery Supplementation Program are transported to the Livingston Stone NFH in either an aerated and insulated 2,000-gallon or 250-gallon fish hauling truck. Transport to the Livingston Stone NFH 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. Sedating and sorting of all collected fish may take up to two hours. Fish detained for broodstock must satisfy the following initial selection criteria:

- the fish is needed to meet monthly collection targets

- the fish has phenotypic characteristics consistent with being a winter Chinook,
- the fish has an intact adipose fin (indicative of natural-origin),
- the fish meets gender needs of broodstock (the hatchery attempts to equalize numbers of males and females)
- the fish is in generally good health (the hatchery attempts to avoid collection of broodstock that are in poor health or appear to have been badly injured during migration)

Fish that satisfy these criteria are given a dart-type tag for identification, sampled for a small piece of fin tissue, and placed into a 20-feet diameter tank for quarantine while the phenotypically-based run determination is verified genetically. Tissue samples are sent to the Service's Conservation Genetics Laboratory in Abernathy, Washington, for "rapid-response" genetic analysis. Genetic confirmation of run is accomplished using a panel of 96 SNP markers. Genetic run verification requires approximately two days. Quarantined salmon that are genetically confirmed as being winter Chinook are treated with an injection of antibiotic and treatment with malachite green as an antifungal and then transferred into a second 20-foot diameter circular tank for holding until ready to spawn.

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

Samples and data are collected during the initial sorting of winter Chinook. Data recorded for each fish include length, sex, and observation of visible marks or tags. Samples of fin tissue are collected from all Chinook salmon and steelhead, except in cases where the number of fish captured is large and density in the transport truck is high. In this situation, samples and data may not be collected from all trapped salmon if it is determined that collecting samples from the fish may require a duration that compromises their health and general well-being. Two color-coded and alphanumeric dart-type tags are attached to Chinook salmon just anterior to the dorsal fin prior to their release into the Sacramento River. These tags enable identification of individual fish if they are encountered again at the KDFT or as carcasses in the Sacramento River Winter Chinook Carcass Survey.

7.7) Describe fish health maintenance and sanitation procedures applied

Various drugs and therapeutic and prophylactic treatments are used on winter Chinook salmon to increase survival of adults, reduce risks of disease transmission to offspring, and to aid in synchronous maturation. Additionally, anesthetics and artificial slime are used to reduce stress on broodstock. The applications of most drugs used at Livingston Stone NFH follow the U. S. Food and Drug Administration Investigational New Animal Drug procedure. Fish health is monitored closely by hatchery personnel and staff from the Service's CA-NV Fish Health Center. Malachite Green is used to control fungus once a fish has been retained for use as hatchery broodstock. Once treated with Malachite Green a fish can no longer be released into the wild.

Table 7.7. Drugs and treatments applied to maintain health of winter Chinook broodstock at Livingston Stone National Fish Hatchery. Life stage designations: A-Adult, E-Embryo, J-Juvenile. The following listing should not be considered all-inclusive as other drugs and treatments may be used as necessary and as recommended to maintain good fish health.

Type	Life Stage	Dosage	Method	Application
oxytetracycline	A	20 mg/kg	IP injection	antibacterial
erythromycin	A	20 mg/kg	dorsal sinus injection	antibacterial
erythromycin	A		oral	antibacterial
iodophor	E	75 parts per million	bath	antibacterial
malachite green	A	1 parts per million	bath	antifungal
formalin	A,E	167 parts per million	flow through	antifungal
MS-222	A,E,J		bath	anesthetic
Eugenol	A,E,J		bath	anesthetic
Luteinizing hormone Releasing hormone analog (LH-RHa)	A	30 :g/kg solution or 30 :g/kg implant	IP injection	induce maturation
Vibrio spp. vaccine	J		bath	vaccination against salt-water *Vibrio* spp.
salt	A,E,J		bath/flow through	stress reducer
artificial slime	A,E,J	1 qt/1,200 gallons	bath/flow through	stress reducer

7.8) Disposition of carcasses

Carcasses of winter Chinook salmon are disposed in a landfill. They cannot be rendered or donated for consumption after they are treated with chemicals.

7.9) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the broodstock collection program

The purpose of the Winter Chinook Integrated-Recovery Supplementation Program is to increase the number of winter Chinook spawners and assist in the recovery of the endangered population. Considerable effort has been made to reduce adverse genetic or ecological effects resulting from the integrated-recovery supplementation program. For example, limits have been established for the collection of winter Chinook broodstock; the lower collection limit is set at 20 fish and the upper collection limit is the lesser of 120 or no more than 15% of estimated run-size. The lower limit is designed to ensure that the Integrated-Recovery Program continues to be operated to provide a demographic benefit during years when winter Chinook abundance is very low. The upper limit to broodstock collection guards against removing too many fish from the naturally spawning population and limits the size of the propagation program. All broodstock for the winter Chinook program are genetically confirmed to be winter Chinook to eliminate the risk of hybridization in the hatchery. In addition, spawning of hatchery-origin broodstock is reduced or restricted to reduce the effects of domestication.

Listed natural origin Central Valley Steelhead or Central Valley Spring Chinook may also be trapped at the KDFT while trapping for winter Chinook broodstock. Several methods are used to reduce incidental impacts of trapping for winter Chinook broodstock at the KDFT. First, incidental impacts to non-target stocks of Chinook salmon are reduced by installing a fish counter at the entrance of the KDFT. The fish counter automatically closes the trap door at a pre-determined count; thereby limiting the numbers of fish allowed to enter the trap and prevents overcrowding. Additionally, the Service recently increased the frequency that the KDFT is emptied, from one day a week to twice weekly. This reduces the duration that non-target fishes will be held captive prior to their release. Lastly, the Service, in 2004, modified trapping protocols at the Keswick Dam to control a problem of otter predation. Since that year broodstock trapping has been restricted to daylight hours to prevent the nocturnal otters from predating upon trapped fishes. Additionally, 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.

SECTION 8. MATING

Describe fish mating procedures that will be used, including those applied to meet performance indicators identified previously

8.1) Selection method

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

The selection of mating pairs is informed by a genetic analysis that assesses kinship amongst individuals that are ready for spawning on the same date. Based on the results of the kinship analysis, most-distantly related parent pairs are preferentially mated together, to the extent feasible. This strategy is intended to reduce the potential for mating siblings and closely related fish. Pairing of broodstock for mating is accomplished without consideration of phenotypic characteristics, except for synchronous spawn timing.

8.2) Males

Winter Chinook jacks are incorporated into the spawning matrix at their rate of collection. Backup males are not used in the Winter Chinook Conservation Hatchery Program.

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

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

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

Since 1998 there have been ten matings at the Livingston Stone NFH utilizing cryopreserved semen. Survivorship of winter Chinook matings utilizing cryopreserved semen is shown in the table below. Displayed data do not include matings involving the use of captive broodstock females. Survivorship of eggs from female broodstock from the Captive Broodstock Program is substantially reduced compared to matings conducted using wild-caught females.

Table 8.4. Winter Chinook matings at the Livingston Stone National Fish Hatchery employing cryopreserved sperm, 1998-2014

Brood Year	Mating ID	Green Eggs	Eyed Eggs	% eye-up	No. Hatch	% Hatch	No. Tanked	% tanked
1998	1F cryo94	1,256	202	16.1	192	15.3	183	14.6
1998	2G cryo94	1,136	856	75.4	849	74.7	810	71.3
2000	28K cryo99	1,029	215	20.9	213	20.7	210	20.4
2000	29I cryo99	1,287	546	42.4	544	42.3	521	40.5
2000	42E cryo99	1,436	805	56.1	801	55.8	792	55.2
2000	42B cryo99	1,042	327	31.4	317	30.4	305	29.3
2003	46G cryo02	1,202	804	66.9	780	64.9	250	20.8
2003	46F cryo02	1,331	992	74.5	966	72.6	950	71.4
2010	1O cryo07	3,232	2,511	77.7	2,501	77.4	2,463	76.2
2010	1Q cryo07	3,326	21	0.6	21	0.6	21	0.6

8.5) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic or ecological effects to listed natural fish resulting from the mating scheme

Pairing of winter Chinook captive broodstock and broodstock in the integrated-recovery supplementation program is informed by a genetic analysis that assesses kinship amongst broodstock that are synchronously 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. Semen may also be obtained from the cryopreserved semen or from males from the integrated-recovery supplementation program. A factorial mating scheme is used to promote the retention of genetic variability from winter Chinook broodstock and increase the effective population size.

SECTION 9. INCUBATION AND REARING -

Specify any management *goals* (e.g. "egg to smolt survival") that the hatchery is currently operating under for the hatchery stock in the appropriate sections below. Provide data on the success of meeting the desired hatchery goals.

9.1) Incubation:

9.1.1) Number of eggs taken and survival rates to eye-up and/or ponding

Survival of egg and juvenile winter Chinook produced in the integrated-recovery supplementation program are shown in the table below.

Table 9.1.1. Number of eggs, number of eggs surviving to eye-up stage, number of juveniles hatched, number of juveniles tanked, and percent of tanked from the eyed-egg stage for the Winter Chinook Integrated-recovery supplementation program at the Livingston Stone National Fish Hatchery, 1998-2014

Brood	Number of Eggs		Number of Juveniles		% Tanked from
Year	Green	Eye-up	Hatched	Tanked	Green Eggs
1998	205,668	185,730	180,357	172,640	83.9
1999	38,303	34,069	30,777	29,165	76.1
2000	216,075	197,511	193,363	179,399	83.0
2001	236,864	225,845	220,998	214,954	90.7
2002	231,375	220,189	210,933	174,465	75.4
2003	223,269	195,689	187,860	180,205	80.7
2004	192,387	177,507	173,319	165,878	86.2
2005	267,803	243,525	234,982	196,211	73.3
2006	279,853	259,348	254,927	189,881	67.9
2007	121,341	111,686	109,589	100,909	83.2
2008	260,370	235,279	228,495	200,696	77.1
2009	324,321	302,544	298,835	267,819	82.6
2010	139,349	129,512	127,749	125,153	89.8
2011	213,739	206,708	203,442	200,436	93.8
2012	204,145	189,427	187,525	185,283	90.8
2013[1]	229,784	201,483	198,756	196,354	85.5
2014	908,479	859,935	849,981	839,005	92.4

1. Excludes fish rescued from the irrigation canals near Colusa.

9.1.2) Cause for, and disposition of surplus egg takes

Winter Chinook broodstock are not retained in excess of collection targets, therefore, surplus salmon eggs or juveniles are not produced.

9.1.3) Loading densities applied during incubation

Sixteen-tray vertically stacked fiberglass incubators are used for winter Chinook salmon. This method of incubation is similar to that used for fall and late-fall Chinook and steelhead at the Coleman NFH. The eggs from each female winter Chinook 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. Loading densities of eggs from wild-caught winter Chinook range from about 1,200 - 3,500 eggs/tray. Loading densities of captive broodstock will be lower, based on the expectation of lower fecundity and reduced egg size.

9.1.4) Incubation conditions

Immediately after fertilization, winter Chinook eggs are placed in Heath incubator trays and disinfected with a 75 ppm iodophor bath for 15 minutes. Sanitary conditions are maintained during the egg incubation stage by disinfecting all equipment between different egg lots. Standard disinfection protocol for this task is to achieve surface contact of iodophor solution at 500 parts per million for a one minute contact time. Incubating eggs are treated twice per week with a 15- minute flow-through treatment of 1,400 ppm of formalin to prevent excessive fungus. After eye-up, non-viable eggs are separated from healthy eggs and removed from the incubation trays. Initial water flow in the incubator trays is four gallons/minute. Flow is increased to six gallons/minute at eye-up. After eye-up, eggs are physically shocked by jarring the egg trays sharply. Shocking allows water to enter through the shell of non-viable eggs, which coagulates the yolk and enables non-viable eggs to be identified and removed. Formalin treatments are discontinued at hatch.

If necessary, water to the hatchery's incubators can be cooled using a chilled re-use system. Water is pumped through two chillers to achieve a temperature less than 54^{o}f. Chilled water is then passed through a series of filters (100, 25, 10 ug) to reduce fine particulates prior reaching the incubator stacks.

9.1.5) Ponding

Winter Chinook sac fry remain in the incubator trays until button-up, at which time they are transferred, by family groupings, to 30-inch diameter (10.2 cubic foot) circular tanks where they are started on commercial feed. Data regarding temperature units to hatch are available but have not been summarized. Length and weight measurements are not collected at the time of initial ponding in order to reduce handling. As fish size increases during rearing, it is necessary to combine some family groups due to limitations of tank space.

9.1.6) Fish health maintenance and monitoring

Immediately after fertilization, winter Chinook eggs are placed in Heath incubator trays and disinfected with a 75 ppm iodophor bath for 15 minutes. Sanitary conditions are maintained throughout the period of egg incubation by disinfecting all equipment between uses on different egg lots. Standard disinfection protocol for equipment is surface contact of iodophor solution at 500 parts per million for a one minute contact time. Incubating eggs are treated twice per week with a 15- minute flow-through treatment of 1,400 ppm of formalin to prevent excessive fungus. After eye-up, non-viable eggs are separated and removed from healthy eggs in the incubation trays. Initial water flow in the incubator trays is four gallons/minute and later increased to six gallons/minute at eye-up. After eye-up, eggs are physically shocked and non-viable eggs removed. Formalin treatments are discontinued at hatch.

Fish are observed on a daily basis for mortalities and behavioral irregularities. Dead and moribund fish are removed from rearing units daily. In cases of high levels of mortality, necropsies are conducted on diseased and dead fish to diagnose cause of death. Examinations of live juveniles are performed routinely to assess health status and detect problems before they progress into clinical disease or mortality. Appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) are used to alleviate disease-contributing factors.

9.1.7) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation

Eggs are incubated using water from Shasta Lake, which is the same source of water for the natural spawning population in the Sacramento River. The capability exists to chill water used during incubation. Sediments are filtered from the water prior to distribution through the egg incubation stacks.

9.2) Rearing:

9.2.1) Provide survival rate data (*average program performance*) by hatchery life stage (fry to fingerling; fingerling to smolt) for the most recent twelve years (1988-99), or for years dependable data are available

The goal for propagation of winter Chinook at the Livingston Stone NFH is to maximize survival during incubation and every stage of the hatchery rearing process. From 1999 to 2011, overall (i.e., egg to release) survival of winter Chinook propagated at the Livingston Stone NFH averaged 71% (range: 58% -91%).

Table 9.2.1.1. Survival rates for various life stages of juvenile winter Chinook propagated at the Livingston Stone National Fish Hatchery, 1998-2014

	Survival Rate			
Brood Year	Green egg to eyed egg	Eyed egg to ponding	Ponding to release	Over-all egg to release
1998	0.90	0.93	0.89	0.75
1999	0.89	0.86	0.91	0.69
2000	0.91	0.91	0.93	0.77
2001	0.95	0.95	0.89	0.81
2002	0.95	0.79	0.94	0.71
2003	0.88	0.92	0.84	0.68
2004	0.92	0.93	0.89	0.77
2005	0.91	0.81	0.82	0.60
2006	0.93	0.73	0.85	0.58
2007	0.92	0.90	0.71	0.59
2008	0.90	0.85	0.73	0.56
2009	0.93	0.89	0.74	0.61
2010	0.93	0.97	0.99	0.89
2011	0.97	0.97	0.97	0.91
2012	0.93	0.98	0.98	0.89
2013[1]	0.88	0.97	0.98	0.84
2014	0.95	0.98	0.73	0.67
Median	**0.92**	**0.92**	**0.89**	**0.71**

1. Excludes fish rescued from the Sacramento Refuge irrigation canals.

9.2.2) Density and loading criteria (goals and actual levels)

Winter Chinook sac fry 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 started on commercial feed. Males and females are identified by genetic analysis and separated into different tanks when they reach sufficient size to be PIT tagged for individual identification. As fish increase in size, family groups are further combined and transferred to larger rearing tanks. Rearing densities are variable depending on the size of family group combinations and the limitations of available rearing tanks. Rearing densities are variable depending on the size of family group combinations and the limitations of available rearing tanks. Maximum rearing densities during years of standard production are 0.20 to 0.25; however, rearing densities may be increased to about 0.30, if necessary, to accommodate increased production associated with a drought-related program expansion. In this situation, close oversight is provided by fish health experts from the Service's CA-NV Fish Health Center.

9.2.3) Fish rearing conditions

Flow and temperature of fish rearing chambers are monitored daily throughout the period of rearing at the Livingston Stone NFH. Typically, water deliveries from Shasta Reservoir provide water of suitable temperature for rearing winter Chinook. However, during conditions of severe drought the reservoir storage level is reduced and temperatures may exceed the range of suitability for winter Chinook; in this scenarios water Chillers will be secured to maintain suitable temperatures within rearing units. Dissolved oxygen, carbon dioxide total gas pressure are not measured.

Fish are observed on a daily basis for mortalities and behavioral irregularities. Dead and moribund fish are removed from rearing units. When unusually high levels of mortality are observed, necropsies are conducted to diagnose cause of death. Examinations of live juveniles are performed routinely to assess health status and detect problems before they progress into clinical disease or mortality. Appropriate treatments (prophylactics, therapeutics, or modified fish culture practices) are used to alleviate disease-contributing factors.

9.2.4) Indicate biweekly or monthly fish growth information (*average program performance*), including length, weight, and condition factor data collected during rearing, if available

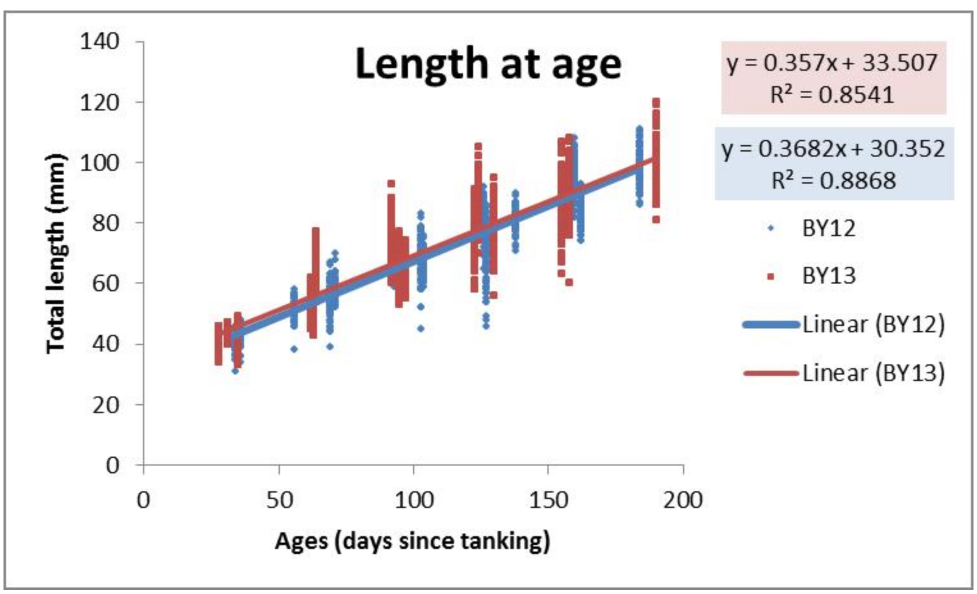

Figure 9.2.4.1 - Length (mm) of Brood Year 2012 and Brood Year 2013 Juvenile Chinook salmon reared at the Livingston Stone NFH. Age is the number of days after removal from the egg stackes (i.e. "tanking").

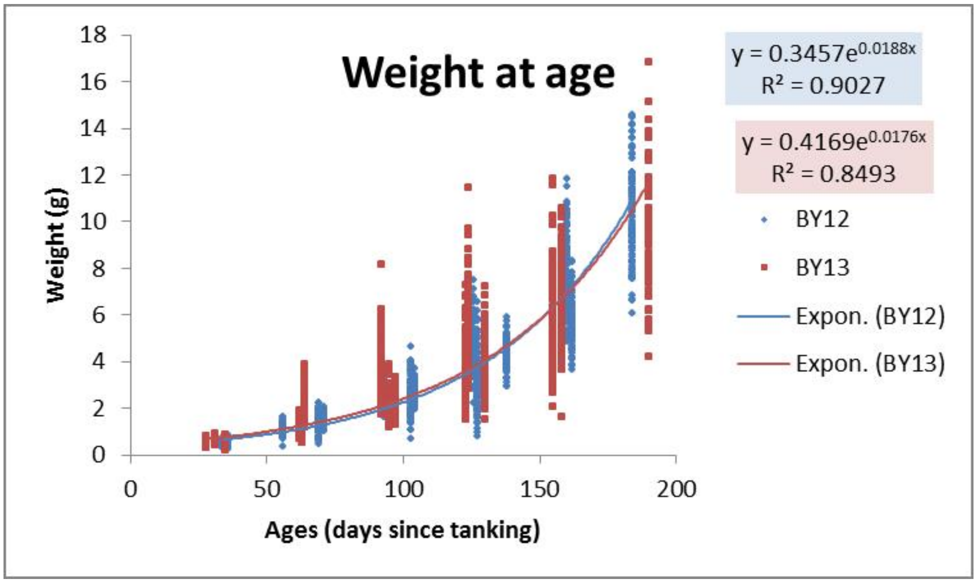

Figure 9.2.4.2 - Weight (g) of Brood Year 2012 and Brood Year 2013 Juvenile Chinook salmon reared at the Livingston Stone NFH. Age is the number of days after removal from the egg stackes (i.e. 'tanking').

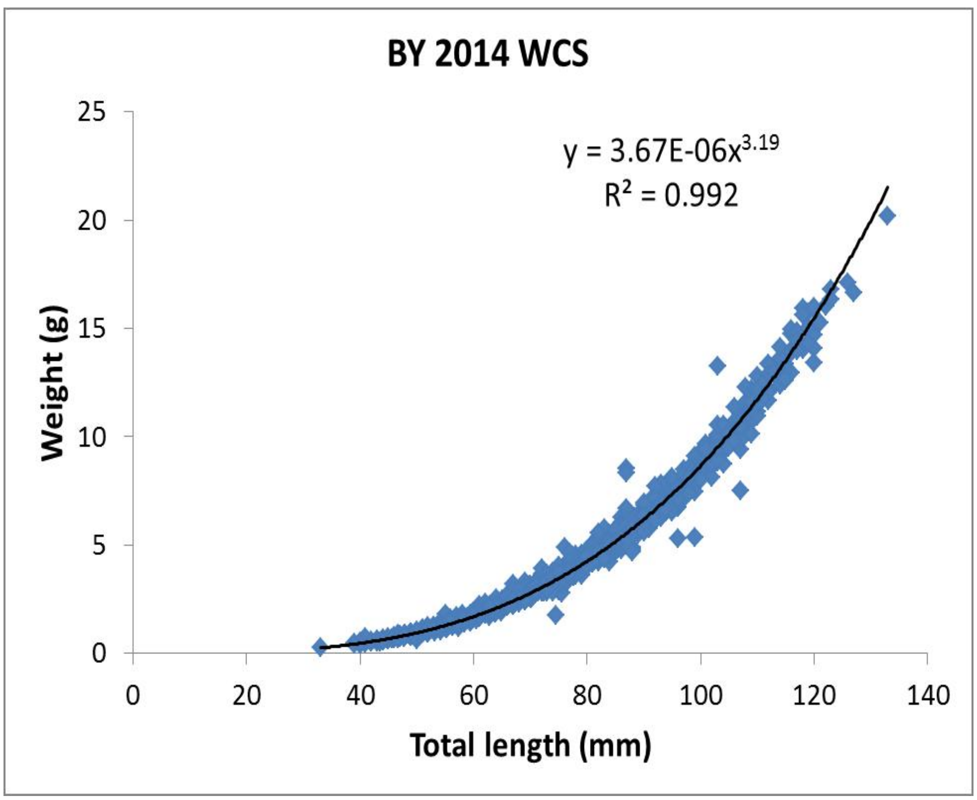

Table 9.2.4.3 - Length-weight relationships of BY2014 juvenile WCS at LSNFH (*n*=1500).

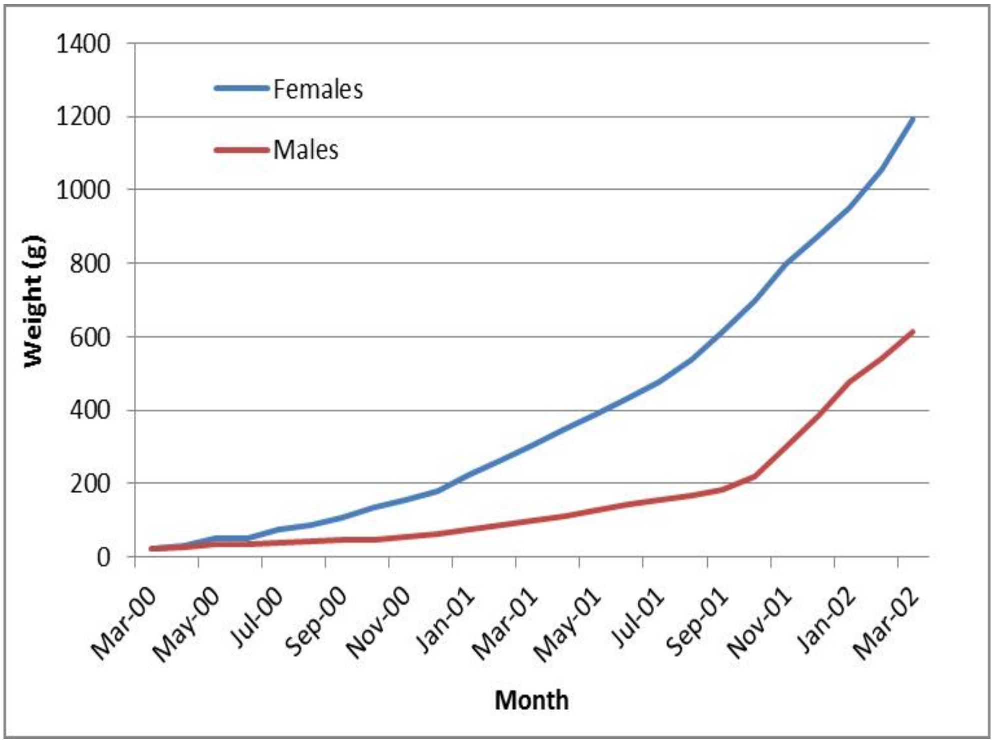

Figure 9.2.4.4– Weight of BY 1999 WCS retained for the Captive Broodstock Program at the Livingston Stone NFH.

9.2.5) Indicate monthly fish growth rate and energy reserve data (*average program performance*), if available

See section 9.2.4. No additional growth rate and energy reserve data are collected.

9.2.6) Indicate food type used, daily application schedule, feeding rate range (e.g. % B.W./day and lbs/gpm inflow), and estimates of total food conversion efficiency during rearing (*average program performance*)

Winter Chinook fry are initially fed a commercial Soft Moist Starter. *Artemia nauplii* (Cyclop-eeze™ from Argent Chemical Laboratories) are added to increase interest in the feed. The fish are subsequently transitioned to Soft Moist Starter #1 and then transitioned again to a Soft Moist Starter #2 until release. Feeding rates are determined using manufacturers feeding guidelines, which indicate the appropriate feed rations based on body size and average monthly water temperature.

9.2.7) Fish health monitoring, disease treatment, and sanitation procedures

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

9.2.8) Smolt development indices (e.g. gill ATPase activity), if applicable

Winter Chinook 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 Chinook. This benefits the fitness of the integrated population consisting of hatchery and natural origin fish. Observances of smolts at the rotary-screw traps at the RBDD soon after release indicate that many hatchery-origin winter Chinook move downstream soon after release, however, hatchery-origin winter Chinook commonly exhibit prolonged residency within the mid- to lower-portion of the river and delta prior to smolting and transitioning into saltwater during the spring months. However, the timing and duration of emigration appears to be influenced by precipitation events invoking high flows and turbidity. Smolt development indices have not been developed for winter Chinook.

9.2.9) Indicate the use of "natural" rearing methods as applied in the program

Juvenile winter Chinook 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.

9.2.10) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation

Winter Chinook 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 winter Chinook in January-March reduces concurrent residence (and thus reduce ecological interactions) with naturally produced winter Chinook in the upper Sacramento River, while encouraging smoltification the same time and size as naturally produced winter Chinook. 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.

SECTION 10. RELEASE

Describe fish release levels, and release practices applied through the hatchery program.

10.1) Proposed fish release levels.

Table 10.1. Maximum fish release level, target size, release date and location for winter Chinook propagated at the Livingston Stone National Fish Hatchery. Numbers in parentheses indicate maximum release levels during drought-related emergency expansion.

Age Class	Maximum Number	Size (fpp)	Release Date	Location
Eggs	0			
Unfed Fry	0			
Fry	0			
Fingerling (Pre-smolt)	250,000 (750,000)	33-205	January –February (releases may be delayed until March if necessary to coincide with desired environmental conditions	Sacramento River
Yearling	0			

10.2) Specific location(s) of proposed release(s).

Stream, river, or watercourse: *Sacramento River*

Release point: Caldwell Park, River Mile 299

Major watershed: Sacramento River

Basin or Region: Sacramento River, CA

10.3) Actual numbers and sizes of fish released by age class through the program Table 10.3.

Table 10.3. Supplementation releases of winter Chinook from the Livingston Stone (LSNFH) National Fish Hatchery and Bodega Marine Laboratory (BML), brood years 1998-2014.

Brood Year	Facility Name	Pre-Smolt/Smolt		Other Experimental Production	Total Production
		Number	Fish/lb		
1998	BML, LSNFH	153,908	56-140	1,218[a]	155,126
1999	LSNFH	30,840[b]	31-115	1,204[a]	32,044
2000	LSNFH	166,206	62-112	1,224[a]	167,430
2001	BML, LSNFH	252,684[b]	56-125	416[a]	253,100
2002	BML, LSNFH	233,613[b]	54-144	402[a]	234,015
2003	BML, LSNFH	218,617[b]	49-97	217[a]	218,834
2004	LSNFH	168,261[b]	51-111	0	168,261
2005	LSNFH	173,344[b]	45-94	0	173,344
2006	LSNFH	196,288[b]	33-74	0	196,288
2007	LSNFH	71,883	43-117	0	71,883
2008	LSNFH	146,211	42-73	0	146,211
2009	LSNFH	198,582	28-73	0	198,582
2010	LSNFH	123,859	34-67	0	123,859
2011	LSNFH	194,264	47-88	0	194,264
2012	LSNFH	181,857	43-103	0	181,857
2013	LSNFH	175,947	35-77	17,208[c]	193,155
2014	LSNFH	612,056	57-149	0	612,056
Average		174,969		1,682	203,027

a Withheld from release group for use as captive broodstock

b Includes produced from captive x natural broodstock (1999: 4,318; 2001: 61,952; 2002: 68,807; 2003: 66,606; 2004: 19,876; 2005: 13,071; 2006: 35,076).

c Progeny from adults rescued from Sacramento Refuge irrigation canals.

10.4) Actual dates of release and description of release protocols.

Table 10.4. Release Dates for winter Chinook salmon reared at the Livingston Stone NFH.

Brood Year	Release Dates
1998	1/28/1999
1999	1/27/2000
2000	2/1/2001
2001	1/30/2002
2002	1/30/2003
2003	2/5/2004
2004	2/3/2005
2005	2/2/2006
2006	2/8/2007
2007	1/31/2008
2008	1/29/2009
2009	2/10/2010 – 2/11/2010
2010	2/3/2011
2011	2/2/2012
2012	2/7/2013
2013	2/10/2014
2014	2/4/2015 – 2/6/2015

10.5) Fish transportation procedures, if applicable

Winter Chinook are reared at the hatchery to the sub-yearling, pre-smolt size. Releases occur generally in late-January or early February; however, actual release timing may occur outside of this target window in order to time the release to coincide with a flow and turbidity event, which are believed to decrease predation during the period of acclimation and to stimulate emigration from the upper river. Juvenile winter Chinook are transported approx. 11 miles to the release site in two groups using aerated and insulated fish distribution trucks. Transportation to the release site in two groups is done to avoid the catastrophic loss of an entire brood of hatchery fish that could be caused by potential difficulties experienced during transport to the release site (e.g., traffic accident). Transportation to the release site requires less than one hour. Releases of hatchery-origin juveniles are conducted at dusk to reduce the risk of predation while juveniles acclimate to the river.

10.6) Acclimation procedures (*methods applied and length of time*)

Winter Chinook from the supplementation are not acclimated prior to their release. Because supplementation winter Chinook are released near to their rearing location (i.e., minimal travel time) and 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 them in acclimation pens prior to release. Releases of winter Chinook from the Integrated-Recovery Program occur at dusk to reduce the risk of predation while they adjust to life in the river environment.

10.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults

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

10.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels

Broodstock in excess of collection targets are not retained for the integrated-recovery supplementation program, therefore, surplus eggs or juveniles are not produced. Most juvenile winter Chinook salmon propagated at the Livingston Stone NFH are released. Beginning in 2014 a small number of juveniles (1,035 in 2014 and approx. 1,000 annually thereafter) will be withheld from the release group and reared to maturity at the Livingston Stone NFH. A separate HGMP is being developed for the Winter Chinook Captive Broodstock Program.

10.9) Fish health certification procedures applied pre-release

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 AFS Blue book and USFWS Aquatic Animal Health Handbook. The hatchery receives an inspection report that lists the pathogens present, if any.

10.10) Emergency release procedures in response to flooding or water system failure

The Livingston Stone NFH is located high above river level and downstream of Shasta Dam, and is therefore not susceptible to flooding. The hatchery employs a redundant water delivery system to ensure that water is available at all times to the fish rearing units. Because of these securities, emergency release procedures have not been developed for winter Chinook at the Livingston Stone NFH. In the event of emergency necessitating rapid evacuation of the hatchery, fish will be loaded into fish distribution vehicles and transported to another facility or released into the wild. All releases will be coordinated with NMFS and CDFW.

Water quality at Livingston Stone NFH is generally suitable for propagating winter Chinook salmon. Suitable water temperature is achieved through operation of various penstocks and the Temperature Control Device (TCD) at Shasta Dam. Turbidity in the hatchery water supply is generally low because most suspended solids settle out of the water column in Lake Shasta reservoir. Suspended sediments are further reduced by filtering water being delivered to eggs and alevins.

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

Additionally, during periods of prolonged extreme drought the intakes for the hatchery may become inoperable due to insufficient reservoir levels. Under these conditions, it may become necessary to construct an alternative hatchery water intake that can draw water from a lower lake elevation.

10.11) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from fish releases

Releases of juvenile winter Chinook salmon from the Winter Chinook Integrated-Recovery Supplementation Program are timed to coincide, when practicable, with precipitation events accompanied by increased flow and turbidity in the Sacramento River. These conditions are believed an opportunity for hatchery fish to acclimate to the river. 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 Chinook are believed to exhibit a short-term residency in the lower Sacramento River or delta prior to entering saltwater in the late spring. Due to the small size of the winter Chinook propagation program at the Livingston Stone NFH and the seasonal timing of releases, concerns of ecological effects resulting from the release of hatchery-origin juveniles are minimal.

SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

11.1) Monitoring and evaluation of "Performance Indicators" presented in Section 1.10

11.1.1) Describe plans and methods proposed to collect data necessary to respond to each "Performance Indicator" identified for the program

Performance Standard B1: Provide a demographic benefit to the abundance of winter Chinook

Relevant Performance Indicators:

- Continue to conduct field surveys to generate adult run-size estimates and evaluate survival, spawning success, and integration of hatchery propagated winter Chinook salmon with the natural population

- o Monitoring and Evaluation Indicator: Information generated from the winter Chinook carcass survey is used to estimate survival and spawning abundance of hatchery origin winter Chinook. By relating this information to the number of hatchery-origin juveniles released we can estimate post-release survival rates.

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- Continue to monitor and evaluate genetic risks of the winter Chinook propagation program to measure potential genetic effects on the natural population
    - o Monitoring and Evaluation Indicator: Genetic risks of the winter Chinook program are assessed by calculating either or both Proportionate Natural Influence (PNI) or the effective population size of the winter Chinook population, as influenced by the release of hatchery-origin winter Chinook

- Conducted a parentage type analysis to confirm reproductive success of the winter Chinook salmon from the propagation program at Livingston Stone NFH
    - o Monitoring and Evaluation Indicator: The grand-parentage type analysis confirmed the likelihood that hatchery-origin winter Chinook are contributing to natural production; however, this analysis is not capable of comparing relative reproductive success of hatchery- and natural-origin fish

Performance Standard B2: Maintain stock integrity and conserve genetic and life history diversity

Relevant Performance Indicators:

- Monitor population trends in fecundity, return rates, return timing, spawn timing, adult size and age composition, survival for different life stages, Effective Population Size or Proportionate Natural Influence (PNI), and other parameters
    - o Monitoring and Evaluation Indicator: Monitoring of fecundity, return rates, return timing, spawn timing, adult size and age composition, survival for different life stages, and Effective Population Size or Proportionate Natural Influence (PNI) are helpful to investigate possible influences of the hatchery propagation program on genetic and phenotypic characteristics. An objective is that phenotypic characteristics be similar for both hatchery- and natural-origin winter Chinook.

Performance Standard B3: Provide fish for approved experiments

Performance Indicators:

- As appropriate for specific experimental designs
    - o Monitoring and Evaluation Indicator: The Service works with researchers to meet the specific requirements for fish that are provided for use in various studies and experiments (as approved by the SERVICE, NMFS, and CDFW).

Performance Standard B4: Conduct research, monitoring and evaluations of hatchery operations and practices

Relevant Performance Indicators:

- Marking and tagging of hatchery-origin winter Chinook to identify origin
    - o Monitoring and Evaluation Indicator: Marking and tagging of hatchery-origin juvenile winter Chinook salmon provides a life-long indicator of origin. This

indicator is used to identify hatchery fish during their emigration from the upper Sacramento River, in ocean harvest, and upon return to freshwater in spawning area surveys and at the KDFT.

- Monitoring of the incidental harvest of winter Chinook in the ocean fishery contributes to the total estimated survival of winter Chinook, which is used to calculate cohort replacement rates and evaluate the effectiveness of the hatchery propagation program
    - Monitoring and Evaluation Indicator: Periodically review and summarize ocean harvest data from the Regional Mark Information System (RMIS)

- Analyze and summarize life history characteristics of hatchery and natural origin winter Chinook collected during mainstem Sacramento River carcass surveys to make comparisons based on origins of fish
    - Monitoring and Evaluation Indicator: Monitoring of these parameters through measurements taken at the Livingston Stone NFH or during the winter Chinook carcass survey are helpful to investigate possible influences of the hatchery propagation program on genetic and phenotypic characteristics. The Winter Chinook Integrated-recovery supplementation program is highly integrated with naturally produced fish and we desire that phenotypic characteristics of hatchery-produced fish be similar to those of natural-origin winter Chinook.

- Broodstock trapping efforts at the Keswick Dam Fish Trap (KDFT) have been investigated for their effects on survival of adult winter Chinook released back into the Sacramento River (i.e., not used as broodstock at the Livingston Stone NFH).
    - Monitoring and Evaluation Indicator: Radio and acoustic tagging have been used to track the movements of winter Chinook trapped at the KDFT and released back into the Sacramento River to spawn naturally. These studies have indicated a substantial portion of winter Chinook trapped at the KDFT do not spawn, but rather move downstream and out of viable spawning areas prior to spawning.

Performance Standard B5: Improve survival of propagated species/stock using appropriate incubation, rearing, and release strategies

Relevant Performance Indicators:

- Analyze trends in survival for different life stages rearing in the hatchery
    - Monitoring and Evaluation Indicator: Trends of survival in the hatchery can indicate that unsuitable conditions in the hatchery environment. Mortality levels throughout various stages of rearing are constantly monitored at the Livingston Stone NFH, to maximize survival.
- Examine rates of ocean harvest, freshwater harvest, and escapement
    - Monitoring and Evaluation Indicator: Monitoring of the incidental harvest of winter Chinook in the ocean fishery contributes to the total estimated survival of winter Chinook, which is used to calculate cohort replacement rates and serves to evaluate the effectiveness of the hatchery propagation program

Performance Standard B6: Improve survival by preventing disease introduction, spread, or amplification

Relevant Performance Indicators:

- Analyze survival trends for different life stages at the hatchery
  - Monitoring and Evaluation Indicator: Mortality levels are monitored throughout various stages of rearing. Unusually high levels of mortality in the hatchery may indicate that unsuitable conditions exist, including disease, which may call for modified rearing conditions or treatments for disease.

Performance Standard B7: Provide a source of winter Chinook salmon to be coded-wire tagged for purpose of informing decisions related to harvest management

Relevant Performance Indicators:

- Report coded-wire tag releases and recoveries to the coast-wide RMIS database
  - Monitoring and Evaluation Indicator: Marking and tagging of hatchery-origin juvenile winter Chinook salmon provides a life-long indicator of origin. This indicator is used to identify hatchery fish during their emigration from the upper Sacramento River, in ocean harvest, and upon return to freshwater in spawning area surveys and at the KDFT. Systematic reporting of coded-wire tag releases are used by others to monitor the locations of juvenile winter Chinook during their emigration through the river system and Delta. Take limits at the Delta pumping facilities are based on observations of coded-wire tagged winter Chinook. Ocean harvest monitoring also relies on the presence of coded-wire tags in winter Chinook.

Performance Standard B8: Provide a source of fish for the winter Chinook Captive Broodstock Program, which can be used to prevent extinction and support reintroduction efforts

Relevant Performance Indicators:

- Report survival across all life-stages of captive broodstock
  - Monitoring and Evaluation Indicator: Monitor survival of captive broodstock and their progeny. High rates of survival to adult are necessary to achieve the objectives of the Captive Broodstock Program.

- Report reproductive success of winter Chinook captive broodstock
  - Monitoring and Evaluation Indicator: High rates of reproductive success of captive broodstock are necessary to achieve the objectives of that program

Performance Standard R1: Reduce potentially harmful genetic and ecological interactions between hatchery- and natural-origin stocks

Relevant Performance Indicators:

- Monitor and assess characteristics of hatchery-origin winter Chinook in comparison to naturally produced winter Chinook
  - Monitoring and Evaluation Indicators: Measure and compare phenotypic characteristics of hatchery and natural winter Chinook observed on the winter Chinook carcass survey, including spawn timing, spawn location, body size, and age at maturity, and spawn success, to monitor for changes resulting from the propagation program

- Calculate estimates of effective population size or PNI associated with hatchery releases winter Chinook salmon
- Conducted a grand-parentage analysis to assess the natural spawning success of hatchery-origin winter Chinook

Performance Standard R2: Do not introduce, spread, or amplify pathogens

Relevant Performance Indicators: Monitor on-station mortality of Chinook salmon

- Monitoring and Evaluation Indicator: conduct visual and histological examinations to diagnose causes of abnormal appearance, behaviors, or mortality levels. Prescribe treatments as warranted to achieve high levels of survival.

Performance Standard R3: Minimize harmful effects of program operations on the ESA-listed population

Relevant Performance Indicators: Research and monitoring are conducted to investigate possible effects that activities associated with the propagation program may have on the survival of winter Chinook

- Monitoring and Evaluation Indicators: Conduct Floy/dart tagging of fishes released from trapping activities to gain insights into the fate of released fish
- Conducted a two-year study to monitor the movements of winter Chinook trapped at the KDFT and released to spawn naturally. A final report of this study is being prepared and will be provided to NMFS upon completion.

11.1.2) Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program

The Service's Hatchery Evaluation (HE) Program at the RBFWO has a staff of approximately eight to ten biologists and technicians dedicated to monitoring, evaluations, and research associated with propagation programs at the Coleman NFH Complex. The HE Program receives annual funding of approximately $0.7M from the USBR, which is included in budget of the Coleman NFH for mitigating effects resulting from Shasta Dam. Additional funding for specific research projects may be secured from outside sources.

11.2) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish resulting from monitoring and evaluation activities

Effects of most monitoring and research activities conducted by the Service's HE Program are considered through a separate section 10 permitting process. Detailed descriptions of monitoring and evaluation activities associated with the winter Chinook propagation program, including estimates of take, are included with other monitoring activities conducted out of the Service's RBFWO (Permit #1415). This permitting process is separate from the section 10 process for fish propagation activities at the Coleman NFH Complex.

SECTION 12. RESEARCH

Provide the following information for any research programs conducted in ***direct association with the hatchery program described in this HGMP. Provide sufficient detail to allow for the independent assessment of the effects of the research program on listed fish***.

12.1) Objective or purpose

Indicate why the research is needed, its benefit or effect on listed natural fish populations, and broad significance of the proposed project.

The Service is currently involved with three research and monitoring projects directly involved with evaluating the effects of the Winter Chinook Integrated-Recovery Supplementation Program ; the Upper Sacramento River Winter Chinook Carcass Survey, an Acoustic Telemetry study to monitor the movements of adult winter Chinook that are captured at the KDFT and not retained for broodstock, and a study using acoustic tags to study emigration patterns and survival of juvenile hatchery origin winter Chinook. The winter Chinook Carcass Survey project is permitted through section 10 Permit #1415, which covers most monitoring activities conducted out of the Service's Red Bluff FWO.

Winter Chinook Carcass Survey:

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

A second objective the winter Chinook carcass survey is to gather information to evaluate the Winter Chinook Integrated-recovery supplementation program at the Livingston Stone National Fish Hatchery. This project is the primary source of information to assess the propagation program and to recommend refinements to increase benefits leading to restoration of a self-sustaining natural population.

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

Acoustic tracking of winter Chinook adults collected at the KDFT:

This study was developed to help reconcile discordant information resulting from broodstock collections at the KDFT and the winter Chinook carcass survey. The original purpose of this study was to track the movements of winter Chinook following their capture at the KDFT and subsequent release into the Sacramento River to elucidate how and when winter Chinook 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 Chinook 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 Service requests that the ongoing acoustic telemetry study being conducted to monitor patterns of movements of adult winter Chinook released from the KDFT be permitted through the section 10 permit associated with the conservation hatchery program. This is the preferred method of permitting this action because this particular research project is highly intertwined with the hatchery production program.

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

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

12.2) Cooperating and funding agencies

The Sacramento River winter Chinook salmon carcass survey is a cooperative project between the Service's Red Bluff Fish and Wildlife Office and the CDFW. Field sampling for this project also includes personnel from the Pacific States Marine Fisheries Commission (PSMFC), which is contracted through the CDFW. Approximately half of the field effort for this project is provided by the SERVICE and the remainder is provided by CDFW/PSMFC. Funding for this project is currently provided by the CalFed Ecosystem Restoration Program, but is expected to be paid by Reclamation as a requirement of the OCAP BO beginning in return year 2014.

The winter Chinook adult radio tagging study is conducted by the Service's Red Bluff Fish and Wildlife Office. Funds for this project are provided by Reclamation through funding provided to the Hatchery Evaluation Program at the Red Bluff FWO.

Acoustic tracking of winter Chinook juveniles is a cooperative study conducted with the NMFS' Southwest Fisheries Science Center and Reclamation. Funding has been provided by the

Ecosystem Restoration Program (ERP) and the Anadromous Fish Restoration Program (AFRP)

12.3) Principle investigator or project supervisor and staff

Principle investigator for the Winter Chinook Carcass Survey and Winter Chinook Adult Acoustic Tagging Study is Mr. Kevin Niemela of the Service's Hatchery Evaluation Program at the Red Bluff Fish and Wildlife Office. Principle CDFW Investigator for the Winter Chinook Carcass Survey is Mr. Doug Killam, CDFW, Red Bluff, California.

Principal investigators for the juvenile winter Chinook reach-specific movement and survival study are Jason Hassrick, USBR, Sacramento, CA and Arnold Ammann, NMFS, Santa Cruz, CA.

12.4) Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2

Stock status is as described in Section 2.

12.5) Techniques: include capture methods, drugs, samples collected, tags applied

Winter Chinook Carcass Survey:

The Winter Chinook Carcass Survey is conducted in the upper Sacramento River from May through August, encompassing the duration of the winter Chinook salmon spawning period. The survey area of this project includes the upper Sacramento River in Shasta County, extending from Keswick Dam at river mile (RM) 301 downstream to near Cottonwood Creek (RM 273). The survey is divided into sections, which are chosen as convenient areas for crews to start or stop the daily surveys. In past years, three (3) to four (4) survey sections have been used to cover the entire survey area. Survey sections will be covered on a rotating basis throughout the survey season.

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

Acoustic tracking of winter Chinook adults collected at the KDFT:

Winter Chinook were collected at the KDFT concurrent with the collection of broodstock for the Integrated-recovery supplementation program at Livingston Stone NFH. Utilizing the KDFT to collect fish for this study concurrent with collections of winter Chinook broodstock required minimal additional handling and did not necessitate additional anesthetization. Trapped fish are transported to the hatchery in a 3,785 liter fish transport truck for sorting, which occurs in the tank of the transport truck. Fish are anesthetized with carbon dioxide to subdue their activity. All captured Chinook received one or two dart-type anchor tags, which are placed into their dorsal musculature. Radio/acoustic tags were inserted into the gastric cavity (gastric tagging) of winter Chinook. Gastric tagging was used to reduce the stress, physical trauma, and tag loss associated with surgical implantation and external attachment. Two bands of surgical tubing (13 mm) encircled each cylindrical tag, separated by a spacing of approximately 25 mm. The surgical tubing provided a non-uniform surface to aid in the prevention of tag regurgitation (Keefer et al. 2004).

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH

Working with study cooperators, we will annually tag and release up to 700 winter run smolts raised by the Livingston Stone National Fish Hatchery. An array of over 300 tag-detecting monitors (VR2W, Vemco Ltd.) will be used to monitor tagged fish during their emigration through the Sacramento River, Delta, San Francisco Bay, and the coastal waters off Point Reyes (Fig. 5). To capture cumulative in-river mortality, transects of monitors will be set up in a linear arrays at the base of the Delta, Benicia, and Golden Gate Bridges. Tag detections by acoustic monitors will be analyzed using mark-recapture models to estimate overall and reach-specific survival probabilities. Collected data will be housed in a relational database hosted at the NMFS laboratory in Santa Cruz and will be available to collaborators via an ODBC connection to allow users to remotely access live tables to keep it updated.

12.6) Dates or time period in which research activity occurs.

Winter Chinook Carcass Survey:

The Winter Chinook Carcass Survey is conducted annually from May through August, encompassing the duration of the winter Chinook salmon spawning period.

Acoustic tracking of winter Chinook adults collected at the KDFT

Tagging of winter Chinook from the KDFT will take place concurrent with the collection of winter Chinook broodstock, which occurs from February – July.

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH

Acoustic tagging of juvenile winter Chinook from the Livingston Stone NFH will occur just prior to the production release of juveniles into the upper Sacramento River. Production releases of winter Chinook generally occur during late January through February; however, the timing of releases may change to take advantage of favorable conditions resulting from unpredictable rainfall events. Tagged fish will be monitored as they migrate downstream using an array of autonomous acoustic receivers positioned throughout the Sacramento River, Delta, and the San Francisco Bay.

12.7) Care and maintenance of live fish or eggs, holding duration, transport methods.

Winter Chinook Carcass Survey:

Protocols for the Winter Chinook Carcass Survey do not require observing and sampling carcasses from areas of the river used by spawning winter Chinook. In order to avoid stressing spawning fish, field survey crews avoid boating through sections of the river that where actively spawning fish are congregating. Survey protocols do not involve the collection, handling, or transport of live fish or eggs.

Acoustic tracking of winter Chinook adults collected at the KDFT

Winter Chinook were collected at the KDFT concurrent with the collection of broodstock for the Integrated-recovery supplementation program at Livingston Stone NFH. Trapped fish are transported to the hatchery in a 3,785 liter fish transport truck for sorting, which occurs in the tank of the transport truck. Fish are anesthetized with carbon dioxide to subdue their activity. All captured Chinook received one or two dart-type anchor tags, which are placed into their dorsal musculature; one tag is applied to fish retained as hatchery broodstock and two tags are used for fish released back into the Sacramento River. Radio/acoustic tags were inserted into the gastric cavity of fish while they were in the tank of the transport truck at the Livingston Stone NFH, immediately after broodstock were selected. Two biologists participated in tagging; one person held the salmon horizontally and ventral side up while the second person inserted the tag. To insert tags, the gently pushed through a short piece of PVC pipe down the pharynx, past the cardiac sphincter, and into the stomach (Bridger and Booth 2003). Radio tagged winter Chinook were released into the Sacramento River according to standard hatchery protocols, along with all other fish not retained as hatchery broodstock. Releases occurred at the Posse Grounds Boat Ramp (RK 479.6) in Redding, California.

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH

Juvenile winter Chinook for this investigation will be obtained from the conservation hatchery program at the Livingston Stone NFH. No additional spawning of winter Chinook at the Livingston Stone NFH will be conducted to accommodate this project. Juvenile winter Chinook to be acoustically tagged will be selected from the general production group a couple days prior to a planned release. Fish will be tagged at the hatchery facility and housed in hatchery tanks until they are released. Acoustically tagged winter Chinook will be interspersed with untagged, general production fish, so that they are representative of the population being released.

12.8) Expected type and effects of take and potential for injury or mortality.

Winter Chinook Carcass Survey:

We anticipate take, in the form of short term and minor disturbance will occur to winter Chinook salmon as a result of conducting this monitoring project. This project monitors the abundance of winter Chinook salmon during a time when they are spawning in the upper Sacramento River. Because this project is conducted during this sensitive and critical life stage, and because this project covers the entire spawn timing and spawning distribution, it is potential that any and all fish in the spawning run could be minimally disturbed by project activities; specifically, operating a motor boat in the vicinity of spawning areas. However, the effects of a disruption are expected to be minor and of short duration and are not expected to affect the spawning success of winter Chinook salmon.

Acoustic tracking of winter Chinook adults collected at the KDFT:

We anticipate a low level of take in the form of minimal extra handling of fish trapped in the KDFT and possible behavioral modifications and mortality resulting from insertion of radio tags into adult winter Chinook. Potential effects of gastrically applying acoustic tags to winter Chinook may affect the behavior and physiology of Sacramento River winter Chinook salmon including:

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

We do not anticipate direct or indirect mortality to result from this study but also cannot completely discount the potential occurrence. We request an allowance of 10% mortality (i.e., lethal take of five fish) of the total number of fish tagged.

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH

Acoustically tagged winter Chinook may experience sublethal effects, such as decreased swimming performance, or direct mortality from the implantation of acoustic tags; however, based on previous experience we anticipate little evidence of such tag effects. Current research focused on the swimming performance of acoustically tagged juvenile salmon may elucidate additional effects.

12.9) Level of take of listed fish: number or range of fish handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached "take table" (Table 1).

Winter Chinook Carcass Survey:

We estimate take resulting from this project, in the form of minimal disturbances to winter Chinook spawners, will potentially affect nearly all of the winter Chinook spawners annually. Effects of this disturbance are expected to be negligible, similar to that experienced when a fishing boat passes through a section of river. Disturbances to actively spawning winter Chinook are reduced by avoiding areas where active winter

Chinook spawning is occurring. Additional take in the form of handling dead carcasses of winter Chinook spawners will occur to approximately half the spawners. This estimate is based on an average handling rate of approximately 50% of total estimated abundance on the carcass survey. We do not anticipate take of other listed species to result from project activities because they are either not expected to be spawning at that time of this survey and/or they are not known to in shallow water habitats of the upper Sacramento River during the time this survey occurs.

Acoustic tracking of winter Chinook adults collected at the KDFT

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

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH

We do not expect any mortality to result from this project but cannot completely discount the potential for either direct or indirect mortality; therefore, we request an allowance of 10% mortality (i.e., take) of the total number of fish tagged.

12.10) Alternative methods to achieve project objectives.

Winter Chinook Carcass Survey:

This study is the primary method of monitoring the effects of the winter Chinook propagation program and estimating the abundance of winter Chinook. No alternative methods are known to exist that accomplish these objectives with a lower level of impacts.

Acoustic tracking of winter Chinook adults collected at the KDFT

The need for this study has been identified in reports of the winter Chinook Carcass Survey for more than a decade. No alternative methods have been identified to meet the study objectives with a lower level of impact.

Acoustic tracking of juvenile winter Chinook released from the Livingston Stone NFH

Acoustic tracking of juvenile winter Chinook is the only method available to provide information on reach-specific survival and movement patterns. Other methods, such as coded-wire tagging, do not provide the clarity of information that can be achieved from acoustic tagging.

12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.

These projects do not negatively affect other runs of Chinook salmon or steelhead.

12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed fish as a result of the proposed research activities.

Winter Chinook Carcass Survey:

No live fish are handled during the course of conducting this monitoring activity. Disturbances to actively spawning winter Chinook are reduced by avoiding areas where fish are actively spawning.

Acoustic tracking of winter Chinook adults collected at the KDFT

This study will be conducted concurrently with winter Chinook broodstock collection to minimize or eliminate any additional stress associated with collection, anesthetization, and transport. Gastric insertion of acoustic tags requires minimal additional handling above and beyond that used in normal broodstock collection activities and will not require additional anesthetization or "mutilation" as no surgery will be performed.

Acoustic tracking of winter Chinook adults collected at the KDFT

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

SECTION 13. ATTACHMENTS AND CITATIONS

Include all references cited in the HGMP. In particular, indicate hatchery databases used to provide data for each section. Include electronic links to the hatchery databases used (if feasible), or to the staff person responsible for maintaining the hatchery database referenced (indicate email address). Attach or cite (where commonly available) relevant reports that describe the hatchery operation and impacts on the listed species or its critical habitat. Include any EISs, EAs, Biological Assessments, benefit/risk assessments, or other analysis or plans that provide pertinent background information to facilitate evaluation of the HGMP.

Reports and other documents associated with the winter Chinook salmon propagation program and the Sacramento River winter Chinook carcass survey can be found at the U.S. Fish and Wildlife Service's Red Bluff Fish and Wildlife Office website:
http://www.fws.gov/redbluff/he_reports.html

A copy of the database of the hatchery evaluation program is available upon request to Kevin Niemela (kevin_niemela@fws.gov) at the Red Bluff Fish and Wildlife Office.

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M. L. Moser. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. National Marine Fisheries Service. 58 pages.

Azevedo, R.L. and Z.E. Parkhurst. 1958. The upper Sacramento River salmon and steelhead maintenance program, 1949-1956. U.S. Fish and Wildlife Service unpublished report. 100 pp. with appendices.

Beamesderfer, R.C.P., M.L. Simpson, and G.J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes. 79 (3-4): 315-337.

Bridger, C. J. and R. K. Booth. 2003. The effects of biotelemetry transmitter presence and attachment procedures of fish physiology and behavior. Reviews in Fisheries Science 11(1): 13 – 34.

Busby, P. J., T. C. Wainwright, G. J. Bryant., L. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memo NMFS-NWFSC-27. 261 pages.

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game comments to NMFS regarding green sturgeon listing. California Department of Fish and Game. 79 pages.

Deng, X., J. P. Van Eenennaam, and S. I. Doroshov. 2002. Comparison of early life stages and growth of green and white sturgeon. In: W. Van Winkle, P.J. Anders, D.H. Secor, and D.A. Dixon, editors, Biology, management, and protection of North American sturgeon, pages 237-248. American Fisheries Society, Symposium 28, Bethesda, Maryland.

Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries, Volume II: Species life history summaries. ELMR Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland. 329 pages.

Erickson, D.L. and J.E. Hightower. 2007. Oceanic distribution and behavior of green sturgeon. American Fisheries Society Symposium 56:197-211.

Fisher, F. W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8(3): 870-873.

Hallock, R.J. 1989. Upper Sacramento River Steelhead, Oncorhynchus mykiss, 1952 – 1988. A report to the U.S. Fish and Wildlife Service.

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (Salmo gairdnerii gairdnerii) in the Sacramento River system. California Department of Fish and Game. Fish Bulletin No. 114. 74 pages.

Hanson, H.A., O.R. Smith, and P.R. Needham. 1940. An investigation of fish-salvage problems in relation to Shasta Dam. U.S. Bureau of Fisheries, Special Scientific Report No. 10. 212 pp. plus appendices.

Israel, J. 2006. Determining spawning population estimates for green sturgeon with microsatellite DNA. Presentation at the 2006 CALFED Science Conference. Sacramento, California. October 23, 2006.

Johnson, R.R., and C.D. Martin. 1997. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River, July

1994 – June 1995. Red Bluff Research Pumping Plant Report Series, Volume 2. U.S. Fish and Wildlife Service, Red Bluff, CA.

Keefer, M. L., C. A. Perry, R. R. Ringe, and T. C. Bjornn. 2004. Regurgitation rates of intragastric radio transmitters by adult Chinook salmon and steelhead during upstream migration in the Columbia and Snake Rivers. North American Journal of Fisheries Management 24: 47 – 54.

Lindley, S.T., D.L. Erickson, M.L. Moser, G. Williams, O.P. Langness, B.W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140:108-122.

Moffett, J.W. 1949. The first four years of king salmon maintenance below Shasta Dam, Sacramento River, California. California Fish and Game 35(2):77-102.

Moser, M.L. and S.T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes. 79:243-253.

Moyle, P.B., P.J. Foley, and R.M. Yoshiyama. 1992. Status of green sturgeon, Acipenser medirostris, in California. Final report sent to NMFS, Terminal Island, California by UC Davis Department of Wildlife and Fisheries Biology. 12 pages.

National Marine Fisheries Service. 2005. Green sturgeon (Acipenser medirostris) status review update. Biological review team, Santa Cruz Laboratory, Southwest Fisheries Science Center, California. February. 31 pages.

National Marine Fisheries Service. 2014. Biological opinion of the Coleman National Fish Hatchery complex artificial propagation programs. National Marine Fisheries Service, West Coast Region, Sacramento, California. February 2014.

Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales (Orcinus orca) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Commn. (special issue) 12: 209-244.

Pauley, G.B., B.M. Bortz, and M.F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) – Steelhead trout. U.S. Fish and Wildlife Service Biological Report 82(11.62). U.S. Army Corps of Engineers, TR EL-82-4. 24 pp.

Poytress, W. 2008. U.S. Fish and Wildlife Service Fisheries Biologist, Red Bluff Fish and Wildlife Office, Red Bluff, California. Personal communication with Bruce Oppenheim, Fisheries Biologist, NMFS, on the status of juvenile green sturgeon passage. September 3.

Poytress, W.R., J.J. Gruber, D.A. Trachtenbarg, and J.P. Van Eenennaam. 2009. 2008 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual

Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, California.

Poytress, W.R., J.J. Gruber, and J.P. Van Eenennaam. 2011. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife SERVICE to U.S. Bureau of Reclamation, Red Bluff, California.

Poytress, W.R., J.J. Gruber, and J.P. Van Eenennaam. 2012. 2011 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife SERVICE to U.S. Bureau of Reclamation, Red Bluff, California.

Service (U.S. Fish and Wildlife Service). 2001a. Final restoration plan for the Anadromous Fish Restoration Program. U.S. Fish and Wildlife Service, Sacramento, California. January 2001.

Service (U.S. Fish and Wildlife Service). 2001b. Biological Assessment of Artificial Propagation at Coleman National Fish Hatchery: program description and incidental take of Chinook salmon and steelhead trout. U.S. Fish and Wildlife Service, Red Bluff, California. June 2001.

Service (U.S. Fish and Wildlife Service). 2002. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. U.S. Fish and Wildlife Service, Red Bluff, California. July 2002.

Service (U.S. Fish and Wildlife Service). 2011. Biological assessment of artificial propagation at the Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of Chinook salmon and steelhead. U.S. Fish and Wildlife Service, Red Bluff, California. July 2011.

Skinner, J.E. 1958. Some observations regarding the King salmon runs of the central Valley. Water Projects Miscellaneous Report #1. Submitted 3/19/1958. Revised 10/14/1958. 8 pages plus figures and tables.

SECTION 14. CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Certified by Bret Galyean Date: 1.20.2016

ACTING PROJECT LEADER

Attachment 1. Study Proposal: Tracking the movements of adult winter Chinook released from the KDFT (March 8, 2013).

Study Proposal:

Tracking the movements of adult winter Chinook released from the KDFT

U.S. Fish & Wildlife Service
Red Bluff FWO: Hatchery Evaluation Program
&
Coleman National Fish Hatchery Complex

March 8, 2013

Background:
In 2012 the U.S. Fish and Wildlife Service (Service) initiated a three year study aimed at tracking the broad-scale movements and eventual spawning locations of winter Chinook salmon collected at the KDFT (KDFT) coincidental with the capture of broodstock for the propagation program at the Livingston Stone National Fish Hatchery (Livingston Stone NFH). Chinook salmon not meeting the broodstock selection criteria and those in excess of monthly collection targets are released into the upper Sacramento River to spawn naturally. A total of 21 winter Chinook from the KDFT were radio tagged during March 2012. Movements of these fish followed three generalized patterns:

1. Three of the 21 radio tagged winter Chinook exhibited localized movements of short duration, with movements ceasing prior to the observed onset of spawning. This movement pattern is presumed to indicate that the radio tags were either regurgitated or the tagged fish died soon after release into the Sacramento River.
2. Six of the 21 tagged fish exhibited successive movements within viable winter Chinook spawning areas of the upper Sacramento River. Movements by these fish extended several weeks after release and ceased during or after the primary spawning period of winter Chinook. This movement pattern is suggestive of spawning behaviors and these fish are presumed to have spawned in naturally the upper Sacramento River.
3. Twelve of the 21 tagged fish remained in the general vicinity of the release site immediately following their release. From two to three weeks after their collection at the KDFT and prior to the onset of the primary spawning period of winter Chinook these 12 fish exhibited sustained downstream movements, taking them far outside of the range of viable winter Chinook spawning areas. Following their downstream migrations, none of these twelve fish were observed to re-enter viable winter Chinook

spawning areas. The extended distance of the downstream movements exhibited by these fish was not indicative of carcass drift.

The observation that the majority of radio tagged winter Chinook released from the KDFT in 2012 moved far downstream and out of viable winter Chinook spawning habitats prior to the onset of spawning was quite unexpected and has raised many questions as to its possible cause(s). At least three possible causes for this behavior have been identified, and are generalized as follows: (1) the observed movement reflects a natural behavior characteristic of Sacramento River winter Chinook; (2) the behavior is atypical of winter Chinook, but results instead from the influence of gastrically-applied radio tags; and (3) the behavior is an incidental effect of the trapping and handling activities associated with the collection and winter Chinook broodstock at the KDFT. It is unlikely that the observed pattern of movement reflects a natural behavior of Sacramento River winter Chinook. Viable spawning habitats for winter Chinook do no occur downstream of Red Bluff, so the movements exhibited by these fish would be maladaptive to their survival and unlikely to be perpetuated within the population. Unfortunately, deciphering the true cause of this observed behavior between the remaining two factors is confounded because the study conducted in 2012 does not provide conclusive evidence to discriminate between the effects of gastrically-applied radio tags versus the incidental effects of trapping and handling winter Chinook at the KDFT.

Modified Study Design for 2013

The design of the study for tracking the broad-scale movements of adult winter Chinook during the 2013 spawning season has been modified from that employed in 2012. The intent of the modifications is to provide additional information that will be helpful to elucidate the effects of gastric tagging on the patterns of movement by fish released into the river. The approach and details of the study design were the focus of a meeting held at the Sacramento office of the NMFS on February 27, 2013, which included representatives from the Service (Hamelberg, Smith, Null, Niemela), NMFS (Alston, Oppenheim, Cranford), and CDFW (Berry). A general study design was agreed to by participants of that meeting, and has since received minor modifications to improve its performance and execution.

Similar to the study conducted in 2012, fish to be tagged in 2013 will be collected during the course of regular trapping of winter Chinook broodstock for the propagation program at the LSNFH. Fish used for this study will be selected from phenotypic winter Chinook captured at the KDFT during March and early April. Winter Chinook collected at during this time period are sexually immature and, based on tagging trials conducted using late-fall Chinook at the Coleman NFH, capable of being gastrically tagged without a high risk of stomach rupture. A sample of fin tissue will be collected from every trapped fish. Tissue samples will be submitted (either through real-time “rapid response” analysis or at the conclusion of the broodstock collection season) to the Conservation Genetics Laboratory at the Service’s Abernathy Fish Technology Center, Longview, WA, for confirmation of run identity. Trapped fishes will be separated into two groups, as follows, including broodstock for the propagation program at the Livingston Stone NFH and a study group to be tagged and released to spawn naturally.

Hatchery Broodstock: Natural-origin fishes both meeting the phenotypic criteria of winter Chinook and falling within the monthly collection targets of the winter Chinook propagation program will be retained for broodstock at the Livingston Stone NFH. Notwithstanding the exceptions listed in Subset A (below), the protocols for capturing and handling these fish will remain unchanged from standard protocols, as described in the Service's current winter Chinook broodstock collection plan (Attachment A) and the project description contained in the current section 10 permit application, including: the total number of broodstock that will be retained (maximum 120), the schedule for collecting these fish, the criteria for selecting these fish, and the protocols for holding these fish in captivity (including the use of malachite green as anti-fungal treatments).

Broodstock Subset A. A subset of fifteen natural-origin winter Chinook that are retained as hatchery broodstock will be gastrically tagged with either an active (n=5) or inactive (n=10) acoustic tag (VEMCO Ltd, Nova Scotia, Canada, model V13-1X). Gastrically tagged broodstock will be housed together in the same tanks as standard hatchery broodstock and will be handled similarly, with the exception that they will not be given an intraperitoneal injection of the antibiotic oxytetracycline. Withholding this prophylactic antibiotic treatment is being done so that the gastrically tagged broodstock component provide a similar representation of the responses to bacterial loads experienced by the acoustic tagged release group (described below). Gastrically tagged winter Chinook broodstock will be observed daily for morbidity or mortality. Active acoustic tags applied to winter Chinook broodstock will serve a dual purpose of also allowing an assessment of tag life. Information gathered from acoustic tagged hatchery broodstock will be used to infer whether the patterns of movements observed in the river are likely a result of gastric tagging or tag failure.

Acoustic Tagged Release Group: Twenty-five phenotypic winter Chinook that are not selected as hatchery broodstock will be gastrically tagged with an active acoustic tag and released into the Sacramento River to spawn naturally. This group may include either hatchery- or natural-origin winter Chinook; however, we anticipate that the majority of fish in this group will be of hatchery-origin as most natural-origin winter Chinook captured at the KDFT are retained for use as broodstock. Broad scale movements of acoustic tagged winter Chinook in the Sacramento River will be monitored using fixed station acoustic receivers (Attachment B).

All winter Chinook receiving an acoustic tag, including hatchery broodstock and the acoustic tagged release group, will receive two dart tags, as per standard protocol for fish trapped and released from the KDFT. Uniquely coded dart tags will enable the identification of acoustically tagged fish and the association of individual fish to a specific trapping event. Any acoustic tagged fish that are subsequently recovered on a carcass survey will be examined internally and externally to investigate the effects of tagging.

Benefits of the modified study design:

- Similar to the study conducted in 2012, the design of the 2013 study will track the broad-scale movements of winter Chinook salmon following their release from the KDFT. Of particular interest is whether tagged fish exhibit movement patterns similar to those observed in 2012, when a majority of tagged fish exited viable spawning areas prior to spawning. The modified design of the study for the 2013 winter Chinook spawning season offers an improvement over the study conducted in 2012 in that it will elucidate whether the observed patterns of movement likely occurred as a result of morbidity and/or mortality resulting from gastric tagging. Observances of morbidity and/or mortality within the acoustic tagged broodstock at the hatchery, and the timing of these occurrences, will be used to infer whether the process of gastric tagging results in movements observed in the river.

Attachment 2: Research Project Proposal:

Tracking reach-specific movement and survival of outmigrating Sacramento winter run Chinook salmon smolts through the drought

Background: California has experienced two consecutive years of unprecedented drought in 2013 and 2014. These drought conditions generally reduce water flow and increase water temperatures, which may impact the movement and survival of outmigrating juvenile salmon. Juvenile winter run are known to take longer to outmigrate than other runs and thus may be more affected by drought conditions than other runs.

Objectives: Funds are sought for three objectives:

1) Extend a study of reach-specific movement and survival of hatchery-raised outmigrating winter run Chinook salmon (*Oncorhynchus tshawytscha*) smolts into 2015
    a. Compare reach-specific movement and survival rates between drought years and non-drought years
    b. Implant 400 Livingstone Stone Hatchery winter run smolts with JSATS (Juvenile Salmon Acoustic Telemetry System) transmitters
    c. Deploy a network of 120 JSATS receivers at 46 locations from Keswick Dam to the Golden Gate bridge
2) Initiate a wild-origin study (Fall 2014) of winter run smolts caught in the Red Bluff Diversion Dam rotary screw trap
    a. Implant 200 wild-origin winter run smolts with JSATS transmitters
    b. Compare with hatchery-origin movement and survival rates
3) Install real time receivers at a site upstream of the Delta Cross Channel
    a. To know in real time when juveniles have arrived at a location just upstream of the DCC
    b. Provide immediate data to better manage water operations

Preliminary Results: Cumulative survival estimates show that 80% of juvenile winter run Chinook salmon died in the upper Sacramento River between Cow Creek (Rkm 538) and Ord bend (Rkm 380) in 2013 (Fig. 1). We have identified a 55 km region of high rearing / non-migratory behavior for the surviving 20% between Ord bend and Colusa (Rkm 325) (Fig. 2). Juveniles remained within this stretch of river up to 30 - 40 days (mean 8 days between receiver sites) before continuing their migration to sea (Fig. 3). The cause of mortality in the upper river is unknown and more acoustic tracking data are needed to determine whether the rearing zone is persistent across years. We have just deployed 359 acoustically-tagged hatchery-origin winter run smolts below Keswick Dam in February 2014 and preliminary results suggest that rearing/holding behavior was less pronounced and survival increased 2-fold to Benicia. We are working with hydrologists at SWFSC to acquire spatially explicit zooplankton, flow and temperature data on the upper river where most mortality occurs and in the area where the retention zone was identified in 2013. Initial results have been presented as a poster at the 2013 Biennial State of the Estuary Conference and at the 2014 IEP workshop. During the third year (2015), a talk will be presented at the Biennial CALFED Bay-Delta Conference. Results have and will also be presented at winter run Project Work Team meetings and used to inform juvenile production estimates (JPE). Peer reviewed manuscripts will be published in the scientific literature following the conclusion of the study.

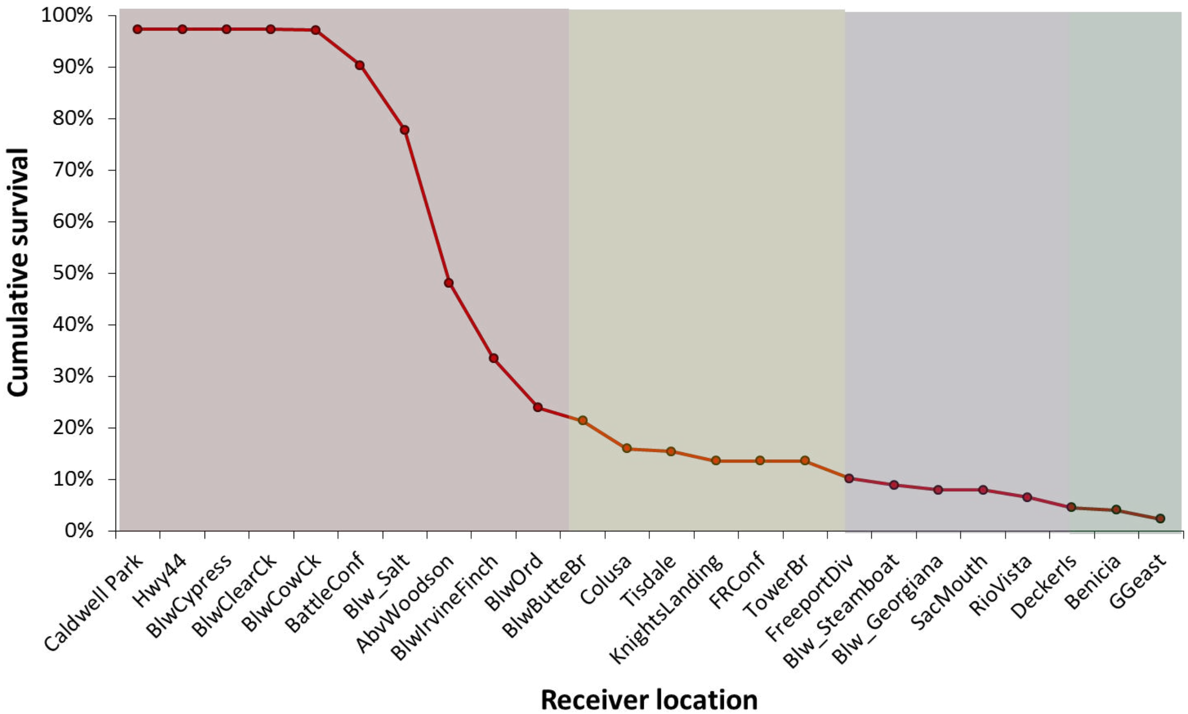

Figure 1. 2013 Cumulative survival estimates for juvenile winter run Chinook salmon from a Cormack Jolly Seber mark-recapture analysis based on detection probabilities at each receiver location. Habitats are color-coded red: upper river, yellow: lower river, blue: delta, and green: estuary following Michel et al. (2013).

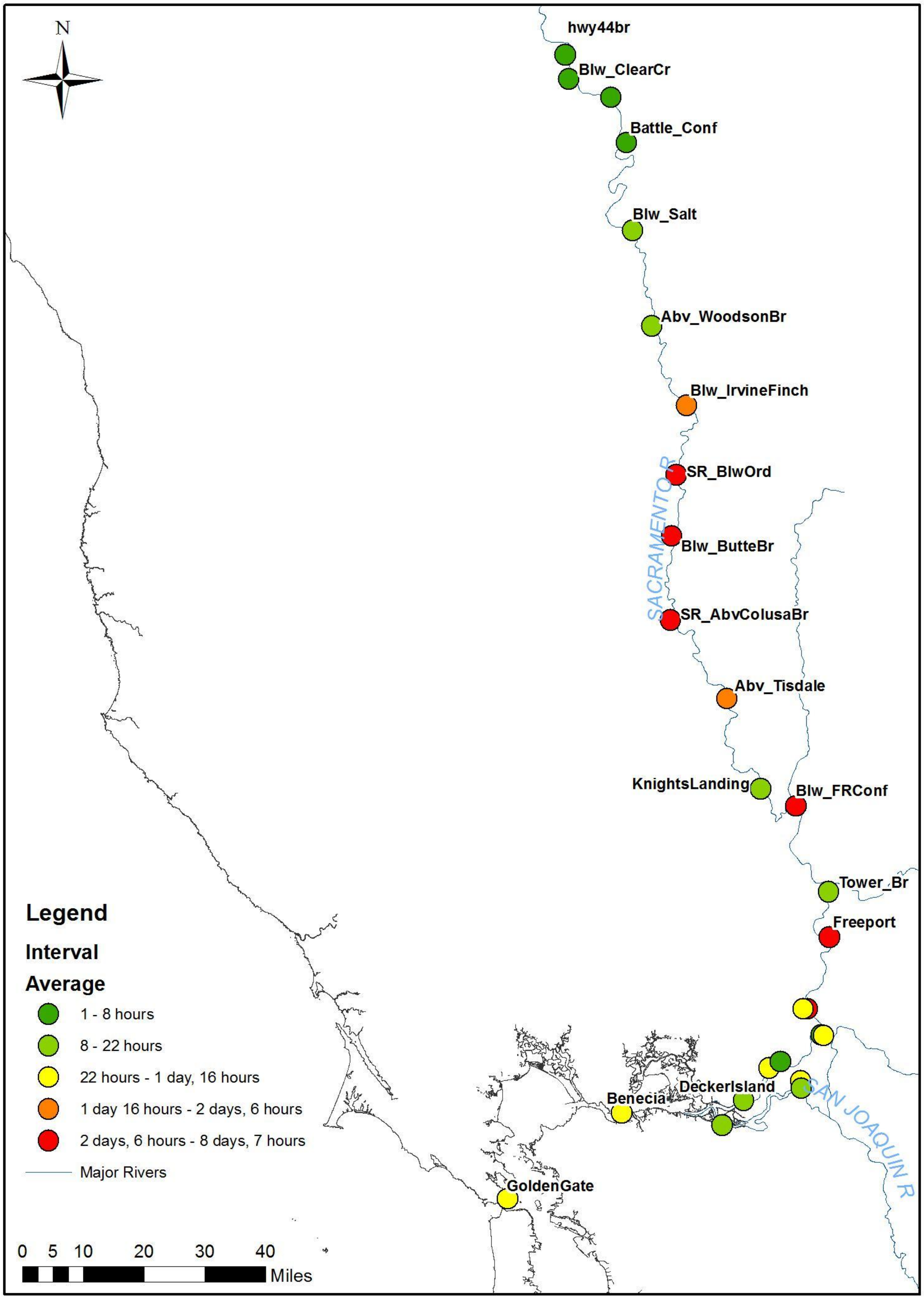

Figure 2. Receiver locations color-coded to reflect the average time juvenile winter run Chinook salmon spent travelling between receivers. Warmer colors represent longer time intervals.

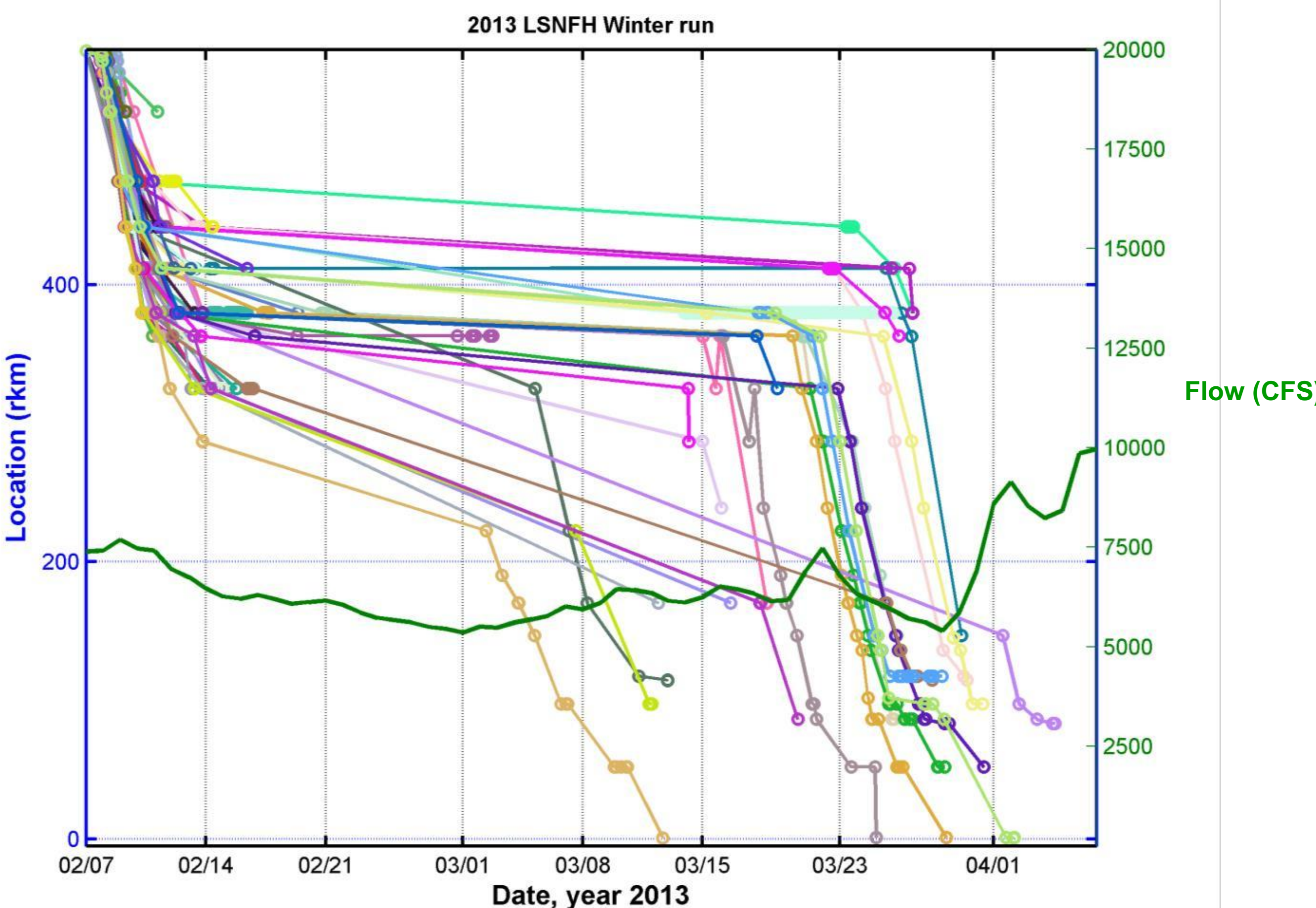

Figure 3. Movement rates of individual juvenile Chinook salmon during their outmigration to the ocean. River flow measured at Butte City is shown on the secondary y-axis.

Attachment 3: Research Project Proposal (Parent Proposal to previous attachment):

Proposal for year 3 to track migration and survival in juvenile fall, winter, and spring run Chinook salmon in the Sacramento River and Delta

Background:

Salmon are an iconic species in the West and support a $255 million fishery, but despite recent attention to precipitous declines in Central Valley stocks, little is known about the migratory and survival patterns of emigrating Chinook salmon juveniles. Some of these unknowns include: (1) a better understanding of populations that emigrate through the Sacramento River; (2) Investigating how survival rates vary among runs; and (3) Discovering areas of increased mortality and investigating whether they are tied to anthropogenic causes. Winter-run Chinook salmon are the most endangered of all Central Valley salmon stocks and are inexplicably experiencing a six year decline, despite improved ocean conditions. The goal of this project was to include tracking winter-run Chinook smolts to better understand in-river movement and survival as an addendum to the Delta Proposal Solicitation Package submitted by the research team in 2010 titled "Survival and migratory patterns of juvenile spring and fall-run Chinook salmon in Sacramento River and Delta".

Recent advances in miniaturized acoustic technology have produced transmitters small enough to be implanted in juvenile Chinook salmon smolts during their outmigration from upriver spawning habitat to sea. In fact, this technology is so new that the first year of the parent project was devoted to field testing acoustic transmitters (tags) and receivers prior to working on threatened or endangered stocks. We conducted a pilot study on hatchery-produced fall-run smolts and discovered two critical problems with the acoustic technology. The first problem involved tags acoustically turning each other off prior to surgical implantation, thereby confounding ensuing survival estimates. Secondly, receivers that ran low on batteries towards the end of the migration had a tendency to reboot and overwrite all of their stored memory. Rather than recording a complete outmigration period, these receivers recorded only the final few days. We were able to field test alternative equipment and initiate a new contract with another vendor prior to the beginning of the second year, in which endangered winter run smolts were the first stock to be tracked on this project.

Conceptual Model:

The purpose of this study is to determine reach-specific survival of three distinct Chinook salmon runs that are exposed to drastically different seasonal river conditions over a two year period. Using a mark-recapture framework to estimate survival, with multiple marking and recapture locations and complete capture histories (Burnham et al. 1987), we will relate measured survival at reaches to the factors that affect predator abundance and activity – flow, temperature, turbidity, channel form, riparian cover, and timing of hatchery releases. Fish will be "marked" with uniquely coded electronic tags and "recaptured" by the monitors. The pattern of recaptures allows estimation of reach-specific survival rates and the probabilities of detection at each monitoring station with a statistical model of the mark-recapture dataset. Fish are tagged and released so that they are representative of the population being characterized. It is important to note that in using this method, fish are not actually handled when they are recaptured and rereleased; they are simply detected by the monitoring stations. The covariates of reach-specific survival rates will be modeled statistically and assessed using Akaike's information criteria (AIC) to evaluate candidate models and rank the models that are best characterized by the explanatory variables.

Approach/Plan of Work

Task 1: Assist existing efforts to expand and maintain the acoustic monitor array to detect fall-, winter-, and spring-run Chinook salmon smolts

An array of over 300 tag-detecting monitors (VR2W, Vemco Ltd.) has already been established within the Sacramento and San Joaquin Rivers, Delta, San Francisco Bay, and the coastal waters off Point Reyes. This array is currently being used to monitor the migrations of late-fall-run Chinook salmon and steelhead smolts, adult green sturgeon, striped bass, cow sharks, and other species. I have assisted in expanding this array by helping place additional Juvenile Salmon Acoustic Tracking (JSATS) monitors from the winter-run release point at Caldwell park to the head of the Delta, including monitors at the mouths of key creeks to record the emigration from tagging sites of wild fall, winter, and spring run smolts. A total of 15 monitors cover the migration routes previously observed for late-fall-run Chinook salmon within the Delta. An additional eight monitors are set up in a linear array at the base of the Delta.

Task 2: Reach-specific survival of hatchery fall-, spring-, and winter-run Chinook salmon
Year two of our study represents the first year that movement and survival of winter-, spring-, and fall-run smolts will be collected for the project. In the first week of February, 2013, we tagged and released 150 winter-run smolts raised by the Livingston Stone National Fish Hatchery. In addition to allowing for comparison of environmental factors such as flow and water temperature, the timing of these releases to the releases into the main stem of the upper Sacramento River will provide information on different runs with different temporal migration patterns and mortality estimates. Similar cohorts of fall- and spring-run smolts will be tagged and tracked in April from Coleman and Feather River National Fish Hatcheries, respectively.

Task 3: Data management and analysis
Collected data are housed in a relational database hosted at the NMFS laboratory in Santa Cruz and available to collaborators via an ODBC connection to allow users to remotely access live tables to keep it updated. Modeled after the California Fish Tracking Consortium's database, the database is modified to incorporate JSATS technology.

A tagged fish is destined to meet one of two fates; it either leaves the study area after completing its seaward migration, or it dies en route. Along its journey, it can be detected as it passes locations of moored monitors with a probability *pi* at the *i'*th location. At branches, the fish can take either of two paths with a probability *ti* and 1 - *ti*, evading the monitors on the other path. Between the *i*'th and the *i*'th + 1 monitoring locations, the fish survives with a probability of φ_i. Following Burnham et al. (1987), the results can be represented as a capture history matrix and the likelihood of the dataset is the product of $2k - 3$ independent binomial distributions (where *k* is the number of monitoring locations + the initial release location), allowing for estimation of the unknown parameters *pi* , *ti,* , and φ*i* with the maximum likelihood method (MLE). To treat the reach-specific survival probabilities as functions of various explanatory variables, we find the MLE's of the parameters that relate the explanatory variables to the survival probabilities, which in turn influence the capture histories.

Monitoring data will also allow us to determine the movement rates between monitor locations. This information is useful for identifying areas that are important to juvenile salmonids, such as holding or nursery areas that could then be protected to increase survival. Furthermore, analysis of movement rates in relation to diversions, bypasses and Delta entrances and other anthropogenic structures will provide insights on the impacts of these factors on the movement patterns of salmonids. Within and across year variability in survival and movement patterns in relation to hydrologic variables, such as flow dynamics and water temperature, will improve understanding of their effects on salmonid outmigration. By collecting data in the Sacramento River and Delta, we can distinguish mortality between two ecosystems and improve our knowledge of their relative contributions to juvenile salmonid mortality. This will ultimately improve our ability to find meaningful solutions to impacts of water projects on salmonids.

To account for uncertainty associated with tag loss and tag influence on survival, correction factors are being developed through captive laboratory experiments with tagged fish. Hatchery Chinook salmon ranging in size from ~ 75 to 120mm FL are used for a series of experiments on three groups of fish – two control groups (sham implant surgery and no surgery) and a third group implanted with a JSATS tag. We will evaluate tag retention, growth, survival and swimming performance.

Benefits to the fellow and research and community mentors:
The strong existing partnership between U.C. Santa Cruz, U.C. Davis and NOAA's Southwest Fisheries Science Center in Santa Cruz and U.S. Fish and Wildlife Service's Coleman and Livingston Stone National Fish Hatcheries will benefit from the work and resources that this proposal adds to the Proposal Solicitation Package. To this end, the research and community mentors will benefit from a post-doctoral fellow who is committed to taking a lead on fulfilling the tasks of the proposed work over the next two years. The SERVICE has wanted to conduct a tracking study of hatchery raised winter-run Chinoook salmon for some time, but has been unable to do so until the tags were sufficiently miniaturized. The timing of the JSATS technology and the addition of the hatchery winter-run Chinook to this migration and survival study will finally make this goal possible. The proposed study offers the research fellow (Hassrick) the opportunity to diversify his skill set and to apply his tracking, handling, and analytical expertise to a system with critical conservation and management needs. As a California Sea Grant Fellow with NOAA's Coastal Services Center, the research fellow is familiar with NOAA priorities and operations, and the proposed study would offer the opportunity to continue working with the agency on salmonid research and conservation, a system that is going to need skilled scientists for the foreseeable future. Also, as a graduate student at U.C. Santa Cruz, the fellow is familiar with the operations of the university. The strong existing partnership between U.C. Santa Cruz and NOAA's Southwest Fisheries Science Center in Santa Cruz will benefit from the work and resources that this proposal adds to the Proposal Solicitation Package. To this end, the research and community mentors will benefit from a post-doctoral fellow who is committed to taking a lead on fulfilling the tasks of the proposed work over the next two years.