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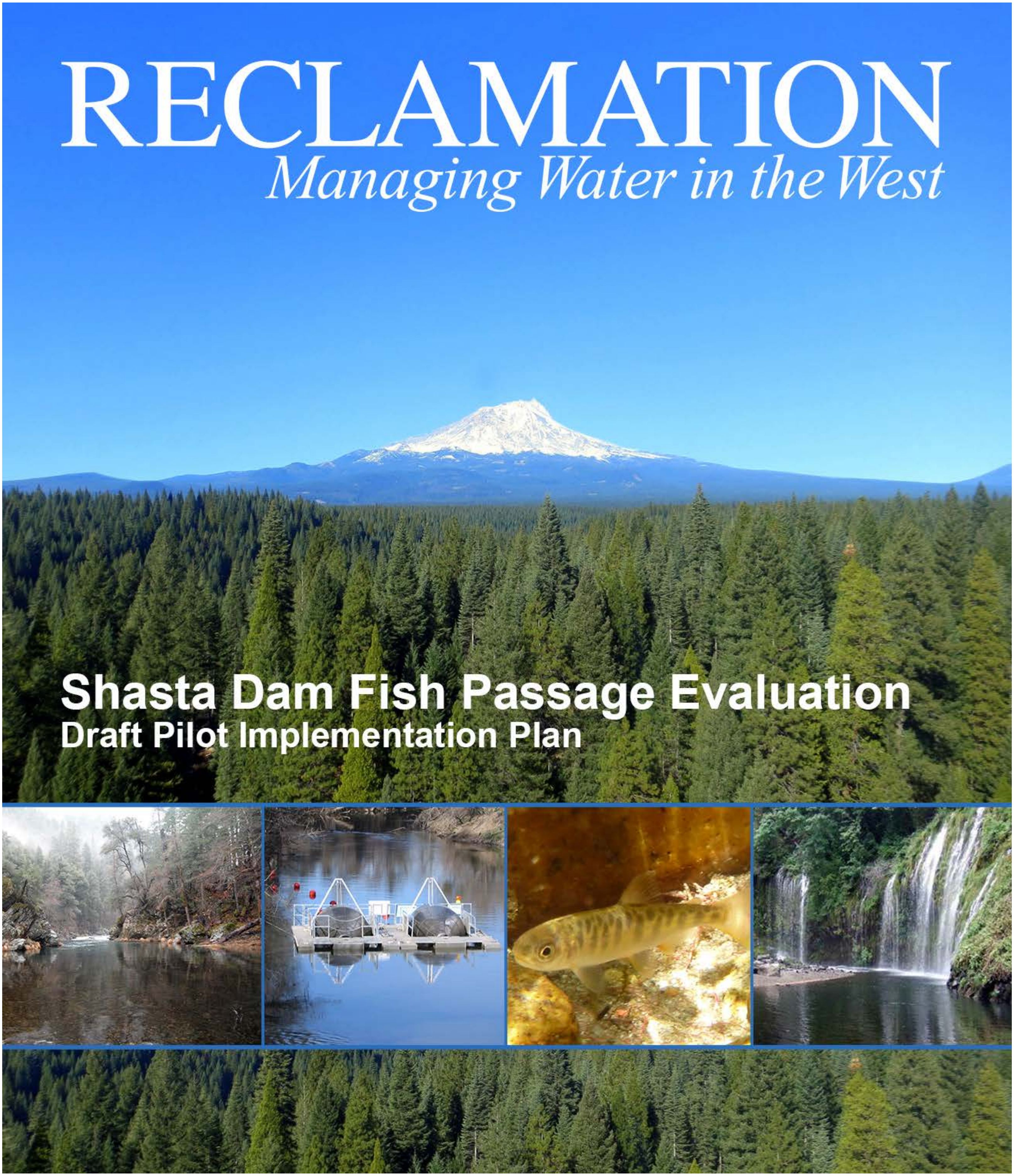

Shasta Dam Fish Passage Evaluation

Draft Pilot Implementation Plan

U.S. Department of the Interior
Bureau of Reclamation - Mid Pacific Region

December 2016

Mission Statements

The mission of the Department of the Interior is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Abbreviations and Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
ATU	accumulated thermal unit
BA	Biological Assessment
BLM	Bureau of Land Management
BO	Biological Opinion
CART	combined acoustic-radio transmitter
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
cfs	cubic feet per second
CVP	Central Valley Project
dd	degree days
DPS	distinct population segment
DWR	California Department of Water Resources
EIS	Environmental Impact Statement
ESA	Federal Endangered Species Act
ESU	Evolutionarily significant unit
FERC	Federal Energy Regulatory Commission
FL	fork length
fps	feet per second
gpm	gallons-per-minute
GPS	geographic positioning system
HGMP	Hatchery and Genetic Management Plan
LRMP	Land and Resource Management Plan
LWD	large woody debris
MAF	million acre-feet
mm	millimeter
MMWAT	monthly maximum weekly average water temperatures
msl	mean sea level
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
OCAP	Operations Criteria and Plan

PG&E	Pacific Gas & Electric Company
Pilot Plan	Pilot Implementation Plan
PNI	Proportionate Natural Influence
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Recovery Plan	*Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead*
RM	river mile
RPA	Reasonable and Prudent Alternative
RST	rotary screw trap
SDFPE	Shasta Dam Fish Passage Evaluation
SL	standard length
State Water Board	California State Water Resources Control Board
STNF	Shasta-Trinity National Forest
Study Area	Pilot Program Study Area
SWP	State Water Project
TL	total length
TU	temperature units
UPRR	Union Pacific Railroad
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator
Y1	Year 1
Y2	Year 2
Y3	Year 3

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Executive Summary

The Shasta Dam Fish Passage Evaluation (SDFPE) is an effort to determine the feasibility of reintroducing Sacramento River winter-run Chinook Salmon and Central Valley spring-run Chinook Salmon and steelhead to tributaries above Shasta Dam. The SDFPE is part of U.S. Department of the Interior, Bureau of Reclamation's (Reclamation) response to the June 4, 2009, Reasonable and Prudent Alternative in the National Marine Fisheries Service (NMFS) *Biological Opinion (BO) and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)* (NMFS 2009).

The purpose of this Pilot Plan is to provide a guide for evaluating the potential to reintroduce winter-run and spring-run Chinook Salmon into their historical habitat above Shasta Dam. The Pilot Plan is part of an adaptive approach which aims to increase the species abundance, productivity, and spatial distribution, and to improve life history, health, and genetic diversity. The Pilot Program, led by Reclamation in coordination with the Interagency Fish Passage Steering Committee, has the immediate goal of determining the feasibility of establishing a self-sustaining population of Sacramento River winter-run Chinook Salmon in the McCloud and Upper Sacramento rivers.

We conducted a habitat assessment of the mainstem reaches of the McCloud and Upper Sacramento rivers as part of the development of the pilot plan. The assessment found good habitat conditions in both watersheds. The McCloud River has a longer reach with water temperatures suitable for Chinook Salmon egg incubation in the summer than the Sacramento River. Approximately nine miles of the Sacramento River meet a mean daily water temperature of 56 F and about eleven miles of the McCloud meet that criterion. The longer reach between the upstream dam and Shasta Lake on the Sacramento River side than on the McCloud River (37.4 miles vs. 23.3 miles from the upstream dam to the high pool elevation of Shasta Lake) results in warmer water reaching the lake in the fall period when young winter-run Chinook juveniles would likely be arriving at the lake from upstream. Spawning habitat within the cold water reach is estimated to be more plentiful on the McCloud River. Spawning habitat availability increases downstream of Ah-Di-Nah on the McCloud and downstream of Dunsmuir on the Sacramento. Rearing habitat quality on both rivers was rated as fair due to limited amounts of cover in the form of large wood using literature based habitat criteria. Abundant boulders and bedrock ledges and undercuts may provide similar cover functions in these large rivers. Both rivers have substantial areas of bedrock control and periodic flashy flows that tend to flush wood from the systems. Both rivers contain rainbow trout and brown trout. In addition, predatory species such as spotted bass and largemouth bass inhabit Shasta Lake and the lower reaches of the rivers.

Sacramento River winter-run Chinook Salmon produced in the Livingston Stone National Fish Hatchery (LSNFH) are planned as the initial source of fish for the

Pilot Program. Low adult returns in recent years and low juvenile survival during drought years resulted in the decision to re-start the winter-run captive broodstock program at LSNFH to produce fish that could be used in the project. Eggs and juveniles from this operation should be available by the late summer of 2017.

The Pilot Program includes multiple pilot (i.e., monitoring) studies intended to be conducted on a short-term basis (over one or more years) to answer questions regarding feasibility of a long-term reintroduction program. The pilot program is envisioned to last until it is determined that Chinook Salmon either can or cannot be feasibly reintroduced above Shasta Dam. If deemed to be feasible then the program would be phased into a long-term reintroduction program with a continuation of the adaptive management concepts. There are four performance measurements that will define the biological feasibility of long-term reintroduction: abundance, productivity, spatial structure, and diversity.

Fish passage technologies are broken down into those for the Pilot Program and those more suitable for long-term reintroduction. For the Pilot Program, fish will be transported in trucks in both the upstream and downstream direction around Keswick and Shasta dams. During this phase, an investigation of the feasibility of technologies to be used for long-term reintroduction, including volitional passage, will also take place. As a first step, the Fish Passage Technology Subcommittee developed potential alternatives for upstream and downstream passage and the technologies used for each.

In the judgement of the technical team, juvenile salmon survival through Shasta Lake to a juvenile collection system at or near the dam is likely to be low. Therefore, juvenile collection in the pilot program will focus, at least initially, on collection in or near the mouths of the tributary rivers. Juvenile survival through the reservoir will be measured to test this assumption. The proposed pilot juvenile collection includes two systems: 1) a juvenile collection system near the mouth of the river will include an inclined plane trap with guide nets directing fish to the trap opening. A debris boom will span the river upstream of the nets to attempt to deflect as much debris as feasible. 2) A juvenile collection system near the head of the reservoir, within about one-half mile of the stream/lake interface, would include a larger floating inclined plane trap with guide nets to direct fish to the trap entrance. A floating debris boom would be anchored upstream of the trap to attempt to deflect as much debris as feasible. A surface to bottom temperature curtain would be placed across the reservoir arm immediately downstream of the trap location to separate the cool tributary water from the warm surface water layer of the lake in the fall period when surface temperatures may be stressful to juvenile salmon. Both systems include upstream passageways for upstream migrating resident fish.

The existing Keswick Dam fish trap would continue to be used to collect adult salmon. Salmon collected here would be transported to LSNFH under the same protocol as currently used for the hatchery operation. Once initial pilot studies occur with juveniles and eggs and a water treatment system is added at LSNFH adults may be directly transported from the Keswick trap to release sites upstream of Shasta Dam within the McCloud River or Sacramento River or into the lake.

A preliminary sequence of colonization experiments and technical evaluations is provided for the first three years of the Pilot Program, beginning with fry or juvenile releases in the first year, fry or juvenile releases as well as in-stream and/or streamside egg incubation in the second year, and juvenile releases, instream and/or streamside egg incubation, and adult releases in the third year. The evaluations would be designed to answer key questions at each lifestage as they relate to feasibility of reintroduction. Anticipated monitoring activities used to determine primary metrics (e.g. transport survival, migration timing, growth, in-river survival, collection efficiency, ecological interactions) relating to the key questions are described for each river (McCloud and Sacramento). The rivers differ with regards to factors such as accessibility, temperature regime, flow, and length so the activities vary slightly between watersheds.

At the completion of each year of the pilot program a summary of results of the studies will be prepared and available to the public. The pilot plan will be updated annually as needed to incorporate lessons learned as the evaluation proceeds. When the information needed to support a feasibility determination has been gathered a comprehensive report will lay out the results. If deemed feasible then the pilot program will be phased into a long-term reintroduction project. The reintroduction would continue to be guided by an interagency steering committee of experts on fish passage and ecology of the species.

Chapter 1 Introduction

The Shasta Dam Fish Passage Evaluation (SDFPE) is an effort to determine the feasibility of reintroducing winter-run and spring-run Chinook Salmon and steelhead to tributaries above Shasta Dam. The SDFPE is part of U.S. Department of the Interior, Bureau of Reclamation's (Reclamation) response to the June 4, 2009, National Marine Fisheries Service (NMFS) *Biological Opinion (BO) and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP)* (NMFS 2009).

The NMFS BO concluded that, as proposed, CVP and SWP operations were likely to jeopardize the continued existence of four federally-listed anadromous fish species: Sacramento River winter-run Chinook Salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook Salmon (*O. tshawytscha*), California Central Valley steelhead (*O. mykiss*), and the Southern distinct population segment of the North American green sturgeon (*Acipenser medirostris*). The BO set forth a Reasonable and Prudent Alternative (RPA) that allows continued operation of the CVP and SWP in compliance with the Federal Endangered Species Act (ESA).

The NMFS RPA includes a Fish Passage Program (Action V) to evaluate the reintroduction of winter-run and spring-run Chinook Salmon and steelhead into their historical habitats that have been blocked by three dams operated by Reclamation: Shasta, Folsom, and New Melones. The near-term goal for Action V is to increase the geographic distribution and abundance of the target species. The long-term goal is to increase the abundance, productivity, and spatial distribution of the target species, and to improve their life history, health, and genetic diversity.

Key terms used in this document are "Shasta Dam Fish Passage Evaluation," "Pilot Program," "Pilot Plan," "pilot study," and "Reintroduction Program."

- "Shasta Dam Fish Passage Evaluation" is a study to evaluate the feasibility of reintroducing Chinook Salmon to tributaries above Shasta Lake and is in partial response to Action V of the June 9, 2009 BO. See Section 1.1, "Project Background" for more information.

- "Pilot Program" is the implementation of the first phase of reintroduction of winter-run and spring-run Chinook Salmon above Shasta Dam developed for the SDFPE and presented in the Pilot Plan as a 3-year (minimum) program.

- "Pilot Plan" is the Pilot Implementation Plan describing the procedures and protocols for the Pilot Program.
- "Pilot studies" are specific reintroduction colonization experiments and associated monitoring activities to evaluate the performance of the Pilot Program.
- "Reintroduction Program" is the general term used to describe the Pilot Program and the long-term reintroduction (if deemed feasible).

This Shasta Dam Fish Passage Pilot Implementation Plan (Pilot Plan) has been developed in response to Action V, NF3, "Development of a Fish Passage Pilot Plan," and is driven by the goals and objectives contained in the RPA. The Pilot Plan is a critical part of the Pilot Program, a multi-step process to evaluate the potential for reintroduction of winter-run and spring-run Chinook Salmon into historical habitat above Shasta Dam, and assess whether restoring this species to its historical habitat will provide a demographic benefit by increasing its spatial structure and abundance. The Interagency Fish Passage Steering Committee (Steering Committee) has prioritized winter-run Chinook Salmon for the first reintroduction above Shasta Dam, due to the limited amount of available habitat for winter-run Chinook Salmon below the dam. Plans for reintroduction of listed salmonids above Folsom Dam and New Melones Dam are beyond the scope of this Pilot Plan, and will be addressed in independent planning studies.

This Pilot Plan has been developed by Reclamation, with the cooperation, coordination, and assistance of the Steering Committee. The Pilot Program Study Area (Study Area) includes Shasta Lake, the Upper Sacramento River from Box Canyon Dam to Shasta Lake, and the McCloud River from McCloud Dam to Shasta Lake.

The Pilot Program is designed to demonstrate the feasibility, or "proof of concept," for reintroduction of listed fish to these watersheds. It will use the scientific method to test many of the uncertainties related to the Reintroduction Program, including methods and tools needed for a successful reintroduction. This process involves obtaining critical data to allow Reclamation and resource agencies to weigh the potential benefits against the risks and constraints. The results will inform whether or not it is feasible, and/or practical to implement a full-scale reintroduction in the watershed above Shasta Dam.

The Pilot Program is framed in an adaptive management structure and includes monitoring (or pilot) studies that will measure results keyed to criteria defining success. This is essential to learn from and adjust the program, as necessary, to increase the likelihood of successful reintroduction. As the Pilot Program progresses, changes may be required and additional monitoring programs may be subsequently added. As a result, this Pilot Plan is considered a living document, and will be updated to reflect those changes to the Pilot Program.

This Pilot Plan provides a general overview of winter-run Chinook Salmon reintroduction to historical habitats in the Study Area, including the recovery priorities for salmon and viable salmonid populations, and the benefits, opportunities and constraints associated with the reintroduction. It provides information on species and habitat conditions within the Study Area, and also discusses stock selection considerations, genetics, and potential sources of donor stock for reintroduction.

In addition, this Pilot Plan describes how the first three to five years of the Pilot Program could be implemented, and describes metrics and performance measures to be used to evaluate the success of the implementation techniques compared to the overall goal of the Pilot Program. It also provides a blueprint for obtaining additional critical information about the opportunity for successful reintroduction. As described above, the Pilot Plan is a living document, and it will be reviewed and updated annually as new information is gained regarding feasibility of reintroduction.

The Steering Committee will use the results of the Pilot Program to make decisions and adjust, as needed or terminate the Reintroduction Program if deemed infeasible. The Steering Committee is made up of members from Reclamation, NMFS, U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), California Department of Fish and Wildlife (CDFW), California Department of Water Resources (DWR), California State Water Resources Control Board (State Water Board), and a member of the academic community. Additionally, Reclamation will use the pilot study results for public outreach, to inform the public of the progress of the Pilot Program, to answer questions, and to address any of their concerns.

The remainder of this chapter provides an overview of the Pilot Program and this associated Pilot Plan, including background information, purpose and need, goals and objectives, Study Area description, and regulatory and management challenges.

Project Background

Reclamation was established in 1902 to help meet the increasing water demands of the West, and is now the largest water provider in the country. Reclamation is responsible for managing the CVP, which stores and delivers about 20 percent of California's developed water – 7 million acre-feet (MAF) – to more than 250 water contractors throughout California.

Shasta Dam and Reservoir were constructed between September 1938 and June 1945. Water storage in Shasta Reservoir began in December 1943, and Shasta Dam was fully operable in April 1949. In 1997, a temperature control device was installed to help provide cooler water for fisheries benefits downstream. Shasta

Dam and Reservoir are integral elements of the CVP, with Shasta Reservoir representing about 41 percent of the total reservoir storage capacity of the CVP.

2009 NMFS Biological Opinion

Pursuant to the ESA Section 7, USFWS and NMFS can authorize “incidental take” of a federally listed species resulting from Federal actions, such as the long-term operation of the CVP in coordination with the operation of the SWP. Protection of listed species is typically addressed through issuance of BOs and incidental take authorization on Federal actions. The resources agencies also have the authority to provide the Federal agency with an RPA in cases where they determine that the Federal action is likely to cause jeopardy to a species. Since the 1993, Reclamation and the DWR have operated the CVP and SWP (the largest state-built, multipurpose water project in the U.S.) under a series of BOs issued by the NMFS and the USFWS, resulting from formal consultations under Section 7 of the ESA.

In 2008, Reclamation reinitiated formal Section 7 consultation as a result of litigation and provided NMFS a new BA on the continued long-term operation of the CVP and SWP (Reclamation 2008). On June 4, 2009, NMFS issued the *Biological Opinion and Conference Opinion on the Long-Term Operation of the Central Valley Project and State Water Project* (NMFS 2009). The new BO concluded that, as proposed, the CVP and SWP operations were likely to jeopardize the continued existence of four federally-listed anadromous fish species: Sacramento River winter-run Chinook Salmon, Central Valley spring-run Chinook Salmon, California Central Valley steelhead, and Southern distinct population segment (DPS) of the North American green sturgeon. The BO set forth an RPA with actions that allow for continued operation of the CVP and SWP in compliance with the ESA. The RPA actions include revised water operations, habitat restoration and enhancement, and fish passage studies.

The NMFS consultation highlighted the difficulty in managing cold water dependent aquatic species below impassable barriers, as such management is often dependent on fluctuating and inadequate coldwater pools. The analysis found that even after all discretionary actions are taken to operate reservoirs to reduce adverse effects of water operations on listed anadromous fish, the risk of temperature induced mortality of fish and eggs remains high, particularly during dry water years.

The analysis also highlighted the potential future effects of climate change on the viability of listed salmonids, resulting from the impact of climate change on hydrology and coldwater pool availability in Central Valley reservoirs. In addition, it documented that impassable dams currently block access to 80 percent of historically available habitat in the Central Valley. The analysis concluded that providing passage for listed species to historical habitat will be needed to maintain viability of these species, so NMFS included Action V in the BO.

Central Valley Salmon and Steelhead Recovery Plan

The effects of Shasta Dam and Reservoir on winter-run and spring-run Chinook Salmon are described in NMFS' final *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead* (Recovery Plan) (NMFS 2014a). Winter-run Chinook Salmon originally spawned in the Upper Sacramento River system (Upper Sacramento (sometimes referred to as the Little Sacramento River), Pit, McCloud and Fall rivers) and in Battle Creek (Yoshiyama et al. 1996). The unique life history timing pattern of winter-run Chinook Salmon, which require cold summer flows, indicates that they are most suited to occupy the Upper Sacramento system and Battle Creek. Watershed development has eliminated access to all historical spawning habitats above Keswick Dam, approximately 200 river miles, and approximately 47 of the 53 miles of potential habitat in Battle Creek (Yoshiyama et al. 1996).

The Recovery Plan states that because the Sacramento River winter-run Chinook Salmon evolutionarily significant unit (ESU) currently only has one population, and that population spawns outside the species historical spawning range (Sacramento River below Keswick dam), introductions into historically occupied habitat are necessary to meet requirements for recovery (NMFS 2014a). In the Recovery Plan, NMFS indicates that the recovery of winter-run Chinook Salmon is affected by the Shasta cold-water pool by stating:

> *"Currently, winter-run Chinook salmon spawning is limited to the mainstem Sacramento River downstream of Shasta and Keswick dams where the naturally-spawning population is artificially maintained by cool water releases from the dams. Within the Sacramento River, the spatial distribution of spawners is largely governed by water year type and the ability of the CVP to manage water temperatures.*

The fact that this ESU is comprised of a single population with very limited spawning and rearing habitat increases its risk of extinction due to local catastrophe or poor environmental conditions. There are no other natural populations in the ESU to buffer it from natural fluctuations. A single catastrophe, such as volcanic eruption of Lassen Peak, prolonged drought which depletes the cold-water pool in Shasta Reservoir or some related failure to manage cold water storage, a spill of toxic materials with effects that persist for four years, or a disease outbreak with effects persisting for four or more years could result in extinction of the Sacramento River winter-run Chinook Salmon ESU, as most winter-run Chinook salmon return as 3-year old fish (Lindley et al. 2007).

After two years of severe drought, Shasta Reservoir storage would be insufficient to provide cold water throughout the winter-run Chinook Salmon spawning and embryo incubation season, resulting in partial or complete year class failure. Based on the Recovery Plan, a severe drought lasting more than 3 years could potentially result in the extinction of winter-run Chinook Salmon. The probability of extended droughts is increasing as the effects of climate change progress (see Chapter 3). California experienced four years of dry conditions in 2012-2015, and winter-run Chinook Salmon experienced low survival, likely due to lack of available cold water throughout the spawning, incubation, and juvenile life stages.

The Recovery Plan recognized the need to reintroduce Sacramento River winter-run Chinook Salmon and Central Valley spring-run Chinook Salmon into habitats that historically supported these fish, but are currently inaccessible because of existing dams. The Recovery Plan also categorized different priority levels for watersheds for reintroduction. It classified both the McCloud River (inaccessible from dam) and Battle Creek (accessible) as highest priority watersheds (i.e., primary watersheds) for reintroduction based on the current understanding of habitat conditions and that reintroduction planning efforts were already underway when the Recovery Plan was published. Those watersheds with less potential, such as the Upper Sacramento River, were identified as candidate watersheds. NMFS is addressing effects of reintroduction efforts on the existing populations of these fish in their experimental population designation and HGMP processes.

Shasta Dam Fish Passage Evaluation

The SDFPE is the first effort to be launched towards Action V. Fish passage at Shasta Dam was selected as the first effort in response to Action V due to the limited amount of existing available habitat for Sacrament River winter-run Chinook Salmon, as described in the Recovery Plan and in this Pilot Plan. The near-term goal for Action V is to increase the geographic distribution and abundance of the ESA-listed fish. The long-term goal is to increase abundance, productivity, and spatial distribution of the target species, and to improve their life history, health, and genetic diversity.

The near-term fish passage actions included the formation of the Steering Committee, led by Reclamation, which coordinates and guides the overall development and implementation of the studies through interagency collaboration. In accordance with the RPA action, the Steering Committee was formulated in 2010. The RPA indicated that the Pilot Program should be operational by 2012, but that was not feasible; Reclamation, with the Steering Committee, however, did begin the establishing Pilot Program before 2012.

As part of the requirements of the RPA, Reclamation, in coordination with the Steering Committee, is developing the Pilot Program, described in this Pilot Plan, as an adaptive management process to evaluate the reintroduction of Chinook Salmon into historical habitat above Shasta Dam. The BO directs Reclamation and partner agencies to annually revise and update this plan, and states that revisions and updates shall be based on results of the pilot studies, construction of new facilities, recovery planning guidance, predicted annual run size, and changes in hatchery management.

Purpose and Need

As described earlier, this Pilot Plan was created in response to Action V, NF3, which requires the "Development of a Fish Passage Pilot Plan" (NMFS 2009). Action V calls for an evaluation of the potential for reintroduction of winter-run and spring-run Chinook Salmon and Central Valley steelhead into their historical habitat above Shasta Dam and the Steering Committee prioritized winter-run Chinook Salmon as the top priority for reintroduction above Shasta Dam.

The purpose of this Pilot Plan is to provide a framework and guide for evaluating the potential to reintroduce winter-run and spring-run Chinook Salmon into their historical habitat above Shasta Dam. The Pilot Plan is a critical part of an adaptive approach which aims to increase abundance, productivity, and spatial distribution, and to improve life history, health, and genetic diversity. The Pilot Program, led by Reclamation in coordination with the Steering Committee, has the overall goal of determining the feasibility of establishing a self-sustaining population of Sacramento River winter-run Chinook Salmon in the Upper Sacramento and McCloud rivers.

Objectives

The objective of the Pilot Program is to implement short-term reintroduction actions and studies that will inform the planning for and feasibility of a long-term reintroduction. The 2009 BO lists the following specific steps to be identified in the Pilot Plan, as well as steps for the other reintroduction programs on the American and Stanislaus rivers which have not yet begun:

1. Identify any operational requirements needed for the passage and re-introduction program.

2. Identify protocols for optimal handling, sorting, and release conditions for ESA-listed fish collected at Reclamation or partner agency-funded fish collection facilities when they are constructed.

3. Identify the number, origin, and species of fish to be released into habitat upstream from Reclamation dams, incorporated into the hatchery broodstock, or taken to other destinations.

4. Identify fish collection and transportation requirements (e.g., four wheel-drive vehicles, smooth-walled annular tanks, large vertical slide gates, provisions for tagging/marking) for moving fish from below project dams to habitats above reservoirs, avoiding the use of facilities or equipment dedicated for other purposes (e.g., existing transport trucks).

5. Identify optimal release locations for fish, based on access, habitat suitability, disease concerns, and other factors (e.g., those which would

minimize disease concerns, recreational fishery impacts, interbreeding with non-native *O. mykiss* strains, regulatory impacts, special authorities for studies/construction, and complications from upstream dams).

6. Identify and evaluate options for providing tailored ESA regulatory assurances for non-federal landowners above the dams where species could be re-introduced.

7. Identify and evaluate interim downstream fish passage options through reservoirs and dams with the objective of identifying volitional downstream passage scenarios and alternatives for juvenile salmon and steelhead migrating through or around project reservoirs and dams. If these options are not considered feasible, identify interim non-volitional alternatives. Near-term operating alternatives that are determined to be technically and economically feasible and biologically justified shall be identified by Reclamation and the steering committee agencies.

8. Describe scheduled maintenance and representative types of unscheduled maintenance of existing infrastructure (dams, transmission lines, fish facilities, etc.) that could adversely impact listed fish, and describe measures to minimize these impacts.

9. Describe procedures for coordinating with Federal and State resource agencies in the event of scheduled and unscheduled maintenance.

10. Describe protocols for emergency events and deviations.

Study Area

The Study Area, described below, includes Shasta Lake as well as the Upper Sacramento River watershed between Box Canyon Dam and Shasta Lake, and the McCloud River watershed between McCloud Dam and Shasta Lake (Figure 1-1). It does not encompass the entire watersheds of these two rivers, but represents only those areas immediately above Shasta Lake where fish reintroduction is being investigated by this Pilot Plan. During the planning process for the Pilot Program, a selection process was conducted to determine the extent of the Study Area. A description of this selection process is provided below.

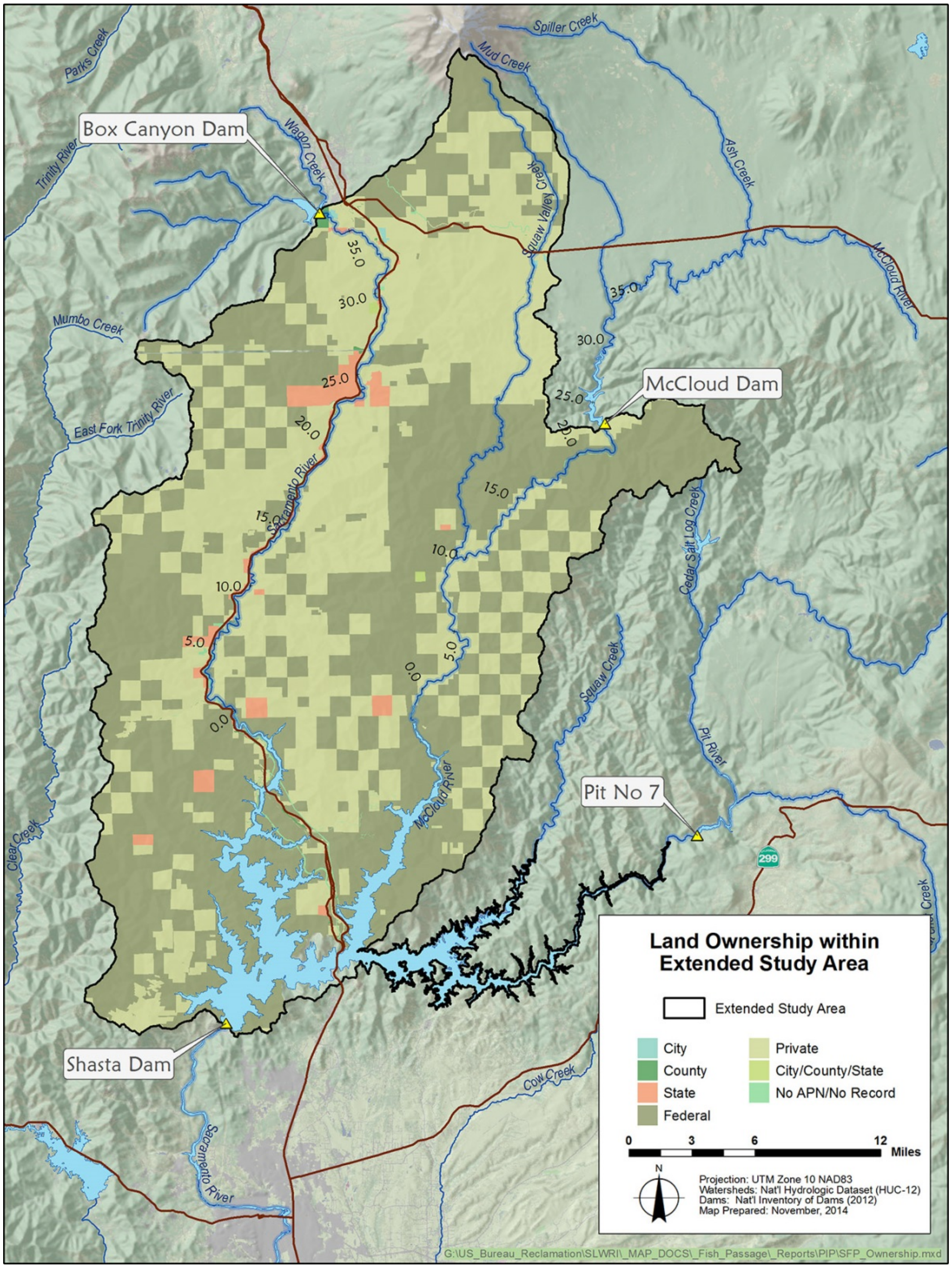

Figure 1-1. Shasta Dam Fish Passage Evaluation Study Area

River Selection Process

The RPA identified the McCloud and Upper Sacramento rivers for long-term passage evaluations at Shasta Dam and reintroduction of winter-run and spring-run Chinook Salmon. The Recovery Plan further described the importance of these two rivers, particularly the McCloud River, for reintroduction to preserve and increase the population of winter-run Chinook Salmon (NMFS 2014a). As described earlier, the Recovery Plan prioritized unoccupied habitats that historically supported winter-run Chinook Salmon, based on their suitability for reintroduction, as either primary areas, candidate areas, or areas that have been ruled out for potential reintroduction. It also classified the McCloud River as a primary area for reintroduction, which is defined as an area where there is a high likelihood that reintroduction would be successful, based on species-specific life history needs and available habitat quality and quantity. The Upper Sacramento River, which had historical populations of winter-run Chinook Salmon, was classified as a candidate reintroduction area, defined as a possible (i.e., lower priority) area for reintroduction.

The Steering Committee identified four categories, each with multiple criteria, to help prioritize studies and study sites in the Pilot Program:

- **Ecological –** Holding habitat, spawning/incubation habitat, rearing habitat, conditions for juvenile migration, estimated spawner capacity, water temperature, water supply reliability, flow variability, predation, resource competition, disease, food, ability to foster life history diversity, and resilience to climate change

- **Stakeholder/Landowner –** Public lands, economic perceptions, recreation, landowner concerns, concerns of the native people, and watershed stewardship organizations

- **Regulatory Implementation –** USFS Land and Resource Management Plan, California Wild and Scenic River protections, California Endangered Species Act, California Forest Practice Rules, and Consistency with the Recovery Plan and RPA

- **Physical Implementation –** Transportation stress on fish, cost of fish collection and transportation, adult release sites, juvenile collection sites, and field studies

These criteria were ranked for each river, with the ecological values based on the habitat assessment results weighted more heavily than the other factors since the success of reintroduction depends on the ecological conditions. While the McCloud River ranked higher on the ecological category, the Sacramento River ranked higher in the remaining categories.

Shasta Lake

Created by Shasta Dam, Shasta Lake is the largest reservoir in California, with a surface area of approximately 29,500 acres, a volume of 4.55 MAF, and approximately 400 miles of shoreline (Reclamation 2014a). The three major tributaries to Shasta Lake are the Upper Sacramento, McCloud, and Pit rivers. Many smaller tributary creeks and streams (both seasonal and perennial) flow into these major tributaries and Shasta Lake.

Upper Sacramento River Watershed

The Upper Sacramento River watershed, located in Shasta and Siskiyou counties, encompasses approximately 383,000 acres. Approximately 30 river miles of the Upper Sacramento River are included within the Upper Sacramento River watershed, from Box Canyon Dam downstream to where the river enters Shasta Lake. Above Box Canyon Dam, flows into Lake Siskiyou are supplied mostly by snowmelt; below the dam, released flows are augmented by spring discharges and rainfall-driven runoff. Between Box Canyon Dam and Shasta Lake, seven key tributaries contribute flow to the Upper Sacramento River – Castle Creek, Soda Creek, Flume Creek, Shotgun Creek, Hazel Creek, N. Salt Creek, and Slate Creek.

Lower McCloud River Watershed

The lower McCloud River watershed, located in Shasta and Siskiyou counties, is approximately 67,073 acres and consists of lands drained by the McCloud River from the McCloud Dam outlet downstream approximately 23 river miles to the McCloud Bridge, where the river enters Shasta Lake. The Hawkins Creek, Claiborne Creek, Squaw Valley Creek, and Chatterdown Creek sub-watersheds are included in the lower McCloud River watershed.

Land Ownership

Overall, the Upper Sacramento and lower McCloud River watersheds primarily consists of Federal (primarily USFS) land and private lands managed for forest and recreational use. Much of the area is undeveloped except for sparse residential developments, several small municipalities, and the hydropower projects on the Sacramento and McCloud rivers. Table 1-1 provides an overview of the land ownership along the study streams, by number of parcels and percentage occurring in each land ownership class.

Table 1-1. Land Ownership along the Project Area Rivers, by Number of Parcels Occurring Within 100 Feet of River Centerline

	Upper Sacramento River Watershed		Lower McCloud River	
River Frontage Land Ownership	**Number of Parcels**	**Percentage of River Frontage**	**Number of Parcels**	**Percentage of River Frontage**
Federal	31	6	27	37
State	37	7	---	---
County	9	2	---	---
City	29	5	---	---
Private	394	71	43	59
No Information Available	45	8	3	4

Source: Shasta and Siskiyou County Assessor Parcel Number Database. Accessed: November 24, 2014.
Note:
Due to rounding, the columns may not equal 100 percent.

Upper Sacramento River Watershed

Private landowners comprise the majority of river adjacent property owners along the Upper Sacramento River. Private land uses in the watershed include timber harvest, residential, agricultural, industrial, and commercial development. A portion of land in the watershed is federally-owned forest land managed by the Shasta-Trinity National Forest (STNF). The Bureau of Land Management (BLM) manages a small portion of the watershed near Shasta Lake west of Backbone Ridge. These federal lands consist of several sections located in a patchwork of private, STNF, and BLM ownership. The California State Parks agency manages Castle Crags State Park, which covers about 4,000 acres of the watershed (NSR 2010).

Lower McCloud River Watershed

The majority of the lower McCloud River watershed is characterized by a checkerboard land ownership pattern. Private landowners own most of the property adjacent to the lower McCloud River. Private ownership activities or designations include nature preserves, fishing clubs, a utility company, timber companies, and ranching (USFS 2011). Large blocks of National Forest land occur in the Hawkins Creek drainage and along the major ridge that forms the southwest border of the watershed. Timber management has occurred in the Hawkins Creek drainage and the upper slopes on the southeast side of the river. Most of the remainder of this portion of the watershed remains essentially roadless (USFS 2011).

Railroads and Roads

Upper Sacramento River Watershed

The Union Pacific Railroad (UPRR) traverses the entire length of Shasta and Siskiyou counties and is immediately adjacent to the Sacramento River throughout the Upper Sacramento River watershed. The railroad is a primary landowner of property immediately adjacent to the Sacramento River. UPRR allows stream access points along their right-of-way, by prior agreement.

The Interstate 5 alignment follows the Upper Sacramento River and lies immediately adjacent to the River throughout the watershed, after passing over Shasta Lake. Interstate 5 and the UPRR are major transportation corridors between the California Central Valley and Oregon, and the two corridors generally run immediately adjacent to each other, through the river canyon.

Lower McCloud River Watershed

The lower McCloud River watershed is somewhat remote, with a moderate level of human uses. However, there are many roads and trails, and its 61 miles of hiking trails includes a portion of the Pacific Crest Trail.

There are no railroad alignments in the lower McCloud watershed area. The transportation system in the lower McCloud watershed totals approximately 227 miles. Roads are mostly related to past timber harvest activities, and tend to be concentrated east of the McCloud River. Most of the area west of the river is roadless, with only occasional logging roads and jeep trails (USFS 2011).

Geology and Topography

Upper Sacramento River Watershed

The Upper Sacramento River watershed is located within the Klamath Mountains and Cascade Geomorphic Provinces which were formed by fluvial and glacial action over the past 1 million years. Alluvial, glacial, and mass wasting deposits are all exposed in the area. Glacial deposits are localized and concentrated in the areas surrounding Mount Shasta and the higher elevation areas along the western portion of the basin (NSR 2010).

Within the entire Upper Sacramento River watershed, topography and elevation are highly variable, with elevations ranging from 1,075 feet near the confluence with Dog Creek to 14,162 feet at the summit of Mount Shasta. Approximately 50 percent of the watershed is located above 3,000 feet, and approximately 16 percent is above 6,000 feet. Volcanic deposits in the northeastern portion of the watershed contribute to the topographic diversity. Mount Shasta is the largest stratovolcano of the Cascade chain. There are seven named glaciers on Mount Shasta; however, none of them drain into the Upper Sacramento River (NSR 2010).

Lower McCloud River Watershed

The lower McCloud River watershed lies within the Eastern Klamath belt. The lower watershed has less permeable surface area than the watershed above McCloud Dam, and receives more precipitation in the form of rain, thereby generating more runoff with a rapid hydrologic response. The McCloud Reservoir is located in the transition of these two distinct geologies. The springs upstream of McCloud Reservoir provide a consistent source of cold water to the river downstream of McCloud Dam.

The river flows at elevations of approximately 2,500 to 1,500 feet above sea level, with the major ridges surrounding the watershed at roughly 4,500 to 5,000 feet. The highest elevation is at Grizzly Peak (elevation 6,220 feet) (USFS 2011).

Soils and Erosion Processes

Upper Sacramento River Watershed

Approximately 25 percent of the soils in the Upper Sacramento River watershed are classified as highly to very highly erodible (NSR 2010).

Debris flow and mass wasting potential increases as one moves downstream in the watershed due, in part by patterns in precipitation, rock types (harder in the upper and weaker in the mid to lower watershed). Erosion processes in this watershed have been altered by fires, timber harvest, and road construction. However, past studies have shown that since 1998, during baseflow conditions, the Upper Sacramento River has met water quality conditions for turbidity (NSR 2010).

Lower McCloud River Watershed

Soils in the watershed are shallow and stony and have slow rates of natural erosion. Given the steep slopes and high rates of precipitation, some degree of natural surface soil erosion is normal in this watershed.

Based on information provided by the USFS (2011), under extreme precipitation, or within the steeper inner gorge area, the lower McCloud River watershed has a moderate to high potential for mass wasting events. Erosion processes have been altered by fires, timber harvest, and road construction. For the most part, however, mass movement events are relatively rare. Most road related impacts occur south and east of the McCloud River where road densities are highest (USFS 2011).

Turbidity in the McCloud River occasionally increases due to increases in debris activity in Mud Creek which then travels through the McCloud Reservoir and Dam, into the lower river. The most recent debris flow occurred on September 20, 2014, and was most likely caused by rupture of a glacier dam, facilitated by extended warm temperatures and recent lack of precipitation. Subsequent rain events may remobilize sediment and debris in the Mud Creek channel.

Hydrology

Upper Sacramento River Watershed

Precipitation occurs as rainfall and snowfall in the watershed; annual rainfall ranges from 50 inches annually in the headwater areas to 70 inches in the lower watershed. A majority of the sub-basin’s annual precipitation falls between December and March (NSR 2010).

The Upper Sacramento River has several perennial tributaries, with baseflow also affected by runoff, most of which is attributed to groundwater discharge. Operation of Box Canyon Dam has not measurably changed the baseflow discharge of the river (NSR 2010).

River temperatures below Box Canyon Dam generally increase from mid-January through mid-October. Despite cold, spring inflows that occur in the Mossbrae Reach (river mile (RM) 30 to 34), water temperatures can warm and exceed the optimal spawning and incubation range for a cold water fishery by the time the river reaches Soda Creek (RM 24). In wetter water years with larger snowpack, when snow melt extends the period of runoff later into the summer, the length of river with suitable spawning temperatures may be longer.

Lower McCloud River Watershed

The lower McCloud River watershed is characterized by the highest rainfall in the STNF. Mean annual precipitation exceeds 70 inches, and approximately 90 percent of annual precipitation occurs from October through April (USFS 2011).

Flows in the lower McCloud River are controlled by releases from McCloud Reservoir, which includes the McCloud-Pit Hydroelectric Project, which diverts water through a tunnel complex into the Pit River drainage at Iron Canyon Reservoir. Dry season flows immediately below McCloud Dam are approximately

200 cfs, while pre-dam where approximately 1,000 cfs higher (USFS 2011). However, the regulation at McCloud Reservoir does not significantly influence peak flow events in the watershed, because tributaries immediately below McCloud Dam supply over three times more runoff during peak flows to the McCloud River than is supplied by the entire upper McCloud River (USFS 2011). During high-precipitation years, McCloud Reservoir usually spills for several weeks in the spring, contributing to higher flows in the lower river (USFS 2011).

River temperatures below McCloud Dam generally increase in spring and summer. For the period from 2003 through 2012, monthly average temperatures measured at the gage above Shasta Lake (U.S. Geological Survey Gage No. 1136800) increased from a low of 41.6 degrees Fahrenheit (°F) in January to a high of 61.0°F in July (Reclamation 2014). However, the McCloud River is a spring-fed system which helps maintain water temperatures for a cold-water fishery. The consistent cold-water source could provide some resiliency to climate change to support winter-run Chinook salmon.

Vegetation

Upper Sacramento River Watershed

Vegetation in the Upper Sacramento River watershed is dominated by Sierran mixed conifer and montane hardwood vegetation communities. Dominant species within these communities are: Douglas-fir, ponderosa pine, sugar pine, incense cedar, and white fir, and occasionally knobcone pine. Hardwood trees are also present and may include canyon live oak, California black oak, mountain dogwood, and big-leaf maple (NSR 2010).

Lower McCloud River Watershed

Dominant vegetation in the lower McCloud River watershed consists of predominantly conifer stands intermixed with a small proportion of hardwoods. Species composition follows elevation and temperature gradients ranging from white fir forests at the highest, coldest areas in the northeast portion of the watershed to ponderosa pine/gray pine/chaparral in the lowest, hottest areas of the watershed (USFS 2011).

Hydroelectric Facilities, Diversions, and Hatcheries

Shasta Dam and Reservoir

Shasta Dam is owned and operated by Reclamation. The dam is 602 feet high and impounds Shasta Lake, with a maximum storage capacity of 4,552,000 acre-feet. Shasta Dam flow releases are scheduled on an annual basis to meet flood control requirements and scheduled agricultural deliveries as well as to help meet the needs of aquatic species listed under ESA and the California Endangered Species Act (CESA).

Upper Sacramento River Watershed

Box Canyon Dam and Lake Siskiyou Box Canyon Dam, completed in 1969, is owned by Siskiyou County. The dam is 209 feet high and impounds Lake Siskiyou, with a maximum storage capacity of 26,000 acre-feet. Recreation is a primary use of Lake Siskiyou and outflows are critical to the maintenance of lake levels and continuous flow in the Upper Sacramento River below the dam; therefore, lake levels are maintained at or near full pool year-around. Box Canyon Dam generates limited hydroelectric power under a Federal Energy Regulatory Commission (FERC) exemption (NSR 2010).

Mount Shasta Fish Hatchery The Mount Shasta Fish Hatchery (formerly the Sisson Hatchery) was established near the present-day City of Mt. Shasta in 1888 on a spring-fed tributary stream to the Sacramento River. The location of the hatchery was chosen for its water supply and proximity to the railroad line, which facilitated shipping the fish throughout the state. In 1950, the hatchery was modernized, the old ponds and several old buildings were removed, and at least 24 new ponds were created (Leitritz 1970). Historically, the hatchery propagated salmon and trout. The propagation of salmon ended several decades ago due to disease transmission concerns. Currently, the hatchery propagates trout and is the broodstock hatchery for CDFW’s statewide hatchery program. Species currently raised at the hatchery include Redband Trout, Eagle Lake Trout, Brown Trout, Brook Trout, and Rainbow Trout (USFWS 2015).

Lower McCloud River Watershed

McCloud Dam and Reservoir McCloud Dam, completed in 1965, is owned and operated by Pacific Gas & Electric Company (PG&E) as part of the McCloud-Pit Hydropower Project (FERC Project No. 2106). The dam is 235 feet high, 630 feet long at its crest, and impounds a maximum capacity of 35,200 acre-feet (FERC 2011). FERC Project No. 2106 diverts water at McCloud Reservoir, through a tunnel complex into the Pit River drainage at Iron Canyon Reservoir to generate hydroelectric power. Collectively, FERC Project No. 2106 includes five dams, four reservoirs, an afterbay, two tunnels, and three powerhouses which generate up to 364 megawatts. McCloud Dam regulates releases from McCloud Reservoir into the McCloud River to protect State-recognized instream beneficial uses in accordance with the FERC Project No. 2106 license (FERC 2011).

Applicable Federal and State Laws

Federal and California Endangered Species Acts: Listing Status

The ESA, authorizes the Secretaries of Commerce and Interior to list species as threatened and endangered, and to provide for their conservation through critical habitat designation, protective regulations, recovery plans, Federal agency consultation, and permitting. As an agency within the Department of Commerce, NMFS implements the agency’s responsibilities under the ESA for marine and anadromous species. Conservation management of listed species occurs at many levels, including Federal oversight of marine and anadromous species by NMFS, as well as state, local, and Native American tribal level development and implementation of on-the-ground measures to further conservation objectives.

NMFS is the Federal agency responsible for administering the ESA for most anadromous salmonid species and Green Sturgeon. While the Pilot Program is focused on Sacramento River winter-run Chinook Salmon, the NMFS BO also addresses Central Valley spring-run Chinook Salmon, California Central Valley steelhead and the Southern DPS of the North American Green Sturgeon. CDFW administers CESA for all State listed fish including Sacramento River winter-run and Central Valley spring-run Chinook Salmon.

Table 1-2 summarizes the Federal and State listing status of key riverine species.

Table 1-2. Fish Identified in the 2009 National Marine Fisheries Service Biological Opinion

Common Name	Scientific Name	Listing Status
Central Valley spring-run Chinook Salmon	*Oncorhynchus tshawytscha*	FT, ST
Sacramento River winter-run Chinook Salmon	*Oncorhynchus tshawytscha*	FE, SE
California Central Valley steelhead	*Oncorhynchus mykiss*	FT
Southern DPS of the North American Green Sturgeon	*Acipenser medirostris*	FT

Source: NMFS 2009
Key:
DPS = Distinct Population Segment
E = Endangered
F = Federally-listed
S = State-listed
T = Threatened

Section 10 of the Federal Endangered Species Act

Take, under the ESA, is defined as harass, harm, pursue, wound, kill, trap, capture, or collect. While the Pilot Program is intended to enhance the propagation or survival of an ESA listed species, it includes activities that will likely result in take as defined by the ESA. Section 10, entitled "Exceptions," offers an avenue to authorize activities such as those included in the Pilot Program that would otherwise be prohibited by the ESA.

Section 10 is designed to regulate a wide range of activities affecting fish designated as endangered or threatened, and the habitats upon which they depend. With some exceptions, the ESA prohibits activities affecting these protected species and their habitats unless authorized by a permit from NMFS. Permitted activities are designed to be consistent with the conservation of the species. For endangered species, permits may be issued for scientific research, enhancement of propagation or survival, and taking that is incidental to an otherwise lawful activity." There are two types of permits issued for take under Section 10: Permits for scientific research or to enhance the propagation and survival of the species (Section 10(a)(1)(A)), and permits when there is no federal nexus for taking species incidental to (not the purpose of) an otherwise lawful activity (Section 10(a)(1)(B)). A Section 10(a)(1)(A) permit is required for research efforts in the Pilot Program, such as abundance surveys, genetic research, hatchery operations, relocations, capture and marking, and telemetric monitoring.

In 1982, Congress made significant changes to the ESA with addition of Section 10(j), which provides for the designation of specific reintroduced populations of listed species as experimental populations established outside the species' current range. Section 10(j) provides greater flexibility in reintroducing listed species into unoccupied habitat, by allowing for the creation of listed experimental populations for which management restrictions can be relaxed. Conversely, a listed species that is relocated outside of its listed range without experimental population status receives full protection under the ESA. However, NMFS may choose to designate a population as experimental if it furthers the conservation of the species, and the experimental population is geographically separate from the rest of the listed species.

Congress intended Section 10(j) to assist the recovery of species through population reestablishment with the cooperation of State and local groups. This was to help alleviate political opposition to the reintroduction of listed species into areas outside their current range. Congress intended that regulations promulgated to designate experimental populations “should be viewed as an agreement among the Federal agencies, the State fish and wildlife agencies and any landowners involved.”

Section 10(j) experimental population designations, in particular non-essential experimental population designations, reduce ESA Section 7 requirements for Federal entities or federally funded and permitted activities. In mixed ownership situations, a non-essential experimental population designation would provide regulatory relief for Federal land managers, and the designation would also provide the option of promulgating a 4(d) rule to reduce the regulatory burden on private landowners engaged in otherwise legal activities. Through Section 4(d) of the ESA, a threatened designation allows NMFS greater discretion in devising management programs and special regulations for the threatened population.

Pursuant to ESA Section 10(j), NMFS is currently seeking an experimental population designation for Sacramento River winter-run Chinook Salmon and Central Valley spring-run Chinook Salmon in the habitat upstream of Shasta Dam. This designation will need to be in place before releasing fish from these runs upstream of Shasta Dam.

Federal Energy Regulatory Commission Licensing in the Action Area

FERC is currently in the relicensing process for FERC Project No. 2106 (described above), and issued its Final Environmental Impact Statement (EIS) in February 2011 (FERC 2011). The EIS evaluated increased minimum instream flows in the McCloud River of 175 cfs year round, augmented by additional flows of up to 175 cfs from February 15 through April 15, depending on the percentage of average runoff from DWR Bulletin 120 for McCloud River above Shasta Lake (FERC 2011). The current minimum release is 50 cfs between May and November and 40 cfs between December and April.

After negotiations with NMFS, FERC recognized that anadromous fish may potentially be reintroduced into the McCloud River basin, based on the RPA for fish passage. Currently, the State Water Resources Control Board is working on Clean Water Act Section 401 Water Quality Certification for FERC Project No. 2106 as part of the relicensing process (National Oceanic and Atmospheric Administration 2014).

Federal Land Management in the Study Area

Overall, land use within the Study Area is a mix of Federal (primarily USFS) and privately managed forest and recreational lands. Much of the area is sparsely developed except for small residential developments, several small municipalities, and the hydropower projects in the Study Area.

Federal land management in the lower McCloud River Watershed is guided by the STNF's Land and Resource Management Plan (LRMP). The LRMP seeks to integrate a mix of management activities that allow use and protection of forest resources, and includes information on how to manage the watershed to maintain water quality, fisheries, recreation, and timber production (USFS 1995). The LRMP was amended by the Northwest Forest Plan, which contains specific Standards and Guidelines aimed at maintaining and restoring aquatic habitat through the "Aquatic Conservation Strategy." The Pilot Plan will not conflict with the LRMP.

California Forest Practice Rules for Anadromous Salmonid Protection

The California Forest Practice Rules for Anadromous Salmonid Protection (ASP) regulations apply to watersheds where listed anadromous salmonids are "currently present or can be restored." Watersheds covered by the rules exclude watersheds above permanent dams, such as Shasta Dam.

In July 2015, NMFS submitted a letter to California's Board of Forestry and Fire Protection requesting a revision to the languages in the ASP to include a provision that specifically excludes listed populations of salmonids which are designated as experimental pursuant to Section 10(j) of the ESA, and for which a 4(d) rule has been promulgated for populations introduced into areas above permanent barriers. The Board of Forestry voted to accept the new language, and the new regulation will be in effect in January 2017.

State Sport Fishing Regulations

Recreational fishing provides an important economic boost to Siskiyou and Shasta counties, with angling opportunities in both the Upper Sacramento and McCloud rivers. California Code of Regulations, Title 14 "Natural Resources," Division 1 "Fish and Game Commission – Department of Fish and Game" provides the

Commission the authority to promulgate sport fishing regulations. Based on these regulations, CDFW releases yearly California Sport Fishing regulations and supplemental booklets, which detail unlawful actions, changes to freshwater fishing, report card and tagging requirements, and ocean salmon seasons.

The McCloud River between the McCloud Dam and the boundary of the USFS loop near RM 16 (approximately 13 miles of river) is designated as a CDFW Wild Trout water, and is open to recreational trout fishing between April and mid-November with special fishing regulations. The river between the upstream boundary of the McCloud River Club downstream to Shasta Lake is under general trout fishing regulations.

The Upper Sacramento River between Box Canyon Dam to Shasta Lake is open to year-round angling, and includes sections designated as CDFW Wild Trout water. There are variable bag limits and gear requirements between the last Saturday in April and November 15 (regular trout season). From November 15 to the last Saturday in April (winter season), the bag limit is zero and artificial lures with barbless hooks are required.

Chapter 2 Reintroduction Planning Considerations

When planning salmonid reintroductions, it is important to describe the benefits, risks, and constraints of the reintroduction. Anderson et al. (2014) defined benefits as specific biological improvements towards recovery objectives, risks as unintended or undesirable negative consequences for nontarget species or nontarget populations of the reintroduced species, and constraints as the factors limiting the ability of colonists to establish a self-sustaining population.

While the Pilot Program is an effort to evaluate the feasibility of reintroducing winter-run and spring-run Chinook Salmon above Shasta Lake, the benefits, risks, and constraints associated with a full-scale reintroduction of winter-run Chinook Salmon upstream from Shasta Dam are briefly described below.

Benefits of Reintroducing Winter-run and Spring-run Chinook Salmon Upstream from Shasta Dam

The specific biological benefits of reintroducing winter-run Chinook Salmon upstream from Shasta Dam can be described using the four parameters of salmon viability: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). Such a reintroduction, could increase the species' abundance regardless of whether the reintroduced fish were ultimately demographically independent from the population below Shasta Dam or integrated with it; either way, the abundance of winter-run and spring-run Chinook Salmon would be expected to increase given the increase in spawning and rearing habitat. The benefits of increasing their abundance include reducing extinction risk due to stochastic variability (Lande 1993), minimizing genetic processes that can reduce their fitness (Allendorf and Luikart 2007), minimizing the risk of depensatory density-dependent processes (Liermann and Hilborn 2001), and providing marine derived nutrients to the McCloud and/or Upper Sacramento watersheds (Gende et al. 2002, Anderson et al. 2014).

The spatial structure of winter-run and spring-run Chinook Salmon also would be expected to increase with a Reintroduction Program. Spatial structure is the geographic arrangement of fish across the landscape and connectivity of populations (Anderson et al. 2014). Currently, winter-run Chinook Salmon have an extremely limited spatial structure as demonstrated by having only one spawning location (i.e., the lower Sacramento River population). Providing additional spawning locations by reintroducing winter-run Chinook Salmon to higher elevation, spring-fed habitats upstream from Shasta Reservoir would reduce the ESU's vulnerability to droughts, climate change, and other catastrophic events.

The diversity of the winter-run and spring-run Chinook Salmon ESU would be expected to increase with a successful Reintroduction Program. Re-establishing these fish in their historical habitats should promote the ecological and evolutionary processes responsible for the local adaptation and diversity that allowed the species to persist for thousands of years (Anderson et al. 2014).

While winter-run and spring-run Chinook Salmon abundance, spatial structure, and diversity are anticipated to increase by re-establishing the species into historical habitat, the outcome for productivity is less certain. Reintroductions can have either positive or negative impacts on the productivity of a given population or ESU, depending on the quality of the new habitat and survival through migration and ocean rearing. In general, a reintroduction resulting in a "sink" has far less value for long-term viability than a reintroduction yielding a population with a cohort replacement rate of one or greater. The pilot studies of survival described in this Pilot Plan will help reduce the uncertainty as to whether the reintroduction will result in a "source" or "sink" to the species (Anderson et al. 2014). "Source" populations are net producers of individuals. In "sink" populations, death rates exceed birth rates and immigration exceeds emigration. Sink populations, by definition, cannot persist without immigration.

Risks of Reintroducing Sacramento River Winter-run and Spring-run Chinook Salmon Upstream from Shasta Dam

Anderson et al. (2014) defined reintroduction risks as unintended or undesirable consequences for nontarget species, nontarget populations, spawning areas, or life history types of the reintroduced species. When considering reintroduction risks it is helpful to split the topic into four categories:

- evolutionary
- demographic
- ecological
- disease

Evolutionary Risk

Under evolutionary risk, salmon reintroductions have the potential to cause genetic homogenization, and/or reduced fitness (Anderson et al. 2014). If salmon originating from the reintroduction site return to adjacent populations as adults, the genetic distinctness among the adjacent populations may be altered. For the winter-run Chinook Salmon ESU, the lower Sacramento River population is currently the only adjacent population to consider when assessing the evolutionary risk of the reintroduction upstream from Shasta Dam. If the reintroduction site was managed to be completely reproductively isolated from the lower Sacramento River population, a genetic bottleneck would likely occur. This would potentially lower the genetic diversity of the population in the Sacramento River below Keswick Dam (henceforth referred to as the lower Sacramento River) when genetically homogenized winter-run from the reintroduction area spawned with winter-run in the lower Sacramento River. In order to both minimize the evolutionary risk to the lower Sacramento River population and maximize the genetic diversity of winter-run reintroduced upstream from Shasta Dam, fish in the two areas will be intentionally reproductively mixed and managed as one integrated population. Reintroductions into Battle Creek would also be integrated into the winter-run Chinook Salmon population. The Shasta and Battle Creek reintroductions will be managed to maintain a viable source population. Initially this is being accomplished with a captive broodstock providing the fish source.

Reintroduced winter-run and spring-run Chinook Salmon will be managed to promote effective migration among spawning areas to maximize genetic diversity and avoid genetic bottlenecks. In the SDFPE reintroduction, transplanting wild or hatchery fish collected from the river and hatchery releases are the two release options and both provide the opportunity to control the number, origin, and life stage, of fish that are allowed to “migrate” to the reintroduction site. Managing the reintroduction site as a sub-population that is integrated with the lower Sacramento River population will allow for local adaptation from the reintroduction site to increase the diversity and fitness of the ESU. As such, the reintroduction has much more potential to provide an evolutionary benefit, rather than a risk.

If successful, the reintroduction would extend the amount and extent of available habitat for winter-run and spring-run Chinook Salmon and thereby contribute to recovery of the ESU by increasing abundance and spatial distribution. .

Demographic Risk

The main demographic risk associated with a reintroduction is the potential for reducing source population viability by removing individuals to support the reintroduction. This is a particularly important risk to consider for winter-run Chinook Salmon because it is comprised of one small population. Taking individuals from the existing population to reintroduce winter-run Chinook Salmon elsewhere could be risky unless it is clear the population has a demographic excess (i.e., it is a true “source” in metapopulation source-sink dynamics) that can sustain removal for multiple successive years (Anderson et al. 2014).

A February 4, 2015 NMFS letter to US Fish and Wildlife Service (USFWS) stated that drought-related impacts and low adult spawner predictions raised questions on the availability of winter-run stock for future reintroductions. In order to protect the population, NMFS recommended USFWS re-establish the winter-run Chinook Salmon Captive Broodstock Program at Livingston Stone National Fish Hatchery (NFH) to create a source population of winter-run Chinook salmon for the pilot study. In the early stages of a reintroduction, there is a risk to the source population associated with taking fish and reintroducing them into habitat above dams. To minimize this risk, the Pilot Program will use fish from the captive broodstock program at Livingston Stone NFH.

While there is a risk of reintroducing fish into new habitat, the reintroduction area, or Study Area, supported winter-run and spring-run Chinook Salmon before construction of the Shasta Dam. A habitat assessment conducted as part of the Pilot Program indicated that there is adequate suitable habitat for all life stages of a small subpopulation in both the Sacramento and McCloud rivers (Reclamation 2014). If the Pilot Program can demonstrate that the reintroduction can produce a statistically significant number of returning adults, then the risk to the ESU will be reduced.

If the Pilot Program is successful, reintroducing winter-run and spring-run Chinook Salmon to the Study Area allows for a greater ratio of production (on a per-adult basis) due to expanded habitat. If successful, the SDFPE would increase the overall numbers of adult fish, thus producing an increased number of additional progeny relative to the extant winter-run and spring-run Chinook Salmon below the dams. The preliminary or pilot phase of the reintroduction is the phase with the highest risk because there are unknowns (e.g., distribution in the Study Area and migration timing). To mitigate the risk associated with the early phases of the reintroduction, the Pilot Program will take a prudent approach to obtaining fish for the reintroduction including taking a small number of eggs or juveniles per cross up to the total number desired, hold them separately, and minimize impacts on any one individual's fitness and survival. This approach would obtain as much diversity as possible from the donor stock and minimize risk to any one individual.

Ecological Risk

Ecological risks from reintroductions are described by Anderson et al. (2014) as, "(i)nvasion by nonnative species and suppression of preexisting native species within the reintroduction site." The risk of nonnative species invasions is more of a concern following barrier removal than with translocation reintroductions, where the species being transferred can be selected. It is likely reintroduction will pose small risk to the native fish fauna in the tributaries above Shasta Dam because Chinook Salmon were once native to the area and other fishes co-evolved with them. Additionally, according to Pearsons and Temple (2007) and Buehrens (2011), the few empirical assessments of reintroduction impacts have found little effect on preexisting native species.

Disease Risk

Reintroductions have the potential to spread harmful pathogens between the reintroduced species and other species. Before implementing the Pilot Program, a

Fish Health Study will be initiated that includes establishing a baseline of pathogen densities within the area allow for better disease monitoring and screening captively reared or transplanted fish before release that will minimize the risk of spreading disease (Anderson et al. 2014).

Constraints Associated with Reintroducing Winter-run and Spring-run Chinook Salmon Upstream from Shasta Dam

A reintroduction constraint is a factor limiting the ability of colonists to establish a population that is sustained by natural production. Anderson et al. (2014) divided reintroduction constraints into five main categories:

- **Barriers –** The presence of Keswick and Shasta dams blocking migration is the most obvious constraint to recolonizing a natural population upstream from the dams. Therefore, some means for recolonization is necessary. Active colonization options, which include transplantation and hatchery releases, can quickly place fish in the reintroduction site, but do not fully address altered biological processes and require ongoing human intervention. While hatchery releases can be used to initiate the reintroduction, a population that sustains itself through natural production will ultimately need to be established for the reintroduction to contribute to ESU recovery. As such, the long-term reintroduction will likely rely on translocation. Means of capturing adults from downstream of the dam and passing them above it, as well as then capturing juveniles from upstream from the dam and passing them below it are critical to countering the reintroduction constraint posed by the presence of Keswick and Shasta dams.

- **Habitat Quality –** Poor habitat quality and/or limited habitat quantity will restrict reproductive success of colonists and survival of their offspring. In some reintroduction programs, habitat restoration is needed before reintroducing fish to the area. This does not, however, appear to be necessary to reintroduce Chinook Salmon into either the McCloud or Upper Sacramento rivers. Reclamation (2014) completed detailed habitat assessments in both the McCloud and Upper Sacramento rivers and found that habitat conditions are suitable for all life stages of Chinook Salmon.

  As described in Chapter 3, the suitability of habitat in the Upper Sacramento and McCloud rivers to support winter-run Chinook Salmon has been evaluated. In general, suitable winter-run Chinook Salmon spawning and rearing habitat exists in both rivers. This is consistent with findings in the Recovery Plan, as both rivers were considered potential reintroduction areas. However, in the Recovery Plan, the McCloud River is prioritized as a primary reintroduction area for winter-run Chinook

Salmon whereas the Upper Sacramento River has a lower priority status, because McCloud River has greater availability of cold water to support winter-run Chinook Salmon spawning and embryo incubation during the summer. This prioritization is consistent with the habitat evaluation results provided in full detail in the Shasta Dam Fish Passage Evaluation Habitat Assessment Final Report (Reclamation 2014) and summarized in the Chapter 3. More cold water is available in the McCloud River than the Upper Sacramento River; this difference will likely be very important as climate change results in a warmer and drier climate.

- **Migratory and Ocean Survival –** Low survival along the migration corridor below Keswick Dam and during ocean residency may limit reintroduction success. Low survival of juvenile winter-run and spring-run Chinook Salmon moving through the lower Sacramento River and out to the ocean is likely to be a constraint that requires action to address. Winter-run Chinook Salmon smolt survival from the Sacramento River near Red Bluff through to the Sacramento-San Joaquin Delta at Chipps Island is estimated to range from two to seven percent (NMFS 2015). As a result, significant attention is being placed on studying and increasing Chinook Salmon smolt survival through the Sacramento River and Delta. An acoustic tagging study to better understand the movement and survival of winter-run Chinook Salmon smolts was initiated in 2013. This study should help direct restoration actions aimed at improving smolt survival.

- **Harvest –** Harvest of adult Chinook Salmon in the ocean and in freshwater reduces the number of potential colonists, thus potentially limiting the chances for a successful reintroduction. However, the ocean salmon fishery is targeted on fall-run Chinook Salmon and is managed to minimize winter-run and spring-run Chinook Salmon bycatch. Additionally, State fishing regulations prohibit the harvest of winter-run and spring-run Chinook Salmon in freshwater through timing of open seasons.

- **Interactions with Other Species and Populations –** Interactions with existing/resident species in the target area could influence the likelihood of a successful reintroduction. Shasta Reservoir is home to populations of non-native fish such as spotted bass, largemouth bass, smallmouth bass, and brown trout, all of which may present predation and competition challenges for juvenile Chinook Salmon. Competition and predation from trout in the Upper Sacramento and McCloud rivers also may constrain Chinook Salmon colonization. Ecological interactions between Chinook Salmon and the existing fish community will be studied as part of the Pilot Program.

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Chapter 3
Salmonid Habitat Above Shasta Dam

This chapter describes the natural setting, watershed characteristics, and aquatic habitat conditions in the area targeted for winter-run and spring-run Chinook Salmon reintroduction in the major tributaries to Shasta Lake, namely the Upper Sacramento River and the McCloud River. It also summarizes the results of the habitat assessment conducted in 2013 for the development of the Pilot Plan (Reclamation 2014b).

Watershed Characteristics

Upper Sacramento River

The Sacramento River originates on the eastern slopes of the Trinity Divide, at an elevation of 6,000 to 7,000 feet mean sea level (msl), where the inland Cascade Range meets the Klamath Mountains in Siskiyou County, California. The Upper Sacramento River portion of the Study Area consists of a 37 mile segment of river running from Box Canyon Dam, in Siskiyou County, to where it enters Shasta Lake, near Campbell Creek in Shasta County (Figure 1-1). The watershed boundaries are formed partly by the steep Klamath Mountains, which direct precipitation and stream channels down mountain faces into the Sacramento River for several miles before the river empties into Shasta Lake above Shasta Dam. Mount Shasta forms the northeastern watershed boundary, and Shasta Dam marks the southern boundary for the Pilot Program. Prominent landscape features of the Upper Sacramento River basin include Mount Shasta, Box Canyon Dam and its reservoir (Lake Siskiyou), Shasta Dam and Lake, Interstate 5, Union Pacific railroad, and the town of Dunsmuir.

The Sacramento River is the largest river system in California. The entire Sacramento River watershed, including all of the major tributaries, encompasses 27,210 square miles, with the Upper Sacramento River portion of the watershed, within the study area, accounting for approximately 600 square miles of this total (Rode and Zuspan 1994, NSR 2010). Watershed elevations range from a low of 1,100 feet msl at the river's confluence with Shasta Lake to over 9,000 feet msl on Mount Eddy in the Trinity Divide (STNF 2001). The average annual precipitation is 40 to 60 inches along the length of the Upper Sacramento River watershed. Approximately 80 percent of this precipitation occurs between October and May, mostly in the form of rain below 5,000 feet msl and in the form of snow above this elevation (STNF 2001).

Besides Shasta Dam, which blocked all runs of anadromous fish from accessing the Upper Sacramento River beginning in 1944, the only other fish migration barrier is Box Canyon Dam, located 37 miles upstream from Shasta Lake, which was built in 1968 by Siskiyou County primarily for recreation and fish and wildlife enhancement, with flood control only a minor function. In 1986, the dam was retrofitted with an in-line, run-of-river (non-peaking) FERC licensed hydropower plant (FERC Project No. 2796). The FERC license currently requires a minimum dam release of 40 cfs or the full natural inflow, whichever is greater, be released to the river channel below the dam. Additionally, water temperature and dissolved oxygen levels of dam discharges are to comply with Basin Plan water quality objectives (Rode and Zuspan 1994, NSR 2010). Annual flows along the Upper Sacramento River are generally about 5 times greater at the confluence with Shasta Lake than at the gaging station below Box Canyon Dam (Rode and Zuspan 1994, NSR 2010). The lowest recorded flow below Box Canyon Dam was 14 cfs in 1972, but summer flows average about 70 cfs at this location (Rode and Zuspan 1994). Near the confluence with Shasta Lake, the minimum recorded flow was 117 cfs in 1977, but summer average flow is about 235 cfs (Rode and Zuspan 1994, Reclamation 2014b).

The Upper Sacramento River flows through a steep-sided canyon below Box Canyon Dam, picking up numerous tributaries and springs downstream to Dunsmuir. The spring inflow adds cold, clear water to the river channel; Mossbrae Falls and Shasta Springs are two of the largest springs in this area. The valley terrain changes and river channel widens downstream of Dunsmuir as larger tributaries in this section contribute flow and sediment to the river channel; though still constrained by the bedrock controlled channel minor alluvial features are formed creating the change (Rode and Zuspan 1994, NSR 2010). Vegetation is dominated by mixed conifer-Douglas Fir-hardwood forest on the mountain slopes and montane riparian vegetation along the river channel and narrow adjacent terraces in the upper half of the watershed and transitions to a mixed hardwood-gray pine-chaparral as the river nears Shasta Lake (Rode and Zuspan 1994, NSR 2010).

McCloud River

The McCloud River, located in southern Siskiyou and northern Shasta counties of California, is a major spring-fed tributary to Shasta Lake and the Sacramento River that drains a watershed area of approximately 800 square miles (STNF 1998). From its origins in Colby Meadow at an elevation of approximately 5,500 feet above msl, in the moderately steep volcanic terrain forming the southeast flank of Mount Shasta, it flows about 50 miles in a southwesterly direction before entering Shasta Lake, where its historical confluence with the Pit and Sacramento rivers is inundated by the reservoir (Figure 1-1). Mean annual precipitation in the McCloud River Basin exceeds 70 inches throughout the watershed; about 80 percent is in the form of rain and 20 percent in the form of snow, except at the highest elevations in the uppermost part of the watershed, where snow on Mount Shasta predominates (Blodgett et al. 1985; Western Regional Climate Center 2011).

The McCloud River has a baseflow of about 40 cfs, where it flows from the southeast flank of Mount Shasta onto a volcanic plateau (known locally as McCloud Flats) until just downstream from Lower McCloud Falls, where two large springs (Little Muir and Big springs) increase flows, transforming the river into a large, very clear and cold river, with summer temperatures rarely exceeding 46°F (7.8 degrees Celsius (°C)) (Rode and Dean 2004). Summer baseflow of the river downstream from these springs is about 800 cfs (Rode and Dean 2004). Lower McCloud Falls, about 35 miles upstream from Shasta Lake, was historically the upstream limit to migration of anadromous fish (Hanson, et al. 1940) before construction of Shasta Dam. McCloud Reservoir, located about 5 miles downstream from Big Springs and about 23 miles upstream from Shasta Lake, was formed by construction of McCloud Dam in 1968 and is the current fish migration barrier on the McCloud River above Shasta Lake.

McCloud Dam and Reservoir is part of PG&E's McCloud-Pit Project (FERC Project No. 2106), which diverts about 70 percent of the inflow at McCloud Reservoir to the Pit River for hydroelectric generation. The current minimum flow releases from McCloud Dam range from 40 cfs (December-April) to 50 cfs (May through November); the minimum flow requirement at Ah-Di-Na Campground gage (3.5 miles downstream from McCloud Dam) ranges from 160 to 200, depending on season and water year type (PG&E 2006). The minimum dam release and flow schedules for the McCloud-Pit Project may change subject to the pending final issuance of the new FERC license. The diversion of water at McCloud Reservoir, however, does not significantly influence the larger peak flow events in the watershed. Tributaries immediately below McCloud Dam, including Hawkins, Claiborne, Chatterdown, and Squaw Valley creeks, supply over three times more runoff to the McCloud River than is supplied by the entire upper McCloud River basin (STNF 1998), although the largest cold spring water inflows occur upstream from McCloud Reservoir.

The physiographic conditions and land use patterns in the McCloud River basin transition from the upper to lower reaches as follows (from STNF 1998):

- The Upper McCloud River (to McCloud Dam)
  - Terrain is generally flat to gentle slopes and includes the McCloud Flats.
  - Vegetation consists of mixed-conifer and ponderosa pine forest.
  - Land use is predominantly timber management and grazing with recreation use concentrated along the river.
  - McCloud Dam, an earth-and-rock fill dam, impounds McCloud Reservoir (5 miles long, 14 miles of shoreline, 520 maximum surface acres, normal minimum-maximum surface elevation range from 2,635 to 2,680 feet msl).

- The McCloud River (McCloud Dam to Shasta Lake)
  - Terrain consists of a deep canyon through which the river flows.
  - Vegetation is predominantly mixed-conifer and Douglas-fir forest. A large area west of the McCloud River is dominated by hardwoods and chaparral vegetation.
  - Timber management has occurred in the Hawkins Creek drainage and the upper slopes on the southeast side of the river. Most of the remainder of this portion of the river basin remains essentially unroaded.
- The McCloud Arm of Shasta Lake
  - Terrain consists of a deep canyon through which the river flows. However, this section of the river has been inundated by Shasta Lake.
  - Vegetation is predominantly gray pine, knobcone pine, and chaparral.
  - High density recreation use occurs on the lake and its shoreline. Much of the remaining area is rugged, inaccessible, and essentially unroaded.

The water quality of the McCloud River is rated as excellent (STNF 1998, Domagalski, et al. 2000). Turbidity and water temperature are two important factors that affect fish distributions in both lakes and rivers. Elevated turbidity in the McCloud River is generally restricted to the winter and spring during periods of intense rainfall and flood flows. Occasionally, extreme drawdowns of McCloud Reservoir cause sediments to be entrained in discharges to the lower river (Rode 1and Dean 2004, STNF 1998). Additionally, there are extended periods of elevated turbidity caused by glacial melt runoff containing high levels of fine volcanic silt from the Konwakiton Glacier on Mount Shasta. This volcanic silt drains down Mud Creek and into the McCloud River above McCloud Reservoir, occasionally affecting the entire length of the river, as occurred during the summer of 2014 and 2015.

Water temperatures in the McCloud River near Shasta Lake range from the mid-30s to the upper 60s (°F) (NSR 2003, Reclamation 2014b). Maximum temperatures are attained during the mid- to late summer. Water temperatures for a recent representative period (between 2003 and 2012) were recorded and compared in the SDFPE Habitat Assessment Technical Report (Reclamation 2014b).

Potential Resilience to Climate Change

The Recovery Plan recognized that climate change may potentially affect salmon throughout their life cycle and will likely pose stresses additional to the original factors implicated in the listings of Central Valley anadromous salmonids (NMFS

2014a). Changes in precipitation patterns and warmer temperature are projected to occur throughout various regions of the western United States under climate change scenarios, particularly the southwestern United States (Mai et al. 2012). Changes in hydrologic patterns and water temperatures are projected to have profound effects on aquatic habitat throughout most of the Central Valley tributary watersheds (NMFS 2014a). These include earlier peak flows that can flush young salmon from rivers to estuaries before they are physically mature enough for the transition, increasing a variety of stresses including the risk of being eaten by predators. Earlier snowmelt would leave rivers and streams warmer and shallower during the summer and fall (Thomas et al. 2009). Increasing air temperatures, particularly during the summer, lead to rising water temperatures, which increases stress on coldwater fish such as salmon and steelhead. Projected temperatures for the 2020s and 2040s under a higher emissions scenario suggest that the habitat quality and quantity for these fish is likely to decrease dramatically (Mote et al. 2008, Keleher et al. 1996, McCullough et al. 2001, NMFS 2014a).

The Recovery Plan described two important characteristics of “habitat resiliency” and “refugia” relative to salmon recovery and conservation that applies to the Study Area streams selected for reintroduction efforts, as follows:

> *In regard to recovery, habitat restoration, and conservation of at-risk aquatic species, resiliency also requires that certain key habitat characteristics or processes will change little, or not at all, in response to climate change.*
>
> *When it comes to stream aquatic habitat, the most important elements to remain steady are temperature and disturbance regime (Bakke 2009). Resiliency can only function on a landscape scale; there must be enough individual rivers available with the appropriate habitat and connectivity so that a disturbance to one portion of the system has a minimal impact on at-risk aquatic species because other parts of the system are able to support sensitive populations through the recovery and recolonization period (Bakke 2009).*
>
> *But in the context of climate change, refugia can also be places where a population may persist through decades and centuries of unfavorable climate conditions and instability. For coldwater obligate fish species, refugia will continue to be areas where groundwater emergence influences water temperature and volume. These refugia will exist on multiple scales: (1) local areas of cold water emergence within a reach otherwise insufficiently cold; (2) lower sections of rivers downstream of reservoirs with large amounts of coldwater storage; and (3) entire stream systems where groundwater hydrology is dominant or snowmelt hydrology is preserved due to high elevations. Thus, the same set of*

> *circumstances producing cold water conditions in the current landscape may, to varying degrees, produce thermal refugia against global warming.*

The Upper Sacramento River and McCloud River watersheds were recently evaluated for their vulnerability to climate change scenarios by the Shasta-Trinity National Forest (Mai et al. 2012). While precipitation patterns have exhibited, and may continue to be, more variable within areas of the forest, the southern Cascade province, which encompasses much of the two Study Area river watersheds, has varied the least. Stream flows and high water quality, including cool temperatures, are supported by a large number of spring inflows and the vast volcanic aquifer surrounding the perimeter of Mount Shasta. Similarly, average temperatures have exhibited less increase within the Study Area watersheds compared to other forest watersheds in California. Perhaps reflecting this condition, several glaciers on Mount Shasta have continued to grow, in contrast to many other areas in the world, where glacial recession has increased at an alarming rate. Based on Mai's et al. (2012) assessment the McCloud River watershed was determined to be more resistant and resilient to the warming and drying effects of climate on aquatic resources than the Upper Sacramento River watershed, partially due to differences in geographic aspect and levels of watershed development.

Habitat Inventory

In 2013, a habitat assessment was conducted as part of the development of the Pilot Plan (Reclamation 2014b). The purpose of this study was to quantify the quantity and quality of habitat, and the habitat capacity of adult spawners. This information is important for establishing the basis for selecting release and collection locations for adults and juveniles, spawning sites, and determining the potential to support a viable population of reintroduced Chinook Salmon. Three habitat attributes were scored in the habitat assessment. These attributes include channel morphometry, substrate, and habitat-specific features.

Upper Sacramento River

Overall spawning life stage habitat condition in the Upper Sacramento River computed from habitat inventories indicated that spawning habitat condition in all study reaches throughout the Upper Sacramento River scored from fair-to-good. Substrate attribute scores were the highest of the three spawning habitat attributes. The lowest spawning habitat component scores were for structural habitat metrics (e.g., proportion of pool habitat, maximum pool depth, and spawning substrate area), suggesting that one of the limiting factors of overall salmon spawning habitat condition in the Upper Sacramento River may be the frequency of large-deep pools and the amount of suitable-sized spawning gravel, especially in the river reach upstream from Dunsmuir. However, pool depths and spawning gravel areas may be more limiting under the low, baseflow conditions occurring in the late-summer and fall, when spring-run Chinook Salmon spawn. This would not be the case during the higher flows of spring and early summer, when winter-run

Chinook Salmon spawning peaks, although the later spawning fraction of the winter-run Chinook Salmon would be affected since they spawn as late as August (Vogel and Marine 1991, Moyle 2002).

The quality of physical spawning habitat attributes generally improved progressing downstream. While the component attribute scores comprising the overall spawning habitat condition varied somewhat in the lower reaches of the river, the overall scores indicate that suitable physical spawning habitat for anadromous salmonids occurs throughout the Upper Sacramento River when suitable water temperature conditions occur. However, the long-term thermograph record for the U.S. Geological Survey Delta gage indicates that optimal water temperature conditions for winter-run Chinook Salmon egg incubation [less than or equal to 56.0°F (13.5°C) daily average; USFWS (1999)] are exceeded in most years from June through August, which coincides with much of the winter-run Chinook Salmon egg incubation season. Furthermore, based on the only available longitudinal thermograph record, WY 2012, a below normal water year, winter-run Chinook Salmon spawning habitat within the optimal thermal range is limited in the entire river downstream from about Soda Creek to Shasta Lake. Despite large, cold, spring inflows that occur in the Mossbrae Reach (RM 30 to RM 34), water temperatures often exceed the optimal range for spawning and incubation by the time the river passes downstream from Soda Creek (RM 24). In wetter water years with larger snowpack and when snow melt extends the period of runoff later into the summer, the length of river with suitable spawning temperatures may be extended by an, as yet to be determined, distance.

Similar to the pattern in Chinook Salmon spawning habitat suitability, rearing habitat suitability tends to progressively improve, particularly downstream from Dunsmuir to Shasta Lake. Habitat attribute scores for juvenile salmon rearing conditions were fair in the Upper Sacramento River. Cover attribute scores were typically less than 2, indicating a relatively poor-to-fair cover condition. Generally, the limiting Chinook Salmon rearing habitat attributes were lack of the diversity and quality cover. The literature-based rearing cover criteria used for the habitat assessment are highly dependent on amounts and diversity of large woody debris (LWD) for pool-formation and physical cover. LWD may not be as important in the large river tributaries to Shasta Lake, where bedrock controls are more important than LWD for pool formation and abundant boulders and bedrock ledges and undercuts provide similar cover functions. Rearing habitat substrate metrics and the condition of Chinook Salmon rearing habitat increased longitudinally downstream along the length of the river. The overall rearing habitat condition score indicates the Upper Sacramento River provides fair rearing habitat conditions for Chinook Salmon from at least Dunsmuir downstream to Shasta Lake, including mostly suitable thermal conditions for a majority of the river’s length.

Based on the longitudinal thermographic record for 2012, monthly maximum weekly average water temperatures (MMWAT), which is the maximum 7-day moving average of daily average water temperatures over the course of a given month, did not exceed 66°F (19°C) along most of the river, except at the Delta gage, where the July and August MMWATs were 68.8°F to 69.2°F (20.4°C to 2.0.6°C). Optimal growth conditions for juvenile Chinook Salmon can occur up to about 66°F to 68°F (19°C to 20°C), but chronic exceedances of about 63°F (17°C), especially during the smolt life stage can result in sub-lethal effects on certain physiological processes and ecological interactions, such as vulnerability to predation (McCullough 1999, Sullivan et al. 2000, Marine and Cech 2004).

McCloud River

Overall spawning life stage habitat condition scores in the upper and middle study reaches of the McCloud River (as defined in Reclamation 2014b) were fair-to-good. Field-derived scores indicated similar spawning habitat conditions among the two study reaches. Similar to the Upper Sacramento River, the physical habitat attribute component scores were most important in the overall spawning habitat condition ratings. Low spawning habitat condition scores were mostly a function of the relatively limited frequency of deep pools for adult holding and distribution of spawning areas in many isolated patches. These conditions may, however, be of less importance for winter-run Chinook Salmon than for spring-run Chinook Salmon, which are more reliant on deep pools for over-summering. Collectively, substrate attribute scores were in the upper fair-to-good range for the upper and middle study reaches. Spawning habitat condition scores indicate fair-to-good physical spawning habitat occurs for Chinook Salmon throughout the McCloud River between Shasta Lake and McCloud Dam under suitable water temperature conditions. However, the available long-term temperature records and PG&E's (2009a) recent water temperature modeling information suggest that suitable thermal conditions (i.e., less than or equal to 56°F (13.3°C) daily average temperature) for the entire duration of winter-run Chinook Salmon egg incubation season (late-April through September), under most water types, occurs upstream from about RM 12, between Squaw Valley and Claiborne creeks, to McCloud Dam, a total distance of about 11.6 miles.

Chinook Salmon rearing life stage habitat condition scores were fair-to-good, with little spatial variation in the upper and middle study reaches. Cover attribute scores were the lowest rated component, which influenced the overall rearing habitat condition scores for each study reach. As for the Upper Sacramento River, the cover attribute scores are highly dependent on the amounts of LWD for pool formation and physical cover, which is limited in the McCloud River and may not be as important in the large river tributaries because of the bedrock-controlled channel and pool forming structures. Substrate and habitat attribute scores were fair-to-good. Channel morphometry attribute scores for rearing habitat condition increased with distance downstream from McCloud Dam, a function of increasing frequencies of flatwater habitats (e.g., runs, glides, and pools) preferred by juvenile Chinook Salmon. Physical rearing habitat conditions, including water temperatures through the summer months, are fair-to-good for Chinook Salmon in the McCloud River from McCloud Dam downstream through the middle study reach to at least Squaw Valley Creek.

Spawning Capacity

Upper Sacramento River

The spatial distribution of estimated spawning habitat area and Chinook Salmon spawning capacity (number of females) in the Upper Sacramento River were lowest in the Box Canyon and Mossbrae study reaches and highest in the Canyon study reach (Reclamation 2014b). Nearly 80 percent of the estimated Chinook Salmon spawning habitat in the Upper Sacramento River occurred between North Salt Creek and Dunsmuir, with nearly half of this suitable habitat occurring in the nine mile long section of the Canyon Reach. Potential Chinook Salmon spawning capacity estimates using the representative field survey reach expansion were about 50 percent higher than for those computed using the aerial video-derived habitat inventory, which reflects the lower frequency of riffle habitat, and, consequently, less total spawning riffle area using the latter method. On average, spawner capacity was 16 percent greater at the ordinary high water mark[1] stage than at the baseflow stage. Because the spawning area required by a pair of Chinook Salmon, as reported in the literature, can range substantially, depending on the size of defended territories and other physical and ecological factors, a range of 10 to 20 square meters per redd[2] was used to estimate the potential spawner capacity for the purpose of the Pilot Plan. Assuming a 10 square meter redd size, the Upper Sacramento River is estimated to support between 359 to 536 adult spawning females at baseflow (210 cfs at Delta gage) and 434 to 652 adult spawning females at ordinary high water (around 770 cfs based on a 2.5 year return flow probability [Leopold et al 1964, Olson and Stockdale 2010]). Assuming a 20 square meter redd size, the Upper Sacramento River is estimated to support between 183 to 269 adult spawning females at baseflow and 219 to 324 adult spawning females at ordinary high water.

McCloud River

Estimates of Chinook Salmon spawning habitat and spawning capacity for the McCloud River are currently incomplete due to minimal field sites evaluated. Accordingly, the sources of error and bias associated with the aerial video interpretations described in the paragraph above for the habitat inventory result in a greater level of uncertainty in these estimates for the McCloud River than for the Upper Sacramento River. The spatial distribution of estimated spawning habitat area and Chinook Salmon spawning capacity (numbers of females) in the McCloud River were lowest in the upper study reach and highest in the middle study reach. Around 98 percent of the estimated available spawning habitat occurs in the middle and lower study reaches, with over 60 percent occurring in the

[1] The term "ordinary high water mark," as used here, is adopted from the definition provided in 33 CFR Section 329.11(a)(1),and means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas

[2] See accompanying Habitat Assessment Final Report (Reclamation 2014b) for scientific supporting literature, background, and derivation of these criteria.

middle study reach, from Squaw Valley Creek to Ah-Di-Nah campground. The particle-size distribution of the extensive sediment deposits in isolated patches, lateral deposits and pool tails, particularly downstream from Claiborne Creek, were difficult to fully classify for the purpose of determining spawning habitat quality. Field observations in the middle and upper study reaches suggest a large volume of alluvial material was introduced and distributed during a large storm event in December 2012, which was reported to have mobilized landslides and abundant sediment runoff in the McCloud River and adjacent watersheds as a result of the Bagley Fire (Bachmann 2013). Total spawner capacity was about 19 percent greater at the ordinary high water mark stage compared to the baseflow stage, based on the aerial video interpreted spawner estimates. Assuming a 10 square meter redd size, the McCloud River is estimated to support up to 2,480 adult spawning females at baseflow (270 cfs at the gage upstream from Shasta Lake) and 2,493 adult spawning females at ordinary high water (around 450 cfs based on a 2.5 year return flow probability [Leopold et al 1964, Olson and Stockdale 2010]). Assuming a 20 square meter redd size, the McCloud River is estimated to support up to 1,240 adult spawning females at baseflow and 1,246 adult spawning females at ordinary high water.

Fish Species

This chapter provides a general overview of the life history focusing on winter-run Chinook Salmon as well as the key resident trout species that occur in the Study Area.

Sacramento River Winter-run Chinook Salmon

Winter-run Chinook Salmon have characteristics of both of the two Chinook Salmon generalized freshwater life history types, stream- and ocean-type. Like stream-type salmon, winter-run Chinook Salmon adults enter fresh water months before spawning, but like ocean-type salmon, winter-run Chinook Salmon juveniles migrate to the ocean within their first year (Healey 1991). Table 3-1 shows the timing of major events in the winter-run Chinook Salmon life history.

The historical records described in this chapter are based solely on the single winter-run Chinook Salmon population below Keswick Dam, and are meant to provide a general overview of the characteristics of winter-run Chinook Salmon life history. However, winter-run Chinook Salmon reintroduced above Shasta Dam may react differently than the current population below Shasta Dam. The pilot studies will evaluate whether any of the life history traits are likely to change or vary once winter-run Chinook are released into their historical habitat above Shasta Dam.

Table 3-1. Sacramento River Winter-run Chinook Salmon Life Stage Timing

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult migration[1]												
Spawning[2]												
Egg incubation/ emergence[3]												
Rearing / emigration[4]												

Sources:
[1] Moyle 2002, NMFS 2014a
[2] Vogel and Marine 1991,NMFS 2014a
[3] NMFS 1997, Fisher 1994
[4] Poytress and Carillo 2010, 2011, 2012; Snider and Titus 2000a, 2000b
Note:
Darker shades indicate months of peak activity, white indicates no activity.

Adult Distribution and Spawning

Adult winter-run Chinook Salmon spend 1 to 3 years in the ocean. Adult escapement consists of 67 percent 3-year-olds, 25 percent 2-year-olds, and 8 percent 4-year-olds (Hallock and Fisher 1985, NMFS 2014a). Adult winter-run Chinook Salmon leave the ocean and migrate through the Delta into the Sacramento River from November through July, passing Red Bluff Diversion Dam (RBDD) on the Sacramento River from mid-December through July, with peak migration occurring during March (Moyle 2002, NMFS 2014a). Most migrating adults have passed RBDD by late June (Moyle 2002, NMFS 2014a). Winter-run Chinook Salmon adults prefer water temperatures ranging between 57 and 67 °F (14 to 19°C) for upstream migration (NMFS 2009). Winter-run Chinook Salmon are sexually immature when upstream migration begins, and they must hold for several months in suitable habitat before spawning (NMFS 2014a).

Winter-run Chinook Salmon are unique because they spawn during summer months – between late-April and mid-August, with a peak in June and July – when air temperatures approach their yearly maximum (Vogel and Marine 1991, NMFS 2014a). As a result, winter-run Chinook Salmon require stream reaches with cold water sources that will protect embryos and juveniles from the warm ambient conditions in summer (NMFS 2014a). Winter-run Chinook Salmon were adapted for spawning and rearing in the clear, spring-fed rivers of the Upper Sacramento River Basin, where summer water temperatures were typically 50°F to 59°F (10°C to 15°C), and require clean loose gravel from 0.75 to 4.0 inches in diameter for successful spawning (NMFS 1997). Spawning occurs in fast-moving, moderately shallow riffles or along banks with relatively high water velocities (Resources Agency et al. 1998), ranging from 1.54 feet per second (fps) to 4.10 fps at a depth of 1.4 to 10.1 feet (NMFS 2014a).

Prespawn Mortality Rate Understanding the prespawn survival rates of reintroduced Chinook Salmon is important, particularly if, as found in other studies (Keefer et al. 2010, USFWS 2011), the prespawn survival rate decreases relative to the natural population.

The estimated prespawn mortality rate for naturally spawning winter-run Chinook Salmon is typically low, around 1 to 2 percent. Survival rates are high because once reaching the Upper Sacramento River above RBDD, winter-run Chinook are typically successful in holding for several months in temperature controlled cold waters (NMFS 2014b).

For winter-run Chinook Salmon transported to the Livingston Stone NFH, prespawn mortality is variable, with an average of 8 percent for return years 2000 through 2008, and a range of 0 percent to 16.4 percent over those same years (California Hatchery Review Group 2012).

Egg Incubation and Emergence

Winter-run Chinook Salmon embryo incubation occurs from late April through November, and fry emergence occurs from mid-June through November. Within the appropriate water temperature range, eggs normally hatch in 40 to 60 days, and newly hatched fish (alevins) normally remain in the gravel for an additional four to six weeks (NMFS 1997). Physical habitat requirements for embryo incubation are the same as the requirements for spawning; however, it is also important that flow regimes remain relatively constant, not decreasing significantly during the embryo incubation life stage, or increasing to an extent that might result in redd scour (NMFS 2014a).

Egg-to-Fry Survival According to USFWS monitoring of juvenile winter-run Chinook Salmon at RBDD for brood years 2002 through 2012, winter-run Chinook egg-to-fry survival estimates averaged 26.4 percent, with a range of 15 percent to 49 percent (USFWS 2014). A significant relationship between the number of adult females and egg-to-fry survival rate was observed, and was determined to account for roughly half of the variability associated with egg-to-fry survival rates, as a result of varying levels of competition for optimal spawning habitat.

Flows and temperatures in the Sacramento River are highly regulated during the winter-run Chinook spawning period, and the high egg-to-fry survival rates are consistent with studies of other highly regulated aquatic systems. The very low coefficient of variation (38 percent) observed in egg-to-fry survival rates is also consistent with a highly regulated system (USFWS 2014). The winter-run Chinook Salmon ESU is considered the most vulnerable Chinook Salmon run to temperature management operations conducted by Reclamation. However, temperature management of the Sacramento River via Shasta/Keswick releases by Reclamation for winter-run Chinook Salmon appeared to be effective during the period from 2002 through 2012, as evidenced by the relatively favorable and stable egg-to-fry survival estimates (USFWS 2014).

The highest life-stage specific mortality rate in salmonids generally occurs during the incubation period and is often related to the characteristics of the spawning habitat. Studies on salmonid spawning habitat requirements have tended to focus on stream depth, velocity and physical properties such as substrate size and compositions. However, other physical and biological habitat features such as water quality, interspecific interactions, overhanging vegetation, woody debris and undercut banks affect spawning site selection (Quinn 2005, McRae et al. 2012). Cover features have the potential to provide protection from predators as well as adverse stream conditions, such as high stream velocity.

Egg-to-fry survival is an important survival rate as a high mortality in these early life stages can often result in subsequent low adult returns.

Fry and Juvenile Rearing, Distribution and Migration

Upon emergence from the spawning gravel, Chinook Salmon fry swim or are displaced downstream. Juvenile salmon move downstream from spawning areas in response to many factors, including inherited behavior, habitat availability, flow, competition for space and food, and water temperature. The timing and magnitude of juvenile movement is highly variable, and is apparently triggered by storm events that result in high flows and turbidity (NMFS 2014a).

Once downstream movement has commenced, Chinook Salmon fry either continue this movement until reaching the estuary, or they reside in the stream for a time period that varies from weeks to a year (Healey 1991). Juvenile Chinook Salmon migration rates vary considerably, depending on the physiological stage of the juvenile and hydrologic conditions, and winter-run Chinook Salmon fry in the Sacramento River may travel up to 30 kilometers (18.6 miles) per day (Kjelson et al. 1981). Rearing habitat value is strongly related to the availability of sufficient water quantity and floodplain connectivity necessary to maintain a sufficient levels of habitat complexity and diversity. Fry seek streamside and other shallow water habitats containing beneficial aspects such as riparian vegetation and associated substrates that provide food, predator avoidance cover, slower water velocities for resting, and favorable environmental temperatures (NMFS 2014a).

Winter-run Chinook Salmon downstream from Keswick Dam primarily migrate as fry The quality of migration corridors is linked to water quantity and quality, absence of barriers to fish passage, and the availability of natural cover such as submerged and overhanging large wood, native aquatic vegetation, large woody debris, rocks and boulders, side channels, and undercut banks.

Winter-run Chinook Salmon juveniles rear in the Sacramento River above RBDD from July through March (Hallock and Fisher 1985), and fry and juvenile emigration past the RBDD primarily occurs from July through November (Poytress and Carillo 2010, 2011, 2012). According to USFWS monitoring of juvenile winter-run Chinook Salmon at the RBDD from brood years 2002 through 2012, weekly passage tended to increase consistently through September to a peak in early October, with 75 percent of average annual passage occurring by mid-October. Weekly passage varied considerably during August through December, with some weeks' passage totals accounting for more than 20 percent of annual passage values. Weekly passage between October and December indicated wide variability over the 2002 to 2012 period, but tended to show steady decreases followed by a second increase or mode of winter passage in November and December. Overall, winter-run Chinook Salmon passage was 99 percent complete by the end of December each year, with sporadic pulses of smolts through March that contributed minimally to the annual total winter passage estimate (USFWS 2014).

Juvenile migration past Knights Landing (located approximately 155.5 river miles downstream from the RBDD) primarily occurs between November and March, with a peak in December (Snider and Titus 2000a and 2000b, NMFS 2014b). Juvenile winter-run Chinook typically enter the ocean during March and April of each spring (Pyper et al. 2013, USFWS 2014), though smolts may migrate to the ocean any time from November through May (NMFS 2014a).

USFWS monitoring has revealed the importance of the first storm events of the fall or winter period on the redistribution of juvenile winter-run Chinook Salmon. Passage of juvenile winter run Chinook from the Upper Sacramento River above RBDD to the lower river and Sacramento-San Joaquin Delta typically increases exponentially with the first Sacramento River stage increases that follow the summer and fall Sacramento River flow regulation period. In addition, monitoring results indicated that fry size-class winter-run Chinook Salmon exhibit decreased nocturnal passage levels during and around the full moon phase in the fall, whereas pre-smolt/smolt winter-run Chinook Salmon appeared less influenced by nighttime light levels and were much more influenced by changes in discharge levels (USFWS 2014).

Juvenile Production According to USFWS monitoring of juvenile winter-run Chinook Salmon at the RBDD from brood years 2002 through 2012, annual total passage estimates ranged between 848,976 and 8,363,106 juveniles (USFWS 2014). On average, winter-run Chinook Salmon passage was composed of 80 percent fry and 20 percent pre-smolt/smolt size-class fish. A highly significant positive relationship between the estimated number of female adult winter-run Chinook Salmon upstream from RBDD and estimated fry-equivalent winter-run Chinook Salmon was detected during this period (USFWS 2014).

Winter-run Chinook adult escapement and subsequent juvenile passage began a marked decline in 2007, and it is believed that juvenile winter-run Chinook suffered from poor marine conditions upon ocean entry in the spring of 2005 and 2006. Winter-run Chinook Salmon juvenile cohort replacement rates dropped below 1.0 starting with brood year 2007, and the lowest passage estimate between 2002 and 2012 occurred in 2011 at 848,976 (USFWS 2014).

Rainbow Trout

There are both resident and migratory rainbow trout populations in the McCloud River. They are vigorous, active fish that primarily inhabit swifter portions of pool and pocket water habitats. Most rainbow trout in the McCloud River are primarily year-round stream residents. Some rainbow trout have been observed to migrate into the McCloud River from Shasta Lake, presumably to spawn. These rainbow trout were noted to migrate from Shasta Lake in the spring and fall months. Although the genetic origin of these fish has not been reported, the numerous strains planted in Shasta Lake over the years have likely resulted in some introgression among migratory rainbow trout in the McCloud River. The degree to which this migratory population of rainbow trout contributes to the wild trout fishery of the McCloud River is not known; however, available data do not indicate that its contribution is significant.

Wild rainbow trout typically mature in their second to third year and spawn in the mainstem McCloud River and its tributaries from February to June. The eggs typically hatch in three to four weeks, depending on water temperature, and fry emerge from the gravel two to three weeks later. The fry remain in quiet waters close to shore, among cobbles, or under overhanging vegetation for several weeks. As the fish grow, they move into swifter water habitats. The optimum temperature range for growth and for completion of most life stages of rainbow trout is between 50 and 70°F (10°C to 21°C), though they seem to prefer and thrive at temperatures in the lower two-thirds of this range. Rainbow trout in lakes and streams seldom live for more than six years.

The rainbow trout fishery in the Upper Sacramento River is a self-sustaining wild population. For decades, triploid hatchery-reared catchable rainbow trout have also been released into the Upper Sacramento River in the vicinity of Dunsmuir, as part of a catch and keep allotment for the city of Dunsmuir. Native rainbow trout are the dominant salmonid in the Upper Sacramento River, making up approximately 99 percent of the wild trout population; introduced wild brown trout make up the remainder.

Brown Trout

Loch Leven (brown) trout, as well as brook trout, were transferred into the McCloud River from fish hatcheries in the eastern United States to “improve” and diversify the fishery. These species appear to have been established in the river by around 1900 (Wales 1939). Brown trout have naturalized in Shasta Lake, spawn in the McCloud River, and reside year-round in some of the perennial streams/rivers flowing into Shasta Lake. They remain a prized sport fish in both the river and lake (Rode and Dean 2004). Like the rainbow trout, brown trout are both resident and adfluvial in the McCloud River, but exhibit migrations between the lake and river to a greater extent. They are not as abundant as the rainbow trout and are thought to have replaced the extinct bull trout ecologically in the McCloud River. Brown trout migrate into the McCloud River from late spring through the fall in preparation for spawning in the river and its tributaries. Only a portion of the brown trout migrating from Shasta Lake that passed a counting weir in the McCloud River were observed upstream in the Wild Trout Management Area, which encompasses the 7.3 miles of the McCloud River immediately downstream from McCloud Dam (Rode and Dean 2004), so the actual extent of the spawning grounds of migratory brown trout is not fully known. While residing in the river, brown trout prefer the slow, deep pools with abundant boulder and bedrock ledge cover.

Brown trout mature in their second or third year. Some fish may mature in the river while others may migrate to the lake to feed and return to spawn. The stimulus for upstream migration is often a rise in stream flow and/or changing lake temperatures. Spawning takes place from November through December, when water temperatures fall to below 50°F (10°C). Eggs typically hatch within seven to eight weeks, depending on water temperature. Fry emerge from the gravel three to six weeks later. The habitats used by juvenile brown trout are similar to those of rainbow trout; however, as brown trout grow, they tend to select habitats with slower water and more cover than rainbows. The timing of emigration of juvenile brown trout to the lake is not known.

River-resident brown trout have diets similar to those of rainbow trout but appear to feed on the stream bottom for benthic prey to a greater extent than rainbow trout. As brown trout grow, their diet expands to include larger invertebrate prey and fish. Larger brown trout are voracious predators, especially on fish, including their own young. In lakes, small brown trout feed heavily on zooplankton, gradually switching to larger benthic invertebrates and then to fish. In Shasta Lake, brown trout prefer threadfin shad as a staple prey. Brown trout growth in the McCloud River appears to increase after age three; the increase is attributed to their migration to Shasta Lake to exploit the forage fish populations there. Brown trout grow best at water temperatures ranging from 45 to 69°F, but near the upper half of this range they are known to competitively dominate other trout species.

Chapter 4
Donor Stock Selection and Genetic Management

Relative to stock selection, there are four specific actions that can be associated with reintroduction of anadromous salmonids:

1. Donor stock selection and collection
2. Rearing/culture of individuals from the donor stock(s)
3. Reintroduction/release of these individuals
4. Post-introduction monitoring of donor stock populations and reintroduced populations

This section is focused solely on the selection of donor stock and their genetic management for reintroduction to tributaries above Shasta Dam, and relies on examples and recommendations used in reintroduction planning for other projects including the San Joaquin River Restoration Program and other relevant stock selection and reintroduction efforts.

Donor Stock Selection

Selecting a source genetically similar to the historical population that inhabited the reintroduction area should maximize the benefit and reduce the risks of a reintroduction. Reintroduced salmonid populations are expected to have a higher probability of success when they originate from donor populations that are most adapted to environmental conditions of the river systems to which they are being reintroduced (Nielsen and Powers 1995, Huntington et al. 2006).

Understanding local environmental conditions of a reintroduction area is important for selecting stocks that have life histories and environmental tolerances most compatible with the existing habitat. Factors such as timing and magnitude of flows, locations and seasonality of migration barriers, water temperature, pool density and depth, cover, and spawning substrate quantity and quality are all key habitat attributes that influence the potential reintroduction success.

Winter-run Chinook Salmon produced in the Livingston Stone NFH are planned as the initial source for the Pilot Program. These fish are part of the Sacramento River winter-run Chinook Salmon ESU, which historically spawned in the Upper Sacramento and McCloud rivers (as well as the Pit River) before the dams were constructed. Thus, although the McCloud and Upper Sacramento rivers are outside the current range of the listed ESU, they are within the historical range of winter-run Chinook Salmon. Spring-run Chinook Salmon are also being considered. Non-ESA listed fish stocks (fall/late fall-run Chinook) are planned to be used for testing reintroduction methods and juvenile collection efficiency.

Genetic Management

The USFWS' winter-run Chinook Salmon propagation program at Livingston Stone NFH is currently operated to supplement natural production in the Sacramento River below Keswick Dam. The hatchery was constructed in 1997 for the explicit purpose of propagating fish from the ESA-listed winter-run Chinook Salmon ESU to supplement natural production and assist in their recovery. The program provides a source of marked and tagged winter-run Chinook Salmon which are used to monitor and assess impacts resulting from the commercial and sport ocean salmon fishery. Additional propagation of a captive broodstock will now contribute to reintroductions into historical habitats above Shasta Dam and may contribute to the reintroduction in Battle Creek.

The winter-run Chinook Salmon hatchery program at Livingston Stone NFH is operated consistent with the Recovery Plan (NMFS 2014a) and operational strategies employed are reviewed for alignment with the recommendations provided by the California Hatchery Scientific Review Group (California Hatchery Scientific Review Group 2012). The propagation program is considered an integrated-recovery program. Hatchery-propagated winter-run Chinook Salmon are managed for integration into the natural population of winter-run Chinook Salmon in the lower Sacramento River and are intended to provide a demographic enhancement to aid in rebuilding and recovering that population. Hatchery-origin winter-run Chinook Salmon are intended to return as adults to the Sacramento River, spawn in natural areas, and become reproductively and genetically assimilated into the natural spawning population.

USFWS recently completed two Draft Hatchery and Genetic Management Plans (HGMP) for the Livingston Stone NFH – one for the Integrated-Recovery Program, and the second for the Captive Broodstock Program. The HGMPs describes all aspects of the propagation program at Livingston Stone NFH including all hatchery practices and facilities, broodstock and egg collection, production targets, juvenile rearing and release methods and genetic management protocols. Winter-run Chinook Salmon broodstock are mostly of natural-origin (i.e. unmarked and untagged) and are collected from mid-February into July. Under the Integrated-Recovery Program, a maximum of 10 percent hatchery-origin adults were used as broodstock through 2009. From 2010 to 2013, only natural-origin winter Chinook were used as broodstock to further reduce the effects of domestication selection. The collection target for winter-run Chinook Salmon broodstock is 15 percent of the estimated run size, up to a maximum of 120 natural-origin adults. A minimum of 20 winter-run Chinook Salmon adults are targeted for capture during any year regardless of run size (e.g., run size of less than 133 natural-origin adults) (USFWS 2011). Allocation of the total collection target into monthly collection targets is determined based on the percentages of historical run timing past the Red Bluff Diversion Dam. To be selected as hatchery broodstock, adult winter-run Chinook Salmon must satisfy both phenotypic criteria (e.g., run/spawn timing, collection location, and physical appearance) and genetic criteria based on genotypes from 95 single nucleotide polymorphism (SNP) loci that provide effective discrimination of winter-run Chinook Salmon plus another marker (GHpsi) on the Y chromosome that identifies gender. In combination, the genetic and phenotypic criteria enable accurate identification of winter-run Chinook Salmon for use in the program (USFWS 2011).

The size of the Captive Broodstock Program is being determined on a year to year basis. In 2015, 1,035 winter-run Chinook Salmon juveniles were withheld to be reared to maturity. USFWS anticipates withholding approximately 1,000 fish from future releases, however, the actual number of juveniles entered into the Captive Broodstock Program will be reconsidered on an annual basis by USFWS, NMFS, and CDFW. The ability of the Captive Broodstock Program to achieve the multiple program objectives while balancing the negative effects resulting from removing winter-run Chinook Salmon from the wild population will be considered in determining the actual number of juveniles entered into the program.

The Pilot Program may initially use fish propagated at Livingston Stone NFH and thus all aspects of collection and propagation will be integrated with the propagation program and would rely on protocols as described in the Livingston Stone HGMP, as well as additional practices that may be identified as the Pilot Project moves forward (based on input from agency geneticists, pathologists, etc.). The Integrated-Recovery Program HGMP includes these key performance standards to minimize adverse genetic effects:

- Constrain the collection of broodstock to lower the demographic and genetic risks to the naturally spawning population
- Use only natural-origin winter-run Chinook Salmon 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 percent of hatchery production

The Captive Broodstock Program HGMP, however, includes these key performance standards in order to supplement broodstock for introduction efforts upstream from Shasta Dam and in Battle Creek:

- Developed a hatchery facility designed specifically for propagating Sacramento River winter-run 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 to achieve high rates of survival

The first years of the Pilot Program will be limited to studies using fry, juveniles, and/or eggs (see Chapter 7) obtained from Livingston Stone NFH. The potential for unintended or undesirable evolutionary (homogenized population structure and/or reduced fitness) and demographic (depletion of source population) risks may be low because fish will be sourced from Livingston Stone NFH rather than from the wild population, and because homogenization risk is lower with the small number of hatchery-origin fish being released into an area that is unoccupied by wild Chinook Salmon.

As mentioned above, all hatchery-origin winter-run Chinook Salmon and any natural-origin fish in excess of broodstock requirements are returned to the Sacramento River below Keswick Dam. After the installation of a water treatment system at Livingston Stone NFH, wild adult winter-run Chinook Salmon may be moved up to the Study Area as part of the Pilot Program. A portion of hatchery-origin winter-run Chinook Salmon from Livingston Stone NFH that are in excess of the broodstock requirements (that would normally be returned to the lower Sacramento River) may also be used in the Pilot Program.

If the Pilot Program indicates that a full-scale reintroduction is feasible, a detailed plan to avoid unintended consequences (e.g., mining effects) will be further developed and implemented. The colonization strategy for a full-scale reintroduction may rely on reintroduction of juvenile and eggs propagated at Livingston Stone NFH, with subsequent reliance on natural spawning in the reintroduction area. The population would continue to be demographically dependent on hatchery production until reestablishment of natural production occurs over time. The reintroduction would also need to be integrated with Livingston Stone NFH's propagation program to ensure retention of the target genetic diversity present in the founders of the captive broodstock. To reduce the potential for significant impacts to the source population, criteria for collection strategies will balance development of reintroduced stocks with minimizing risks to the source population.

If a full-scale reintroduction project moves forward, the length of time over which hatchery supplementation is planned must be considered. Evolutionary and ecological risks increase with the duration and magnitude of hatchery releases into the Study Area. The goal is to aim for brief releases of from one to two generations followed by cessation for a similar time frame, accompanied by a monitoring program to track performance. Such a pulsed release would provide colonization to establish a population and subsequently permit natural and sexual selection to shape local adaptation and the expression of natural diversity patterns. Abundance targets for naturally spawned fish would be established to indicate when the incipient population has sufficient reproductive potential without supplementation.

Donor Stock Uncertainties

Specific pilot studies are currently being developed. These studies will be affected by the uncertainty regarding the availability of fish. Because of the current low numbers of winter-run Chinook Salmon, the fish reared through the captive breeding program at the Livingston Stone NFH may be needed to sustain the population in the lower Sacramento River. Therefore, information such as the run, numbers and life stages of fish that will be available for the pilot studies will be determined on a year-to-year basis.

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Chapter 5 Adaptive Management Focus of the Pilot Program

In general, pilot programs serve to inform and guide long-term programs because they generally present an opportunity to learn in a setting structured to minimize risks and mitigate identified unintended consequences. Monitoring is an important component of pilot programs because results can be used to determine areas of preliminary success or failure that can be replicated or corrected, i.e., using an adaptive management framework.

Adaptive management is the combination of design, management, and monitoring to systematically test assumptions to learn and adapt. In a conservation objective project such as the SDFPE, adaptive management is about applying a scientific approach to a set of defined actions to achieve a desired outcome.

A central component of adaptive management for the SDFPE is the iterative refinement of the Pilot Program to meet goals and objectives as new information becomes available. The monitoring, assessment, evaluation, and adaptation process is used to revise actions as new knowledge is acquired and understanding of the system and project constraints improves.

The adaptive management approach will allow the Steering Committee to: (1) maximize the likelihood of success of the Pilot Program, (2) increase learning opportunities, (3) identify data needs to reduce uncertainties, (4) use the best available information to provide technical support that will increase the confidence in future decisions and recommendations, and (5) prioritize possible future management actions.

The key steps in adaptive management are displayed in Figure 5-1, and are briefly described below:

- **Goals and Key Questions –** The goals and key questions are the driving factors for undertaking the Pilot Program. These questions are the starting point that shapes the objectives and outputs of the program, as well as all other parameters of the study design. The key questions provide focus in the face of a potentially overwhelming volume of data by identifying the specific problem elements to be studied.

- **Conceptual Model –** The conceptual model for the Pilot Program is a depiction of the assumed variables and their limiting factors as identified through the literature review and institutional knowledge.

- **Pilot Studies –** The research and learning process begins with pilot studies which are developed to 1) address the intent of the program,2) understand the environmental drivers that are important to the program success and, 3) ultimately provide a measurement of program success.

- **Assess and Adapt –** The analysis and interpretation of the results of the pilot studies is critical for decision makers in assessing whether: (1) the program is successful, (2) adaptations must be made and goals or key questions revisited, or (3) new studies implemented.

Adaptive management requires development of goals, objectives and intended benefits that are closely tied together. Establishing goals is a key first step for any project. For the SDFPE, the goals are based on the Action V requirements, but ultimately target the reestablishment of a self-sustaining populations of winter-run and spring-run Chinook Salmon upstream from Shasta Dam for conservation and recovery purposes. The goals should lead to specific and measurable objectives, which provide the benchmarks to determine when and if the reintroduction program has achieved success. Finally, identifying desired benefits of the Pilot Program helps determine whether the Pilot Program is consistent with the goals and objectives and thus provides an initial check for whether a long-term reintroduction program is appropriate to pursue.

Including a reasonable timeframe to achieve reintroduction benefits will help bound expectations and establish temporal benchmarks. Some reintroductions only take a few generations to establish, whereas others take decades. Establishing a realistic time frame is crucial in preventing a premature end to a reintroduction program. Reintroductions targeting genetic diversification generally take longer to achieve due to the need to accommodate multiple generations.

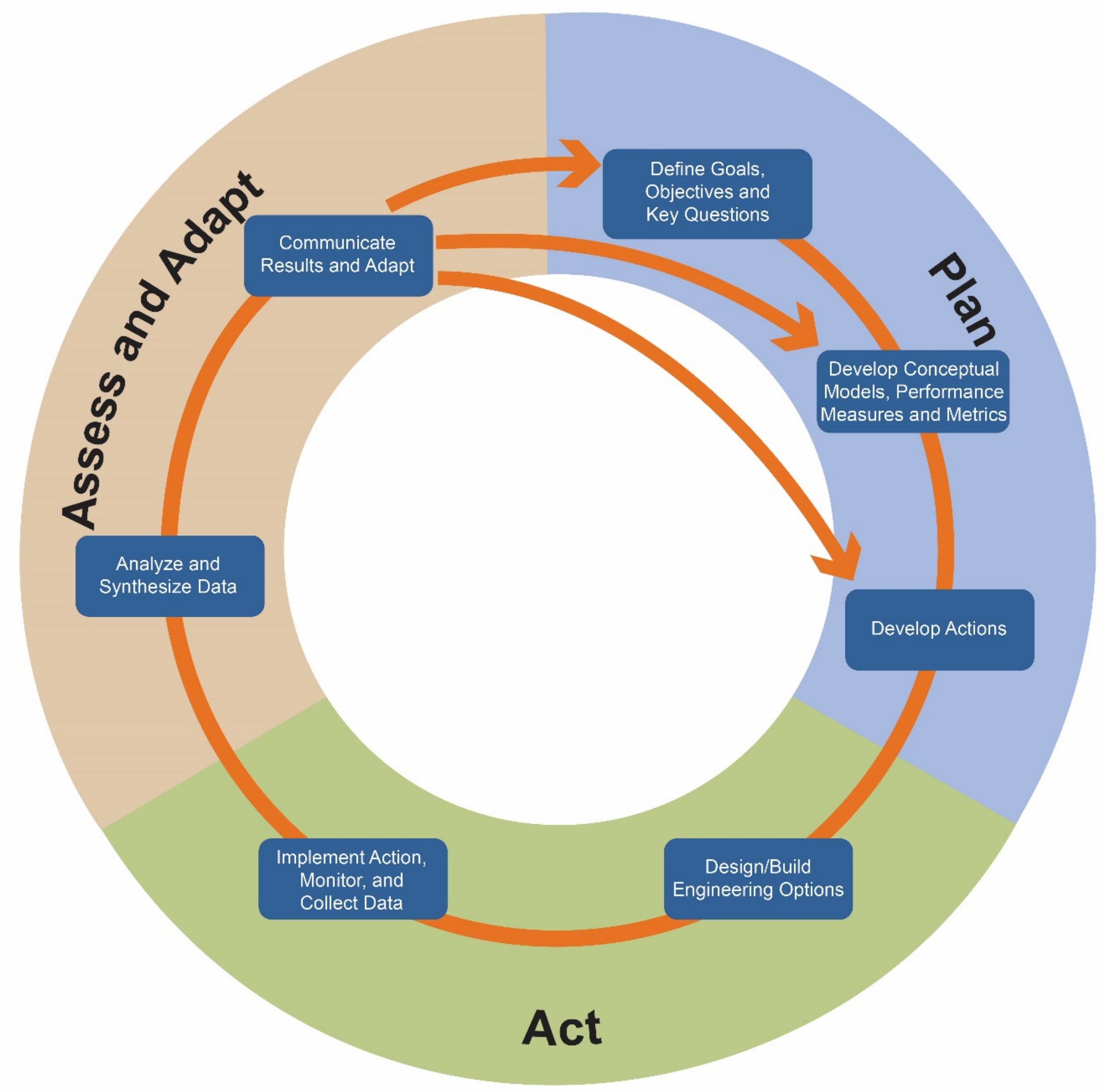


Figure 5-1. Adaptive Management Framework for the Shasta Dam Fish Passage Evaluation Pilot Program

For the SDFPE, adaptive management will allow the Steering Committee to use a variety of strategies and techniques that are refined over time based on an improved understanding of the outcomes of the Pilot Program in relation to the streams and watersheds, landowner, and other management challenges. Thorough monitoring and evaluation of adaptive management actions are essential to resolution of the biological uncertainties, as well as potential stakeholder uncertainties (though it is the biological uncertainties that direct the pilot studies), surrounding the reintroduction of winter-run and spring-run Chinook Salmon upstream from Shasta Dam. The public outreach plan, Stakeholder Communication and Engagement Plan, is posted on the project website at https://www.usbr.gov/mp/BayDeltaOffice/shasta-dam-fish-pass.html. The draft

Pilot Implementation Plan for the Shasta Dam Fish Passage Evaluation was circulated for public review and comment from January 14, 2016 through February 24, 2016. A press release, announcing the availability of the draft Pilot Implementation Plan, was released on January 14, 2016. A summary of the comments received on the draft document are included as an appendix to this version of the plan. This version of the pilot plan was updated to address the comments.

Pilot Program Overview

The Pilot Program provides a strategy for obtaining essential information on the feasibility of successful Chinook Salmon reintroduction to historical habitats upstream from Shasta Dam.

The Pilot Program includes multiple pilot (i.e., monitoring) studies that are conducted on a short-term basis. One of the goals of the Pilot Program is to help improve the methods for monitoring, measuring, or interpreting data, in particular by explaining cause-and-effect relationships. This allows the Steering Committee to be able to respond quickly to new information and/or concerns, assess new technical approaches, investigate key questions that have defined endpoints, and evaluate new directions for the Pilot Program. A critical point is the decision about whether the Pilot Program should be modified, transitioned into the long-term reintroduction program, or terminated.

McClure, et al. (2011) developed general guidelines for an anadromous salmonid reintroduction planning process for the Pacific Northwest, which was recently applied to development of the *Upper Yuba River Anadromous Salmonid Reintroduction Plan* (Hendrix et al. 2014). These guidelines are applicable to the Pilot Program, and include the following:

1. Establishing goals, objectives, and identifying potential benefits

    a. Set goals – specific to the SDFPE is principally reducing extinction risk and contributing to long-term recovery of Sacramento River winter-run and spring-run Chinook Salmon

    b. Establish objectives that are measureable, time-limited, specific, and scientifically-based

    c. Identify potential benefits – focused on improving viability characteristics of abundance, productivity, spatial structure, and diversity

2. Evaluating biological risks and constraints

   a. Reintroduction risks – primarily related to evolutionary, demographic, ecological, and disease processes

   b. Constraints on reintroduction – affected by barriers, habitat quality, migratory and ocean survival, harvest, interactions with other species, changing conditions

3. Implementing reintroduction actions

4. Monitoring of management actions

While the Pilot Program focuses on biological feasibility, it does acknowledge socioeconomic, landowner, stakeholder, and other concerns that are crucial for policy decisions regarding the continuance of the Pilot Program and the potential long-term reintroduction.

Phased Approach to Reintroduction

The purposeful sequencing of management actions in a way that provides for evaluating and addressing key environmental limiting factors, along with a specific timeline and approach for reintroduction, is required to maximize the likelihood of any successful reintroduction program (McClure et al. 2011). Because reintroducing anadromous fishes to areas that they historically inhabited that are currently blocked by dams entails a number of inherent uncertainties, it is important that reintroduction programs are designed so that efforts in early stages can inform approaches, procedures, and decisions that must be made in later stages of the program. Consequently, reintroduction of anadromous fish should proceed in phases, which require some level of iteration between developing the sequences of actions to support reintroduction and strategies and techniques for recolonizing fish populations (McClure et al. 2011).

Successful reintroduction of winter-run and spring-run Chinook Salmon to the tributaries above Shasta Dam will require addressing the connectivity of habitats above Shasta Dam to the lower Sacramento River. Because Shasta and Keswick dams will not be removed to reconnect these habitats, both upstream and downstream fish passage will need to be facilitated. The type and location of potential fish passage facilities will be investigated during the Pilot Program. Similarly, successful reintroduction will require implementation of an effective strategy and procedures for recolonization of suitable tributaries above Shasta Dam. Both the fish passage facilities and the strategies and procedures for reintroduction will be developed and concurrently and iteratively investigated throughout the Pilot Program. Accordingly, the general sequence, relationships, and important aspects of each of two reintroduction program stages can be characterized as follows:

1. Restoring Connectivity – short-term (pre- and full implementation of the Pilot Program) and long-term (types, locations, and timeline for provision of fish passage facilities which largely determine options for passive and active recolonization strategies)

2. Operational Reintroduction Stages

    a. Pilot Program addresses immediate uncertainties associated with initial regulatory and technical procedures and biological constraints that would preclude successful reintroduction; experiments with colonization strategies; assesses limiting factors that may affect whether or not Chinook Salmon can recolonize and establish self-sustaining sub-populations; design temporary, interim fish passage/conservation facilities constructed and operated during this phase. The Pilot Program will last until it is determined that Chinook Salmon either can or cannot be feasibly reintroduced above Shasta Dam.

    b. Long-Term Reintroduction, with adaptive management includes evaluating and incrementally improving performance of fish passage/conservation facilities and monitoring viability attributes of diversity using genetic and evolutionary characteristics; evaluation of reintroduced population's contribution to recovery and ESU status (recommended criteria) (McClure, et al. 2011). This phase includes investigation into:

        i. Degree of genetic differentiation from the source (primary ESU population)

        ii. Self-sustaining population or dependent on conservation hatchery supplementation

        iii. Local adaptation and divergence from the source population

        iv. Metapopulation/population dynamics

        v. Duration and apparent durability of self-sustaining population

Three phases bracket the Reintroduction Program – preservation, local adaptation, and sustainable natural population. These three phases match up, and overlap with the Pilot Program and the long-term reintroduction.

a. The preservation phase occurs early in the Reintroduction Program, and the goal is to safeguard the broodstock, or source population by preserving their existing genetic and life history diversity.

b. The local adaptation phase occurs during the Reintroduction Program (if extended beyond 3 years) and into the long-term reintroduction stage, where the goal is to maintain or increase the life history diversity of the source population through local adaptation to the introduced habitat until the minimum number of returning spawners and outmigrating juveniles are reached, and the reintroduced fish distribute throughout the introduced habitat.

c. The sustainable natural population phase is when the self-sustaining and (if applicable) exploitable populations are able to continue and the target for a viable salmonid population has been met.

The reintroduction should increase the capacity of an existing population by expanding the available habitat area. Ideally, the potential for population growth within extant populations is roughly determined by the proportional increase in the currently occupied habitat and should be evaluated relative to clearly defined long-term performance measures. As shown in other adaptive management programs (McElhany et al. 2000, Anderson et al. 2014, Peters et al. 2014), there are four specific performance measurements that will define the feasibility of long-term reintroduction: abundance, productivity, spatial structure, and diversity. An example of the decision matrix for these four performance measures is shown in Table 5-1, and each is further described below.

Abundance

Abundance is the total number of naturally spawned fish. Reintroduction benefits to abundance include an increased carrying capacity of an existing population by expansion of its range, or an establishment of a new, discrete, demographically independent population.

In the preservation phase of the reintroduction program, which includes the Pilot Program, the number of fish for pilot studies will be constrained by the availability of sufficient numbers of the target life stages from Livingston Stone NFH. Because of the limited number of fish in the lower Sacramento River, a captive broodstock will be used for the Reintroduction Program for the first few years, until the fish originating from the Upper Sacramento and/or McCloud rivers through the Pilot Program return to spawn (which will be differentiated through either genetic or physical marking when possible), or unless there are high numbers of returning lower Sacramento River spawners available to be used in the Pilot Program.

In 2013, a habitat assessment was conducted in both rivers (See Chapter 3.0) to determine the distribution of potentially suitable habitat and an estimate of spawner capacity of each system. Because of access and timing restrictions in the McCloud River, only a partial assessment could be completed; therefore, additional assessments of the distribution of potentially suitable habitat in the McCloud River may be conducted prior to or during the Pilot Program. This assessment could provide more accurate information on spawner capacity which can produce values that should establish a sustainable natural population goal based on estimated habitat capacity.

Table 5-1. Sample Table Where Metrics for Each Performance Indicator at Each Phase in the Reintroduction Program Can Be Identified

Performance Indicator	**Measureable Factors**	**Preservation**	**Local Adaptation**	**Sustainable Natural Population**
Duration	Years			
Abundance (identify monitoring methods)	Number of Natural Spawners			
	Proportion of hatchery-origin spawners			
	Prespawn mortality rate			
Productivity (identify monitoring methods)	Number of juveniles collected per adult female			
	# pre-fishing recruits/spawner			
	Smolt-to-Adult ratio			
	Cohort Replacement Rate			
Spatial distribution – Sacramento River (identify monitoring methods)	Number of miles used: Spawning Rearing			
Spatial distribution – McCloud River	Number of miles used: Spawning Rearing			
Diversity (genetics, smolt traps?)	Timing of juvenile migration			
	Difference in genetic makeup from lower Sac fish			

Note: Values in each cell under each phase identifies the metric.

Key:

= Number

Preservation = Prevent extinction and preserve the existing genetic and life history diversity of native salmonid populations

Local Adaptation = Maintain or increase life history diversity of natural-spawning populations through local adaptation to the Sacramento and/or McCloud River ecosystem until minimum levels of spawner abundance, productivity, and distribution are met

Sustainable Natural Population = Ensure that self-sustaining and exploitable population levels continue once desired values for all VSP and habitat parameters have been met and hatchery production is no longer needed for protection or recovery

Productivity

Productivity is the product of the initial stock and survival over multiple life stages; however, its final metric is generally defined as the cohort replacement rate, which is the ratio of number of Chinook Salmon in generation "G" to the number of Chinook Salmon that produced them in generation "G-1." Productivity is a primary driver of long-term persistence of a population. When considered in isolation, populations with productivity that exceeds the replacement rate are self-sustaining (greater than 1.0), whereas those with persistent negative production rates (less than 1), even with current high abundance, cannot persist in the long-term. Metrics often used to identify the productivity include the number of juvenile outmigrants per female spawner, as well as the adult spawning escapement. Productivity will be monitored at various life stages, and in multiple locations both within and downstream from the Study Area.

Survival at each life stage as well as in different cohort years may vary significantly; however, productivity integrated through multiple life stages and years ultimately shows the trend in abundance. The use of hatchery-origin fish will confound productivity of natural spawners in the early period of the Pilot Program. However, as the number of hatchery-origin broodstock used for supplementing returning naturally-produced fish are reduced, natural productivity is expected to increase.

Spatial Structure

Spatial structure refers to the geographical distribution of the Chinook Salmon across their range, the distribution of spawners within a population, the connectivity of populations linked by dispersal, and the processes that produce these patterns. Reintroductions offer an opportunity to restore historical distributions, reduce isolation, and restore natural patterns of dispersal and connectivity within a metapopulation. The risk of extinction due to single catastrophic event would be decreased in most ESUs by increasing the number of extant populations and subpopulations (NMFS 2014a).

Because the salmon will not, at least initially, have volitional access to the Study Area, they will require human intervention to transport them to the appropriate habitat. Therefore, colonization of the tributaries above Shasta Dam will be dictated by the number of fish transported upstream.

Diversity

Diversity is defined as any potential changes in spawning behavior, outmigration timing, as well as any phenotypic and genetic change from the parent population. Phenotypic, genetic and life-history diversity provide for resilience of populations to unpredictable natural and anthropogenic environmental change, effectively stabilizing population fluctuations over time. Diversity is expected to change over time. The difficulty is predicting the length of time required for the change, particularly based on the fact that a high percent of the broodstock will come from the hatchery.

In some reintroduction programs, it is necessary to evaluate genetic divergence, either from the source population or among distinct sub-basins within the reintroduction site, to demonstrate enhanced diversity. The need for this evaluation for the SDFPE, however, is yet to be determined.

Key Milestones and Decision Points

The foundation of the Pilot Program is the development of a Pilot Plan. The Steering Committee has already worked through, and will continue to work through multiple key steps and milestones in the development of the Pilot Program and Pilot Plan, including:

- Anticipating environmental and social issues/concerns
- Anticipating the public concerns and communicate with the public how these concerns will be addressed
- Continuing to practice environmental stewardship
- Bringing environmental issues into long range planning
- Transferring information to subsequent phases
- Connecting vision and goals with alternatives selection through the development of an Environmental Assessment
- Structuring decision-making by using a formal process with interagency collaboration
- Using performance measures and evaluation criteria
- Continuing to collaborate through the Steering Committee with the public

During the development of this Pilot Plan, frequent coordination with the Steering Committee and multiple interagency subcommittees, including the Pilot Planning Subcommittee, Habitat Subcommittee, Public Outreach Subcommittee, and Fish Health and Genetics Subcommittee, was necessary to identify the key issues, concerns, and assumptions required for the initial stages of an adaptive Pilot Program. Through this process, key milestones and decision points were more thoroughly formulated.

Pilot studies provide a means to evaluate the Pilot Program performance and affect any management actions. Exogenous variables (e.g., prey availability, variables outside the Study Area), on the other hand, also provide information regarding why reintroduction is progressing as observed but may not automatically result in altered management actions that will be directly associated with the Pilot Program. These variables outside the Study Area include factors affecting fish survival downstream from Keswick Dam, and including the Delta and Pacific Ocean.

A decision framework provides structure for defensible decision-making, and works well in adaptive management, particularly when the decision-making body (such as the Steering Committee) includes multiple agencies with diverse missions. The framework helps in determining alternate management actions if triggers indicate they should be modified. A decision support tool may be developed to assist the Steering Committee in determining if the approach to the Pilot Program should be altered and if a long-term reintroduction is warranted.

Metrics and Performance Measures

To determine the Pilot Program success, metrics and performance measures need to be established before its implementation. Metrics and performance measures assist in developing expectations of the Pilot Program, and should be:

- Specific
- measureable
- accurate
- reliable
- time-limited (i.e., the time in which the objectives are to be achieved is specified and realistic)
- scientifically-based

These metrics and performance measures are tied to the key questions identified, which are based on the objectives identified in the BO. The key questions (listed in Chapter 7) are evaluated based on how much the pilot studies can successfully contribute to the overall Pilot Program objective of obtaining sufficient surviving juveniles/smolts per female to contribute to an increasing population. . This directly assesses the feasibility of a long-term reintroduction program.

Environmental and fish monitoring data is needed to: (1) provide baseline conditions for pre-project and long-term monitoring, (2) characterize conditions and variability effecting fish metrics, and (3) identify risk associated with the feasibility and performance of various study options and passage alternatives (See Chapters 6 and 7).

At the end of each year, the Steering Committee will use the metrics to determine the level of success and to decide on the next steps of the Pilot Program or whether to move to the next phase of reintroduction. The Steering Committee can use tools such as shown in Table 5-2 to determine the next step.

Table 5-2. Sample Decision Tables for Pilot Program Success

Number of spawning females	Predicted Number of Redds (assume 5,000 eggs per female)	Success/ Decision	Predicted Number of fry per female	Success/ Decision	Predicted Number of Juveniles Collected	Actual number of juveniles collected	Success/ Decision	Predicted Number of returning adults	Success/ Decision

Highlighted columns are hypothetical survival rates. Red shading highlights variable survival rates in stages where fish are handled.

a	b	c	d		f	g	h	i	j	k	l	m	n	o	p	q	r
Adults transported	Adult survival to spawn	Spawners	Eggs/female	Eggs in gravel	Egg to fry survival	Emergent Fry	Survival to Collector	Juveniles available for collection	Collection survival (to below dam)	Emigrants	Survival to ocean	Ocean juveniles	Smolt to Pre-harvest adult survival	Adult Production	Harvest Survival	**Returning adults**	**Cohort replacement rate**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.9	24,322	0.2	4,864	0.028	136	0.8	**109**	**0.91**
120	0.8	96	4596	220,608	0.35	77,213	0.4	30,885	0.9	27,797	0.2	5,559	0.028	156	0.8	**125**	**1.04**
120	0.9	108	4596	248,184	0.35	86,864	0.4	34,746	0.9	31,271	0.2	6,254	0.028	175	0.8	**140**	**1.17**
120	0.95	114	4596	261,972	0.35	91,690	0.4	36,676	0.9	33,008	0.2	6,602	0.028	185	0.8	**148**	**1.23**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.8	21,620	0.2	4,324	0.028	121	0.8	**97**	**0.81**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.7	18,917	0.2	3,783	0.028	106	0.8	**85**	**0.71**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.6	16,215	0.2	3,243	0.028	91	0.8	**73**	**0.61**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.5	13,512	0.2	2,702	0.028	76	0.8	**61**	**0.50**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.4	10,810	0.2	2,162	0.028	61	0.8	**48**	**0.40**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.3	8,107	0.2	1,621	0.028	45	0.8	**36**	**0.30**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.2	5,405	0.2	1,081	0.028	30	0.8	**24**	**0.20**
120	0.7	84	4596	193,032	0.35	67,561	0.4	27,024	0.1	2,702	0.2	540	0.028	15	0.8	**12**	**0.10**

Survival assumption basis by column:

d - from winter run JPE - LSNFH 2013 brood average

f - literature has range of values; jpe uses 27% egg to Red Bluff Diversion Dam survival

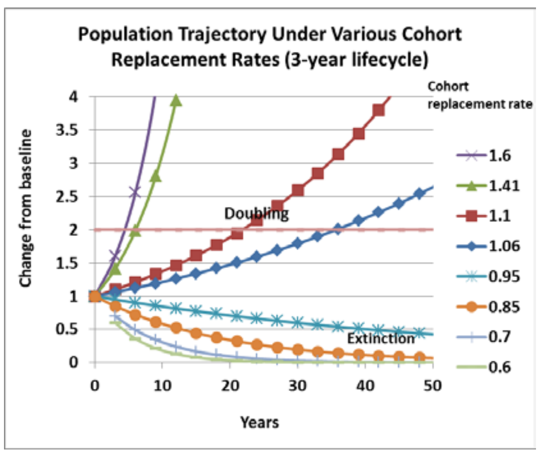
h - BPJ average assuming that many will emigrate as fry but hopefully a proportion will rear in-river (resulting in lower in-river survival) and get larger before heading downstream where conditions not as favorable

j - variable collection survival - closer to the 0.1 range for the initial test if screw traps used

l - fry to smolt in mid sac = 0.59 and migrating smolt to delta = 0.39 for a river to delta survival of 0.23 (updated to 0.27). Using 0.2 survival Keswick to ocean because emigrants assumed to be larger; reality may be lower (LS hatchery release survival assumed to by 0.16 in JPE)

n - based on 20 years of adult production data and known hatchery release numbers at Carquinez Strait - described in analysis for killer whale effects for 2009 BO

p - from NMFS winter-run cohort reconstruction for analysis of ocean fishery impacts - average for 1998 - 2005 brood years



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Chapter 6
Fish Passage Option Evaluations

Fish passage technologies are broken down into those to be used for the Pilot Program and those for long-term reintroduction. For the Pilot Program, fish will be transported in trucks in both the upstream and downstream direction around Keswick and Shasta dams. During this phase, an investigation of the feasibility of technologies to be used for long-term reintroduction, including volitional passage, will also take place. As a first step, the Fish Passage Technology Subcommittee (Technology Subcommittee) developed potential alternatives for upstream and downstream passage and the technologies used for each.

Below is a description of the technologies that will be used for the Pilot Program as well as those that could be used for long-term reintroduction.

Pilot Program – Upstream Passage Options

Collection and Transport

Collection and transport methods allow reintroduction to target specific sites for release. For example, spawning adults could be released into the highest quality habitat or dispersed among several upstream areas. Collection and transport options may provide a degree of flexibility to adjust release locations, depending on availability of access roads (or other means) to deliver fish to specific release locations. Maintaining water quality during transportation is also a concern with collection and transportation of fish, particularly water temperatures and dissolved oxygen. Fish may experience thermal stress if the water warms up during transport and the water temperature in the transport tanks is not close enough to the water temperatures at the release location. Therefore, emphasis would go into fish transport vessels equipped with life support systems, and acclimation facilities potentially needed at release sites.

If adults from the Sacramento River are transported, the migrating adult Chinook Salmon will be collected at the existing fish trap at Keswick Dam and will be transported by truck to Livingston Stone NFH. From Livingston Stone NFH, adults, juveniles, or eggs will be transported to release, rearing, or incubation sites on the Upper Sacramento and McCloud rivers.

Release, Rearing, and Incubation

The Technology Subcommittee completed initial site visits at several suitable locations on the Upper Sacramento and McCloud rivers. The Technology Subcommittee, along with members of the Steering Committee, will determine which sites provide the best locations for adult release, juvenile rearing, and egg incubation. For adult or juvenile release sites where truck access to the river is limited, temporary release pipes from access points to the river may be used. The size and installation method for these temporary pipes will be determined on a site-specific basis. For juvenile rearing and egg incubation sites, details regarding equipment and water needs, and plumbing will be determined on a site-specific basis.

Pilot Program – Downstream Passage Options

Juvenile Collection and Transport

For the Pilot Program, juvenile migrant collection was initially thought to consist of a system of nets and screw traps located at the downstream end of the tributaries just upstream from Shasta Lake. However, since screw traps are designed for sampling portions of a population and not 100 percent collection, other technologies that may provide higher collection efficiencies were investigated. The Technology Subcommittee and Steering Committee completed initial site visits in June 2015 and selected locations which would be suitable for trap installations.

Pilot Juvenile Collection Methods

In the judgement of the technical team, juvenile salmon survival through Shasta Lake to a juvenile collection system at or near the dam is likely to be low. Therefore, juvenile collection in the pilot program will focus, at least initially, on collection in or near the mouths of the tributary rivers. The initial configuration involves testing of pilot juvenile collection methods both at the head of the reservoir and in the tributaries. With the uncertainty in collection efficiency for untried juvenile collection methods both locations will be tested concurrently to maximize collection efficiency and potential learning. Trap efficiency tests will initially be conducted with test fish and will occur over the range of flows available at the time. Hydraulic performance will be measured as part of the trap testing.

Head-of-reservoir Juvenile Salmon Collection

The juvenile collection system for the head-of-reservoir consists of an inclined plane collector with guidance nets and a temperature curtain that would collect juveniles within approximately one-half mile of where they enter the reservoir from the river. This system will be installed within the lake impoundment. The collector, nets, and temperature curtain would be mobile. The system would be moved to maintain proper hydraulic conditions as the head-of reservoir location moves with changes in reservoir water surface elevation, perhaps at quarter-mile increments. The initial collection season is expected to be approximately August through December and will be adjusted as needed based on migratory timing of the juvenile salmon. During this period the reservoir elevation will be dropping in the first part of the collection season so the collector would be incrementally moved in a downstream direction. As the reservoir fills the collector would subsequently be moved in an upstream direction. The collector is anticipated to be movable in a day and and moves would occur during during daylight hours of days with stable flows. Movements will be timed to coincide with periods expected low numbers of fish emigrating when possible to reduce fish escaping past the trap.

Shasta reservoir is stratified in the late summer and fall with the surface water temperature higher than the optimal temperature for salmonids. Clancy (2016) modeled head of reservoir conditions in Shasta Reservoir and found that a temperature curtain would provide cooler water temperatures upstream of the curtain. The temperature curtain is intended to retain cold water entering from the tributary river upstream of the curtain providing cooler surface water conditions than would otherwise exist. This is intended to enable salmonids to utilize the surface water where the trap is located. Once captured the water temperature at the trap would be cool enough to ensure their survival. The temperature curtain will only be used when needed to maintain suitable temperatures or water velocities past the trap. The stratification near where tributaries enter lake is variable depending on tributary flow, local topography and weather conditions such that the temperature curtain may not be needed in some years. The temperature curtain would be removed or pulled to the side of the arm during periods of flow exceeding design criteria. In general, once higher flows occur from the tributaries water temperatures are cooler and a temperature curtain would no longer be needed for the remainder of the season. Drawings of this system are shown in Figures 6-1 through 6-6. Flexibility is being designed into the system so that configuration changes can be made as needed to improve trapping efficiency.

Key features of the head of reservoir juvenile collection system include:

- A debris boom upstream of the trap
- A guidance net to block 100% of the reservoir cross-section and guide juveniles into the trap
- A floating trap that will have:
    - a deflector to help keep debris out the live box
    - a vertically adjustable inclined plane entrance
    - a live box area that can be adjusted to have several different configurations of live boxes (upper and lower and/or front and back) with slots for gates, separators, etc.
    - juvenile refuge baskets in the live box
    - a removable back panel to allow for ease of cleaning
    - a large working platform with hatches to allow for easy access to all areas of the trap

- Upstream and downstream passage features for resident fish species via a passage cone near the bottom for upstream passage and through the trap for downstream passage.
- A temperature curtain, if needed, at or downstream of the collector to keep warmer reservoir water downstream and cooler river water upstream of the trap
- Provisions for monitoring fish activity in and near the trap via video or other means.

Portability - as the debris boom, net, trap, and temperature curtain will need to be moved periodically as the reservoir elevation drops or rises during the collection "season"

Collector live box features unique to the design include:

- Predator exclusion immediately upon entry through the "horizontal separator." This separator would be a rack with small spaces between the bars to allow juvenile salmon to pass, but not some of the larger predators. Constructing multiple separators, each with a different spacing (perhaps 1/2", 5/8", and 3/4"), will allow testing to determine which spacing works best.
- Larger predators and debris are directed along the separator and through a 6" opening and into the upper live box. Also within this box would be juvenile refuge baskets for any salmon that did not pass through the horizontal separator.
- Juveniles pass through the separator into the lower area of the trap, and move downstream through the mesh cone into the lower live box. The lower box also contains refuge baskets, to allow juvenile salmon to escape other fish that were able to pass through the separator.
- Both live boxes in this concept would be 18 inches deep, 4 feet long, and 3 feet wide.
- The general idea for trap servicing is:
    - Sliding gates are installed at the front and back of the separator.
    - Predators and debris are removed from the upper rear live box, and then the refuge baskets in this box are slowly removed, allowing the juvenile salmon to swim out and be collected.
    - After clearing the upper live box, the larger fish are removed from the area above the separator. Then the horizontal separator is removed and the remaining fish are collected or crowded towards the mesh cone.

- To access the lower live box and process the fish, the floor of the upper live box and the mesh cone are removed. Then the remaining fish are collected and separated. The live box could be outfitted with a false mesh bottom or something similar that could be raised to reduce the depth of water from which the juveniles would be collected.

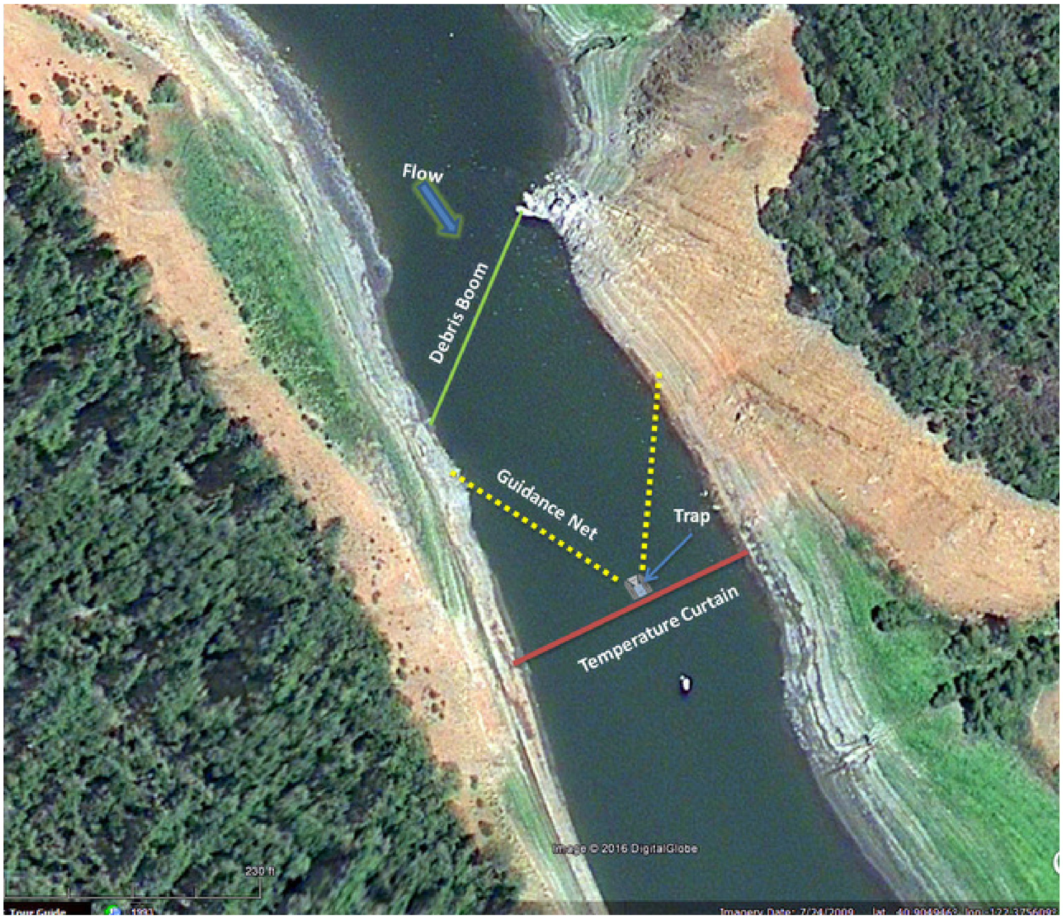
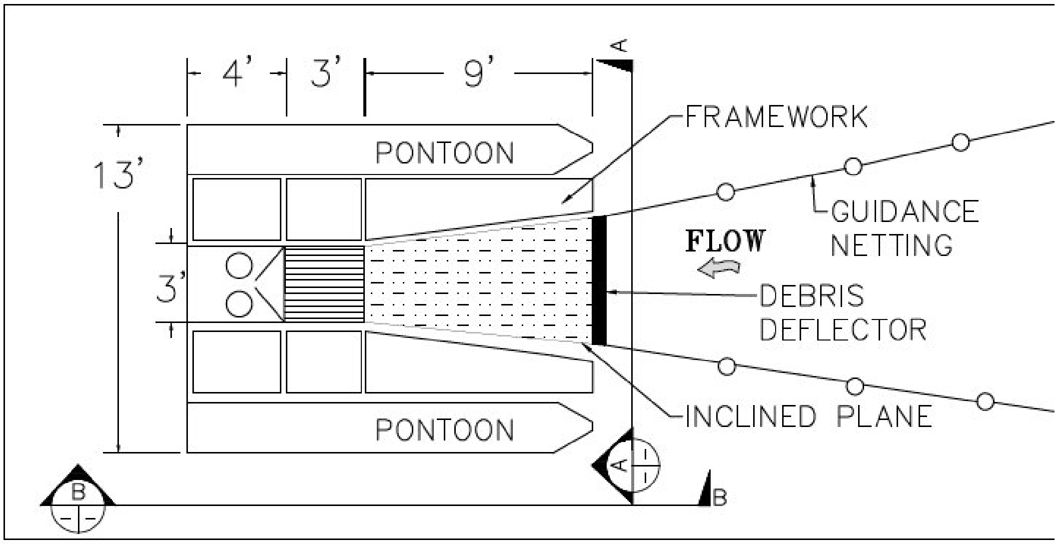
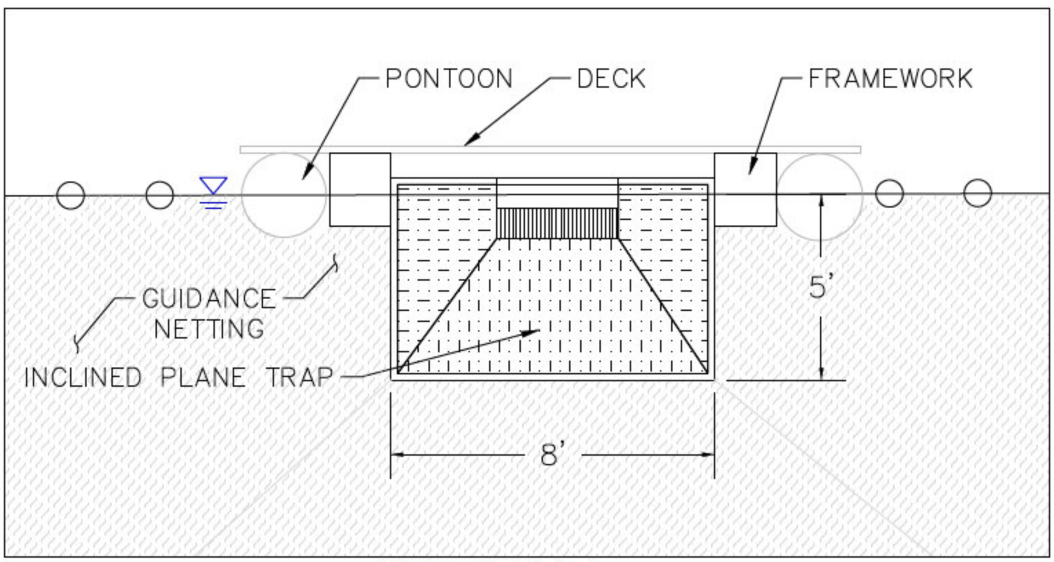


Figure 6-1. Aerial schematic of head of reservoir juvenile collection system configuration.



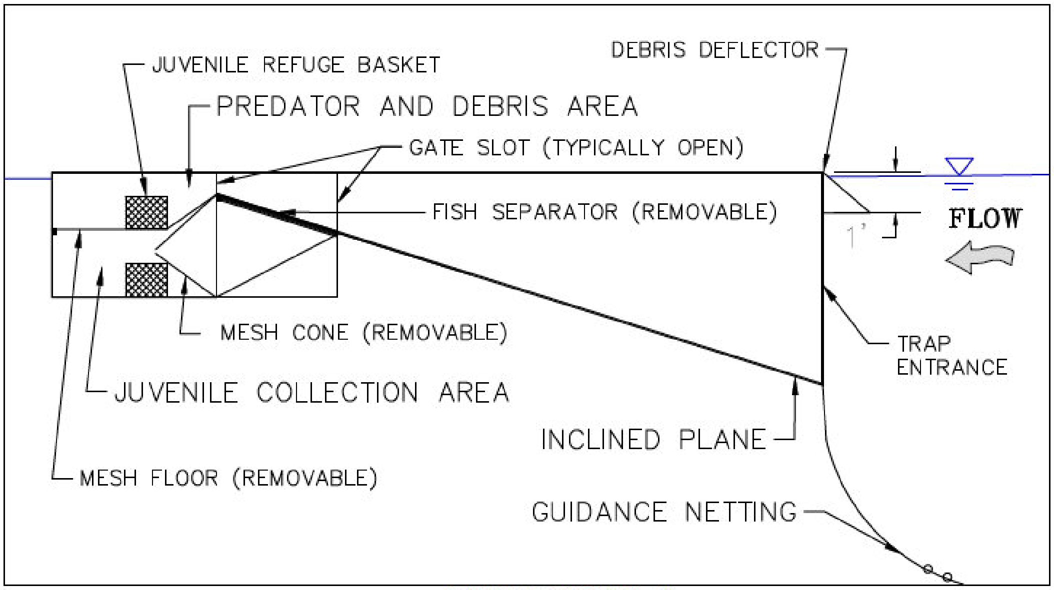
COLLECTOR PLAN VIEW

Figure 6-2. Juvenile collection trap plan view (looking down from above).



PROFILE VIEW: A - A

Figure 6-3. Juvenile collection trap profile view from the front.



PROFILE VIEW: B - B

Figure 6-4. Juvenile collection trap profile view from the side.

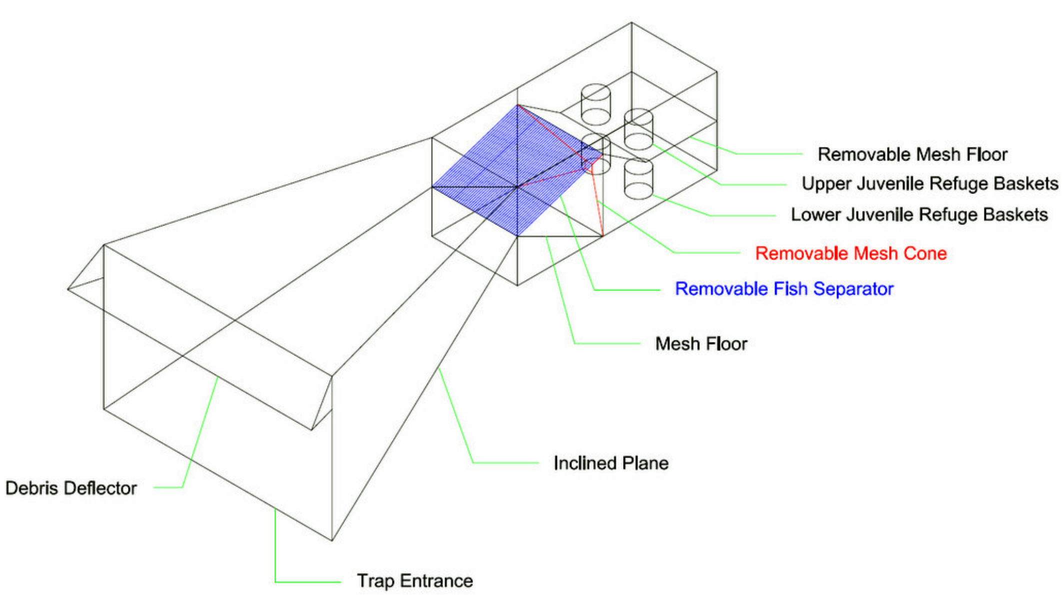


Figure 6-5. Juvenile collection trap schematic.

In-river Juvenile Collection

The in-river juvenile collection system will be of the same general design as the head of reservoir collection. The scale will be smaller with a smaller trap and no temperature curtain will be needed. The system will initially be installed in an appropriate location in the tributary, near the upstream extent of Shasta

Reservoir.Figure 6-6 displays locations considered for collection sites. The in-river collection system will target collection of juveniles at river flows up to at least 500 cfs. When flows exceed 500 to 1,000 cfs it is expected that the netting will need to be removed and the primary collection would occur at the head of reservoir location. The system will be flexible so that the configuration can be modified to maximize juvenile collection efficiency.

The collector will consist of guidance nets leading from either bank to a small floating fish trap located in the center of the river. A floating debris boom will extend across the channel upstream of the guidance nets to help deflect debris away from the trap (Figure 6-7). Debris will be collected from the end of the boom and released on the downstream side of the guidance net. The trap itself will consist of a net transition cone that leads into a live box (similar to a fyke trap), with pontoons on both sides to keep it afloat (Figure 6-8). Passage for resident fish is not shown in the figures, but will be included in the design to minimize impacts to the fishery and comply with the State's McCloud River resource protection code. With this design, launching and retrieving the trap is anticipated to be low-impact. All materials used during trapping would be temporary, and could be pulled from the river before anticipated high flow events and at the end of the trapping season.

Figure 6-6. Locations considered for in-river juvenile collection in the McCloud River. The bridge in the photo is the Fenders Ferry road bridge across the McCloud River.

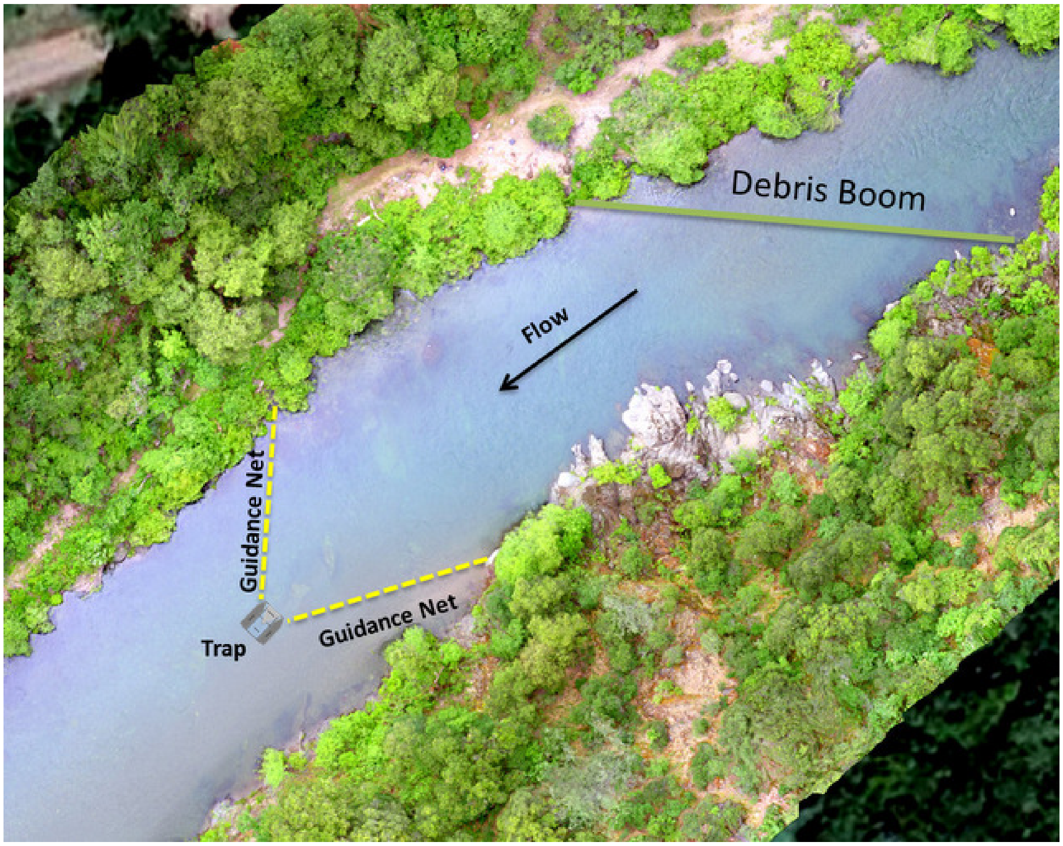


Figure 6-7. In-river collection configuration (not to scale). Location will be shifted as needed based on site specific conditions.

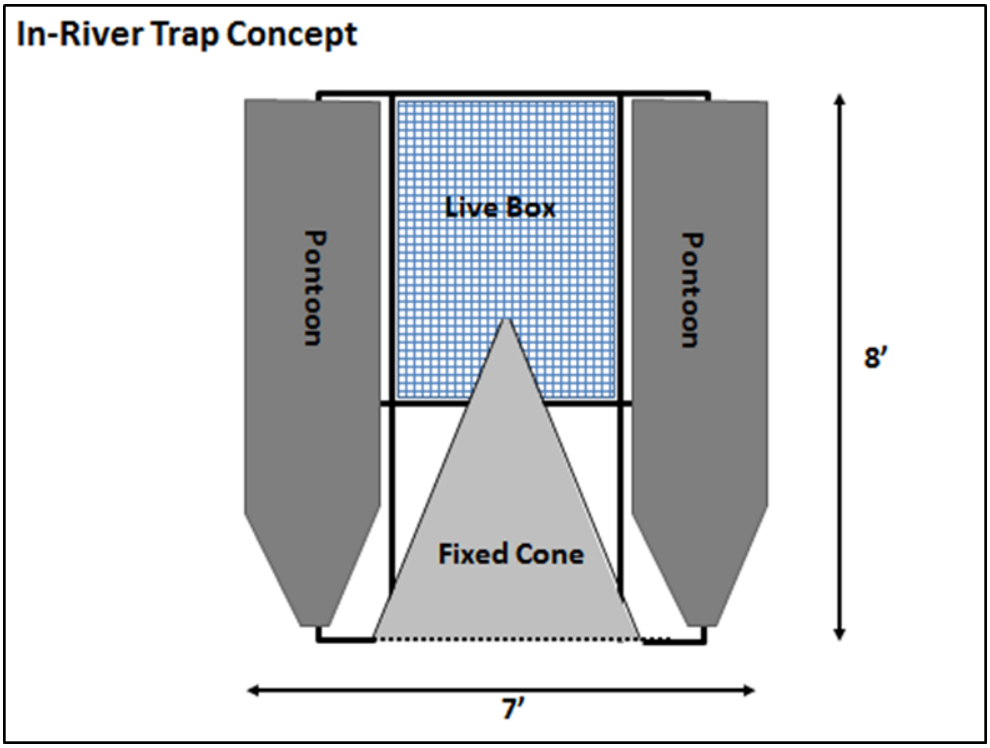


Figure 6-8. In-river trap diagram.

Features common to both collection systems

- Debris boom upstream of collector to reduce floating debris reaching the guide nets and trap. Debris would be removed from the boom as needed to maintain trapping operations

- Upstream and downstream fish passage around the installation for resident fish species.

- Provisions for recreation users to safely pass the sites. Warning signage would be provided. If safe boating conditions exist upstream of the in-lake site then passage for boaters would be provided. If water depth precludes safe boating upstream then boat passage may not be allowed. Portage may be needed for kayakers and rafters passing the in-river site.

- Provisions for moving captured juvenile salmon from the trap to the transport vehicle or vessel.

- Provisions for marking or otherwise identifying juvenile salmon passed downstream of Keswick upon their return as adults

Juvenile transport

Fry and/or juveniles will be transported in the Pilot Program (See Chapter 7). Key assumptions for juvenile transport include:

- Vehicle or boat access is available at the collector sites
- Transport containers are equipped with aquacultural life support systems
- Juveniles are segregated by size within transport containers
- Acclimation facilities are provided when necessary, to manage and minimize stress during transitions of loading and unloading fish

Once the fish are captured, they would be held for a period of time. Fish could be held on or at the trapping facility, moved directly to holding ponds or tanks on shore or to a transport vehicle.

Juveniles transported to a release site downstream from Keswick will be marked or tagged if possible, depending on the size of the fish (e.g., PIT tag, fin clip, coded wire tag), in coordination with other Federal and State programs, so that these fish can be identified as the reintroduced fish upon return to freshwater. Genetic identification methods may also be used.

Transporting juvenile Chinook Salmon for release is a common management practice throughout the Pacific Northwest and the Central Valley to mitigate fish passage impediments and unfavorable environmental conditions along portions of juvenile salmon emigration routes in spawning streams. Juvenile Chinook Salmon are transported downstream from hatcheries for release in California, including the Coleman NFH, and State salmon hatcheries on the Feather and Mokelumne rivers.

Additional Alternatives Considered

Additional alternatives, including volitional passage, were considered but eliminated for near term implementation as pilot study actions. The purpose of the Pilot Program is to evaluate the feasibility of establishing self-sustaining populations of ESA listed Chinook Salmon in the Upper Sacramento and McCloud rivers above Shasta Lake. The Pilot Program seeks to do this by evaluating various aspects of reintroduction including the biological and technological challenges. The Pilot Plan is the first step of an adaptive management approach for evaluating the feasibility of reintroducing ESA listed Chinook Salmon into their historical habitat above Shasta Lake.

Alternatives have been proposed for providing volitional passage around Shasta and Keswick dams during this pilot phase of the project. An alternative that utilizes Sacramento River tributaries downstream of Keswick Dam as an upstream and downstream passage route for adults and juveniles has been proposed. Stillwater Creek, Cow Creek, Little Cow Creek, or Dry Creek could potentially provide a volitional adult passage route to the McCloud River via connection to Shasta Lake. Churn Creek could provide volitional adult passage to the Upper Sacramento River via connection to Shasta Lake. A seasonal dam, collection facility, and pipe could potentially provide volitional juvenile salmon passage from the McCloud River to below Shasta Dam (through a tributary creek).

On February 1, 2016, the Winnemem Wintu submitted comments on the Pilot Plan including a draft proposal. Details on the draft *Winnemem Wintu Salmon Restoration Plan* proposal can be found in Appendix C to the EA.

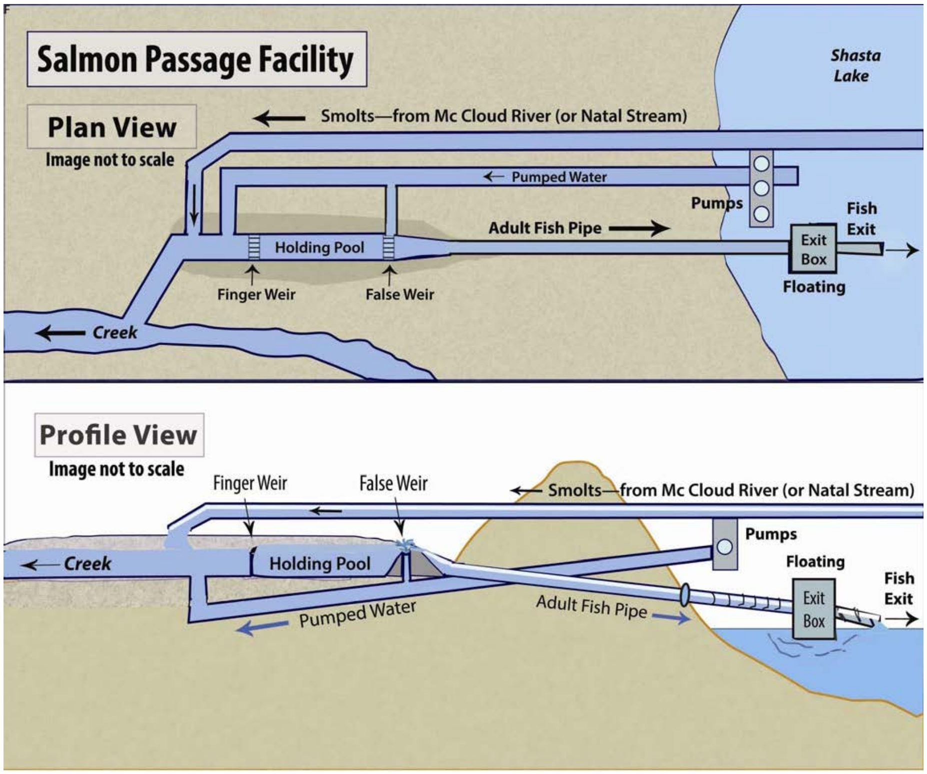


Figure 3-9. Volitional salmon passage facility (Winnemem Wintu 2016).

In the RPA Action V, NMFS included the objective of identifying volitional downstream passage scenarios. If these options are not considered technically and economically feasible and biologically justified, Reclamation and the steering committee shall identify interim non-volitional alternatives that are determined to be technically and economically feasible and biologically justified.

The pilot program is a "feasibility study" intended to determine whether a long-term fish passage program should be implemented. Volitional passage, where adult and juvenile fish are able to complete their upstream and downstream migrations and reproduce under their own volition, would be a preferred option for sustaining the population over the long term. A large construction and water re-routing project would not meet the pilot program purpose and need of determining the feasibility for long-term passage. Volitional passage options would be thoroughly studied as a long-term passage solution during the pilot study as the IFPSC determines whether long-term passage would be feasible. A lot has changed since wild Chinook Salmon last had access to the habitats upstream of Shasta Dam. An up-front question needing to be answered in the pilot program is whether the existing state of the habitat and the species present upstream of Shasta Dam would enable a highly productive salmon population to be sustained over time if a successful passage route can be provided. Constructing permanent fish passage facilities before determining the productivity of the habitat could be considered a premature expenditure of irretrievable resources.

During the Pilot Program, Reclamation shall evaluate adult reintroduction locations, techniques, survival, distribution, spawning, and production, and juvenile rearing, migration. Under RPA Action V (NF 4.1), Reclamation, with assistance from the Steering Committee, shall design, construct, install, operate and maintain new or rebuilt adult fish collection, handling, and transport facilities. The objective is to provide interim facilities to pass fish above project facilities and reservoirs. In near-term action NF 4.3, NMFS describes the use of upstream fish passage for adults via trap and transport facilities, while Reclamation conducts studies to assess volitional alternatives.

NMFS considers volitional passage via a fish ladder or other fishway to be the preferable alternative in most circumstances. In the short term, upstream passage can be provided with fish trap and transport mechanisms, while Reclamation evaluates program effectiveness and passage alternatives.

No salmonid fish passage projects at high head storage dams (i.e. dams higher than about 200 feet hydraulic head and without flowing water through the upstream body of water) have successfully provided volitional passage despite the strong desire for such an option to be devised. Shasta Dam provides several unique challenges (height of 602 feet; large, fluctuating reservoir) towards volitional passage that would need to be investigated.

Long-Term Reintroduction

The pilot program is a study of the feasibility of a long-term reintroduction program at Shasta. As part of the Pilot Program, the Technology Subcommittee will develop a summary report describing potential technologies to pass salmonids. Additionally, the Technology Subcommittee will investigate the potential alternatives for long-term reintroduction to develop a technical report detailing their feasibility for the long-term reintroduction. This includes volitional and non-volitional options described below. For each potentially viable alternative, the report will provide the following:

- A description of how each alternative could work
- Conceptual drawings
- Operations and maintenance requirements

- Cost estimates (capital and operations and maintenance, including inflation)
- A discussion of pros and cons, especially those related to life stage needs
- Potential impacts to stakeholders (water supply, flood, recreation, tribal, aesthetics, fishing)
- Water requirements (from Shasta Lake)
- Routing options for downstream and/or upstream passage
- Flexibility of operation, especially given variable hydrology and reservoir elevations
- Energy usage
- A description of similar technologies and where they are currently being used (with photos)
- Level of design and construction effort

Each conceptual fish passage alternative from the matrix that could be used for long-term reintroduction is described briefly below. Please note that more alternatives could be added or that concepts could change during future development. Additional studies that are not system specific will be conducted during the Pilot Program, and are further described below.

Any long-term reintroduction would require additional environmental analysis and documentation. This would be developed from the results of the Pilot Program, including technical report on long-term reintroduction alternatives.

Types of Passage

Upstream adult fish passage and downstream juvenile fish passage methods will be investigated. The technical report will include details on volitional and non-volitional forms of fish passage. NMFS identified in the RPA and Recovery Plan that volitional passage is the preferred method for long-term reintroduction. The Pilot Program will be utilized to determine the feasibility of different types of passage for long-term reintroduction.

Types of Tanks, Truck Versus Boat Transport

The types of tanks that are available for the transport of fish will be investigated as part of a potential collector system development. This would include looking at trucks with permanent tanks and also tanks that are portable, such as those that sit on a flatbed truck. A determination will be made as to which would be best for the long-term reintroduction. In addition, the best method for transporting fish; volitional, truck or boat/barge will be investigated. Boat or barge transportation will likely be required for any in-reservoir collection technologies to get the Chinook Salmon juveniles from the collector to the truck. In these cases it may be more feasible to leave the fish on the boat/barge all the way to an established ramp or transfer facility near Shasta Dam.

Stress Relief/Acclimation Areas

Some fish passage facilities in the Pacific Northwest use stress/ acclimation facilities (e.g., tanks, net enclosures, pond) to allow juveniles a place to recover from their journey before their release into the river downstream from the lowest dam in the system. These allow the juveniles to volitionally leave the area on their own after they have recovered. The proper design and location for the stress relief area will be determined during the planning process.

Upstream Passage Options

Collection and Transport from Keswick Dam

Adult migrants would be collected at the existing trap at Keswick Dam, transported to a sorting location, such as Livingston Stone NFH, and the selected fish transported by truck to release sites on the Upper Sacramento and McCloud rivers. Boats or barges could be used as part of the transport process.

Natural Channel Using Downstream Tributaries

A tributary downstream from Keswick Dam, such as Little Cow Creek, Stillwater Creek, or Churn Creek, would be used to route adult migrants upstream to a location close to and higher in elevation than Shasta Lake. Fish would then be attracted or enticed into a pipe that would transport them by gravity flow down to the reservoir. This has the potential to be a volitional alternative, would require a constant flow from Shasta Lake, and would need to be able to handle large reservoir fluctuations.

Volitional Passage over Keswick and Shasta Dams

Adult migrants would pass the dams using a combination of fish ladders, long low gradient transport channels, and nature-like channels. This alternative would allow fish to exit the passage channels directly into the reservoir or tributaries. A constant flow from Shasta Lake would be required and the exit would need to be configured to handle large reservoir fluctuations.

Mechanical Passage over Keswick and Shasta Dams

Adult migrants could pass upstream at Keswick and Shasta dams through fish locks, elevators, hoppers, and/or trams. This is a semi-volitional passage alternative and would require water from Shasta Lake to attract fish into the device. It would also need to be able to handle large reservoir fluctuations.

Downstream Passage Options

Juvenile Bypass Pipe

A seasonal dam and collection facility would be built in-river. Juveniles would be allowed to access a pipe connecting the river to below Shasta Dam (through a tributary creek). This method is utilized, along with trucks and barges, on the lower Columbia River to bypass run-of-the-river dams with hydropower facilities.

Floating Surface Collector System near Shasta Dam

Juveniles would be collected in a floating surface collector located near Shasta Dam and similar to the ones used at the Baker reservoirs in the Pacific Northwest. After collection, the fish will pass the dams either in a truck or by bypassing them into one of the tributaries downstream from Shasta Dam (Little Cow Creek, Stillwater Creek, or Churn Creek). For those loaded on a truck, fish will be released into stress relief ponds located below Keswick Dam if needed. After an acclimation period in the ponds, tagged fish will be released into the lower Sacramento River.

Floating Surface Collector System at Head of Reservoir

Juveniles would be collected in a floating surface collector located at the head of the reservoir where the tributaries enter. This floating surface collector would likely be similar to the ones used at the Baker reservoirs in the Pacific Northwest. A smaller floating surface collector, similar to the one being used at Cougar Reservoir, could be used instead of a larger one. After collection, the fish will be loaded onto a boat or barge for transport to a truck. After being loaded on a truck, fish will pass Shasta and Keswick dams and be released into stress relief ponds if needed. After an acclimation period in the ponds, tagged fish will be released into the lower Sacramento River.

Permanent Collection Facility at Head of Reservoir

A new low-head dam would be constructed near the full-pool elevation of Shasta Lake to create a small permanent reservoir for collecting fish. This facility would have the capability to operate regardless of the water surface elevation in Shasta Lake. The new dam would have a fish collection facility that could handle most of the water that enters from the tributary, a spillway to handle excess flow, guidance nets, a fish ladder to pass lake fish upstream and down, and debris handling facilities. The collection facility would be a gravity flow system. After collection, the fish will be loaded onto a truck, driven past Shasta and Keswick dams, and released into stress relief ponds if needed. After an acclimation period in the ponds, tagged fish will be released into the lower Sacramento River.

Permanent Collection Facility in Tributary

An inflatable dam would divert water and fish into an off-channel permanent facility for collecting fish. The fish would be screened into holding tanks and the water would flow back into the tributary just below the inflatable dam. The collection facility could be placed on the outside of a river bend to enhance entrainment. Since it is in the tributary, this facility would have the capability to operate regardless of the water surface elevation in Shasta Lake. The collection facility would be a gravity flow system. After collection, the fish will be loaded onto a truck, driven past Shasta and Keswick dams, and released into stress relief ponds, if needed. After an acclimation period in the ponds, tagged fish will be released into the lower Sacramento River.

Temporary Collection Facility in Tributary

A temporary barrier, such as one using pickets, would divert fish with a small amount of water into an off-channel facility for collection. The fish would be screened into holding tanks and the water would be put back into the tributary just below the inflatable dam. The collection facility could be placed on the outside of a river bend to enhance entrainment. Since it is in the tributary, this facility would have the capability to operate regardless of the water surface elevation in Shasta Lake. The collection facility would be a gravity flow system. After collection, the fish will be loaded onto a truck, driven past Shasta and Keswick dams, and released into stress relief ponds, if needed. After an acclimation period in the ponds, tagged fish will be released into the lower Sacramento River.

Behavioral Guidance Collection Facility in Tributary

Fish would be diverted into an off-channel collection facility by using a behavioral guidance barrier (louvers, light, sound, bubbles) or a natural river feature (constriction or outside bend). The fish would be screened into holding tanks and the water would be put back into the tributary just below the inflatable dam. Since it is in the tributary, this facility would have the capability to operate regardless of the water surface elevation in Shasta Lake. The collection facility would be a gravity flow system. After collection, the fish will be loaded onto a truck, driven past Shasta and Keswick dams, and released into stress relief ponds, if needed. After an acclimation period in the ponds, tagged fish will be released into the lower Sacramento River.

Chapter 7 Colonization and Biological Feasibility Evaluation

The following section describes three years of planned investigations of implementation options based on different life stage colonization strategies during the Pilot Program. Existing information on key aspects of each life stage relevant to their reintroduction into historical habitat and forming the basis of pilot-level colonization strategies is provided in Chapter 3. For each life stage, key questions are listed, in a priority order, based on the most important uncertainties concerning reintroduction focused on winter-run Chinook Salmon as determined by the Pilot Planning Subcommittee. Metrics to address key questions are identified along with potential approaches for their evaluation. Finally, pilot studies and methodologies that will provide information to address the key questions are described.

A preliminary sequence of colonization experiments and technical evaluations is provided for the first three years of the Pilot Program, beginning with fry or juvenile releases in the first year (Y1), fry or juvenile releases as well as in-stream and/or streamside egg incubation in the second year (Y2), and juvenile releases, instream and/or streamside egg incubation, and adult releases in the third year (Y3). It is not expected that all of the Pilot Program options and pilot studies will be conducted in Y1, and some options may not be exercised at all during the Pilot Program, depending on availability of experimental fish and lessons learned; however, any reintroduction options and studies not pursued during any one year of the Pilot Program may be considered at any time during other phases of the overall Reintroduction Program. Chapter 8 lays out a recommended time line for pilot studies described here that are anticipated to be implemented in the first three years. Figure 7-1 displays a conceptual depiction of factors influencing Chinook Salmon survival upstream of Shasta Dam with a focus on juvenile downstream survival through the system to the lower Sacramento River. This framework is being used to integrate the project into a winter-run Chinook lifecycle model near completion covering the areas below Keswick Dam.

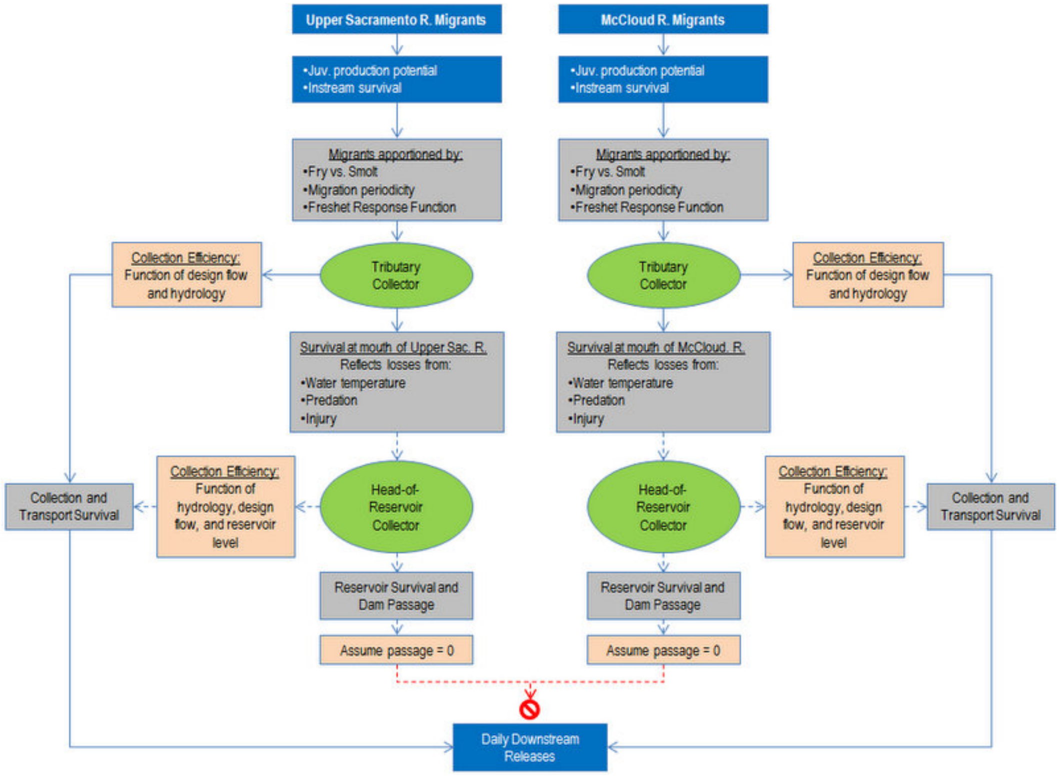


Figure 7-1. Conceptual framework of downstream passage routes, facilities, and performance metrics associated with the reintroduction of Chinook Salmon upstream of Shasta Dam.

Year 1

Life Stage Key Questions

The following key questions are listed below for the juvenile life stage colonization strategy. Some or all of these questions may be addressed in the first year of fish release (Y1); however, some questions may need to be addressed in the subsequent years of the Pilot Program. Additionally, depending on the outcomes of the pilot studies, some of the questions may be deemed no longer important enough to be addressed by the Pilot Program or even for the overall Reintroduction Program:

1. What are the recovery efficiencies of pilot study juvenile collection device (e.g., rotary screw traps (RST), floating incline plan traps, fyke traps)?
2. Where is the most suitable collection location to capture juveniles (e.g., accessibility, handling transport survival, lowest stress on fish)?
3. If juvenile recapture efficiencies from Y1 are poor, how can they be improved?

4. Where are the most suitable release locations for fry or juveniles (e.g., accessibility, handling transport survival, habitat conditions)?

5. How well do the juvenile fish handle the transport and release process?

6. What is the survival of emigrating juveniles transported downstream to the Sacramento River below Keswick?

7. What type of fish passage devices (singular or multiple) and collection systems can be employed to successfully capture juvenile salmon in tributary environments and what are the most suitable locations?

8. What is the timing and size distribution of juvenile/smolt migrants reaching Shasta Lake? What growth rates and conditions can be achieved?

9. What survival rates from planted fry to juvenile emigrant can be obtained in the Upper Sacramento River and McCloud River?

10. How do juvenile Chinook Salmon distributions throughout the stream progress over the rearing and emigration seasons?

11. Are there differences in the number or quality of juveniles leaving the two tributaries?

12. How do juveniles behave in response to hydrologic conditions?

13. What is the potential level of competition and predation between juvenile Chinook Salmon and resident fishes?

14. Is there a difference between the timing of emigration and fitness of in-river produced and hatchery-produced fry/juveniles?

15. What is the variation in numbers of emigrating juveniles from year to year (e.g., emigrant recruits/adult female)?

Pilot Studies

Objectives

The main objectives for the pilot studies in Y1 are to determine transport and handling survival of hatchery-released juveniles; in-river survival; size and growth rates; relative abundance; habitat use; movement in the study reach; potential for adverse competitive and predation interactions between reintroduced winter-run Chinook Salmon and resident fishes of the Upper Sacramento and McCloud rivers.

The number of successfully outmigrating juveniles produced during the Pilot Program will partially determine the number of adults subsequently returning in later years to be returned to the Upper Sacramento and/or McCloud rivers. Multiple environmental and biological factors may affect juvenile production, including transport survival; water temperature; habitat quality and availability; and prey availability.

Primary Metrics

1. *Post-stocking/handling survival of hatchery-released juveniles (48 hour post release mortality)* – transportation of juveniles is a common practice, and handling techniques are well established; therefore, it is anticipated that the survival rate will be high. A 48-hour post-release survival ratio will be used for this metric.

2. *Change in size over rearing season and at outmigration (growth rate)* – juvenile Chinook Salmon should be healthy and achieve growth rates within the natural range of variability for natural populations. Length frequency statistics and trend analysis along with otolith analyses of daily growth rates for subsamples of fish collected periodically will be used for this metric. Additionally, length and weight measurements will be used to evaluate condition indices for comparison of intra- and inter-annual growth patterns and for comparison with other populations of Chinook Salmon.

3. *Relative abundance along study reach* – because Chinook Salmon have not inhabited the Upper Sacramento or McCloud rivers since the 1940s, patterns of habitat use are unknown for these fish. Systematic surveys of the occurrence of juvenile Chinook Salmon along the Study Area will be used to develop frequency of occurrence curves across key habitat parameters and compute habitat preference statistics. Distribution will be influenced by juvenile release and adult spawning locations so this information would be updated as more natural spawning and emergence occur in the river.

4. *Relative abundance among rearing habitats* – see description for metric 3

5. *Outmigration patterns and associations with time, fish size, river flow, water quality, and weather* – because Chinook Salmon have not inhabited the Upper Sacramento or McCloud rivers since the 1940s, the patterns of movement and migration timing is unknown. Systematic spatiotemporal monitoring of abundance at fixed locations along the Study Area and monitoring of temporal patterns of occurrence and abundance at downstream migrant trapping stations near the head of Shasta Lake will provide juvenile movement metrics.

6. D*istribution and relative abundance of resident fish along study reaches*

7. *Distribution and relative abundance of potential native and non-native predators of Chinook Salmon along study reaches*

8. *Habitat overlaps between resident trout and reintroduced winter-run Chinook Salmon*

9. *Size and growth of resident trout*

10. *Chinook Salmon movement through Shasta Lake*

General Approach and Methodologies To address the Pilot Program study objectives for juvenile salmon, a combination of different monitoring and analytical techniques will be necessary to obtain data and information for the selected metrics. Decisions have not been finalized by Federal and State fishery management agencies about availability and appropriateness of specific life stages to use for reintroduction of winter-run and spring-run Chinook Salmon to the two tributaries above Shasta Lake; accordingly, Pilot Program study approaches assume that release of hatchery-reared juveniles, as well as natural production from eggs or adult salmon transported to the Study Area in subsequent years may occur during pilot studies. Additionally, some evaluations of transport and handling procedures and collection trap efficiency calibrations will likely require use of surrogate Chinook Salmon, at least during the early years of the Pilot Program. Surrogates would be from a triploid source, likely from Coleman Hatchery, meeting state of California guidelines.

Since some handling and transport-related mortality of released hatchery-reared juvenile fry and parr salmon can be expected, samples of fish from each release group will be carefully netted in the receiving water at the end of release pipes and retained in floating net-pens secured to the bank in protected location with gentle current speeds for 48 hours. Fish in the net pens will be examined daily and mortalities removed, counted and recorded. Examination and necropsy procedures for dead fish, including collecting and recording data on obvious signs of pre-existing disease and transportation-related injury, will be coordinated with Federal and State fish health specialists. Mortalities determined to be directly associated with transportation handling will be distinguished from those attributable to pre-existing causes. Data compiled will include records for hatchery lots and transportation equipment specifications for each release group. Data and summary statistics will be compiled to inform outplanting procedures and equipment design. Before release of surviving fish, a sample of 50 to 100 live fish from the post-stocking mortality net pens will be measured for fork, and total lengths and wet weight to facilitate evaluation of growth of outplanted juveniles.

Spatial distribution, habitat use, and size and growth of hatchery-reared and outplanted and naturally-produced juveniles during the period of rearing in the Study Area can be monitored using direct observation techniques supplemented by electrofishing. For this study purpose, a number of fish distribution index monitoring sites, 400 to 800 feet long and strategically located along the rearing reach, will be pre-selected and established for each study river. These monitoring sites will be selected, in consultation with Federal and State fishery management agencies, based on reach characterizations provided in Reclamation's (2014b) habitat assessment and access and personnel safety considerations. Site boundaries will be recorded using geographic positioning system (GPS) and, where possible, monuments (e.g., tree tags, reflectors, flagging, or rock tags) will be established at the upstream and downstream boundaries of each site. The relative position and distance to recognizable physical features (e.g., road crossing and gaging sites) will be recorded for each monument. Site documentation will include photographs looking upstream and downstream through the upper, middle, and lower portions of each site.

Direct observation by snorkeling is expected to be the primary technique because much of the Upper Sacramento and McCloud rivers is too deep and swift for effective electrofishing. Supplemental electrofishing and or seining can be conducted near shallower stream margins at each snorkeling site to verify species identifications and to obtain a representative number of fish for verifying lengths and to measure weights.

Snorkeling techniques will follow those outlined by Thurow (1994), Dolloff et al. (1996), and O'Neal (2007). Snorkeling surveys will be conducted during the day and be scheduled to occur when lighting and visibility are best for underwater observations at each site. The number of snorkelers and width of snorkeling lanes will be determined by the width of the channel and visibility at each survey site. Observers will identify and record counts for each fish species. Fish will be visually categorized into appropriate (e.g.50 mm-interval) interval length classes. Each observer will calibrate underwater size estimation using a ruler and record maximum visual distance for accurate determination of fish species on the field data forms.

Two to three replicate snorkeling surveys should be performed using the same observers to assess efficiency, obtain an estimate of survey variance, and determine a level of confidence for use in abundance estimation (Hankin and Reeves 1988, Slaney and Martin 1987, Snedecor and Cochran 1980). Replicate surveys should be conducted no sooner than one hour between surveys to allow for fish to resume undisturbed positions and activity within sites.

Electrofishing will be used to supplement snorkel surveys and, when employed, will follow procedures presented by Meador, et al. (1993), Reynolds (1996), Stangl (2001), and Temple and Pearsons (2007). A field crew lead operating a backpack or raft-mounted electrofisher will be accompanied by one to three netters[3]. Captured fish will be retained in aerated buckets and monitored until processed. Fish will be identified to species, measured for fork length (FL) and total length (TL), and weighed. Additionally, any mortalities and fish condition (e.g., spinal trauma, burning) will be recorded. Captured fish will be released back into the stream following processing and recovery. Seining may also be used.

RSTs, fyke nets, or other appropriate traps fitted with large live cars, and located either near or at the head of the reservoir will be required to monitor juvenile

[3] All electrofishing procedures will be conducted according to the June 2000 guidelines for safe use of backpack electrofishers in waters containing listed salmonids published by NMFS (http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf)

salmon migrating downstream toward and arriving at Shasta Lake. Additionally, a floating, incline plane collector is under consideration by the Technology Subcommittee and Steering Committee for installation at the head of Shasta Lake in study tributary arms to be used as an alternate or in tandem with in-river traps to collect juvenile Chinook Salmon. RSTs and fyke nets have a well-established history of use in most Central Valley salmon-producing tributaries (USFWS 2008). The Central Valley Project Improvement Act Comprehensive Assessment and Monitoring Program's 2008 guidelines for monitoring juvenile Chinook Salmon production will be followed for installing and operating RSTs and fyke nets in the Study Area, if used. To the extent possible, juvenile collection traps will be secured and anchored to existing large trees, bedrock, concrete-block or permanent structures using 6 to 10 mm steel cables, to avoid ground-disturbing construction activity. Details on the installation and operation requirements for the in-river and the head-of-reservoir collectors are provided in Chapter 6.

When operating the downstream migrant collecting facilities, crews will perform routine maintenance of the traps and process any fish captured daily or more often as conditions dictate or depending on the numbers of fish caught and or debris load to reduce effects (e.g. injury, mortality, etc.). Captured fish will be identified to species, measured (for SL, FL, and TL if feasible), and weighed.[4] Additionally, trap mortalities and fish conditions will be recorded. Juvenile Chinook Salmon will be treated according to final Federal and State fish management agencies' decision on downstream fish passage protocols for the Pilot Program. All other fish species captured will be released downstream from the trap following processing and recovery.

Date, time, weather conditions, and a discrete water quality sample for dissolved oxygen, temperature, and turbidity will be taken daily each at the juvenile collection facilities and weekly at various access points in the Study Area. Data collected will allow for assessment of travel time, water quality during the study, and growth (length frequencies and condition factor) during rearing in the Study Area. In addition, trap efficiencies will be determined periodically to calibrate traps for the purpose of estimating abundance of juvenile Chinook Salmon reaching each collection location.

If large enough fish are obtained for release into the Study Area, PIT tags or other marks may be used to help determine survival and growth rates of individual fish. Tags would be implanted before being transported to the tributary river.

The trap efficiency tests will be conducted periodically, when fish are being captured in the traps. Unless sufficient individuals are captured in a day for efficiency estimation (approximately 100 or more fish needed) the efficiency trials will use hatchery-produced fish from the same brood as those released into the river, if available. The trap efficiency trial fish will be released at least two

[4] Collection of the three different length measurements is a simple process that provides data for evaluating several types of growth and condition metrics

pool/riffle sequences upstream from the trapping site and will be marked for identification of captured fish at the trapping site. Trap efficiency will be determined using the ratio of the numbers of marked efficiency trial fish recaptured to that released. A minimum of five trap efficiency trials will be conducted through the trapping period with the trials timed to coincide with periods when fish are being captured in the traps to the extent possible.[5]

In anticipation of insufficient hatchery-reared juvenile winter-run Chinook Salmon being available to conduct satisfactory trap efficiency trials, the triploid Chinook Salmon will be used at a comparable fish size and range of river flow conditions to determine trap collection efficiencies; although, these trials may be scheduled at different times of the year than when the winter-run juveniles are released in the Study Area. Use of the surrogate fish will be limited to testing of fish handling techniques and to test trap collection efficiencies. Additionally, care will be used in conducting trap efficiency calibration over a range of river flows and turbidities that are comparable to those occurring during the season when winter run juveniles will be collected.

The collection facilities will be checked daily to remove debris and fish. Following collection, juveniles will be moved from the trap into an aerated cooler or live box for transfer to a transport vehicle.[6] If available, a hatchery truck or trailer (truck preferred to minimize hydraulic trauma from water movement) will then transport the fish to the predetermined release location downstream from Keswick Dam. This location will likely be consistent with those used by the Livingston Stone NFH to allow for future comparison of returns, if possible. Once at the release site, fish will be acclimatized according to standard protocol and allowed to volitionally exit the holding pen. Handling and transport will include provisions to protect captured fish from predation.

Specific technical and analytic considerations for each study objective and river is described later in this section.

To address the key questions and objectives of the Pilot Program for ecological interactions of reintroduced Chinook Salmon with resident fish inhabiting the Upper Sacramento and McCloud rivers, several focused investigations along with existing information on resident fish populations can be used. A considerable amount of information is available on fish populations of both the Upper Sacramento and McCloud rivers. State fishery management plans, specific to both rivers, include monitoring programs with abundant data on the historical and current status of the resident fish populations (Dean 2000, Rode and Dean 2004). Additionally, comprehensive, multi-year investigations on the resident fish populations and other aquatic and riparian resources have been developed under the Cantara Program for the Upper Sacramento River from 1995 to 2007 (Cantara Trustee Council 2007) and the McCloud-Pit Hydroelectric Project (FERC Project

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[5] See http://www.fws.gov/sacramento/fisheries/CAMP-Program/Documents-Reports/Documents/CAMP_Rotary_Screw_Trap_Feasibility_Report.pdf

[6] The specific protocol followed may vary dependent on specific site and safety constraints

No. 2106) relicensing studies conducted from 2006 to 2009 (PG&E 2009b). Information will be compiled from these available sources to describe the recent historical baseline for resident fish species compositions, distributions, relative abundances, and size and growth for both rivers. This existing information can be corroborated and augmented by collecting data on occurrence, relative abundance, sizes, and habitat preferences of resident species concurrently, and using the same techniques, during the direct observation and electrofishing/seining surveys described previously for the reintroduced juvenile life stage studies.

Sacramento River – Metrics 1 Through 5 The juvenile Chinook Salmon life stage monitoring methods described above will be applicable throughout the entire length of the Upper Sacramento River, where access is allowed. Release of outplanted hatchery-reared fish may occur within the thermally suitable rearing habitat from Box Canyon Dam for 23 miles downstream to near Gibson Road (RM 9); they are expected to distribute from release sites downstream throughout the study reach as they rear and begin to emigrate. Juveniles produced by natural spawning and egg incubation boxes, which will be limited to nine miles of thermally suitable spawning habitat from about the Dunsmuir wastewater treatment facility upstream to Box Canyon Dam, are expected to initially be concentrated in this reach as fry and distribute downstream throughout the study reach as they rear and begin to emigrate.

Movement Monitoring the movement and distribution of rearing juvenile salmon will be accomplished by establishing one to two survey stations within each of the six homogeneous geomorphic study reaches identified in the habitat assessment (Reclamation 2014b) and conducting snorkel surveys at monthly or biweekly intervals from late July through November, or as conditions and presence of salmon dictate. The occurrence and relative abundance at each station will be used to track the spatiotemporal patterns of distribution of juvenile salmon through the Study Area.

Habitat Use Concurrent with the juvenile salmon distribution surveys in each study reach, fish counts for each habitat type encountered will be accounted for separately. Data on physical habitat, channel metrics, and water quality will be collected at each survey site. Physical characteristics of each habitat unit in the survey site will be measured and recorded for key parameters following the procedures detailed in Reclamation's (2014b) habitat assessment. Key parameters will include unit length, unit type, average width, average depth, maximum depth, amount and type of cover, dominant and sub-dominant substrate, dominant bank substrate, channel confinement, number and size of pieces of LWD, pool-tail embeddedness, and presence and approximate area of spawning gravel. Differential occurrence and relative abundance of juvenile salmon and other species among habitat types will be determined for each survey site. Analysis of spatiotemporal shifts and differential use of habitat types by size class of fish will provide information for evaluating potential limiting factors and species interactions during the rearing season.

Survival Transport mortality will be measured following the above described procedures for each release group of hatchery-reared juvenile salmon. Both triploid fall/late fall-run Chinook Salmon and Livingston Stone NFH winter-run Chinook Salmon will be used for these evaluations. Evaluation of short-term transport mortality factors using this data may include comparison of performance of hatchery brood groups, alternative transport equipment, alternative release site configurations, and alternative pre-release acclimatization procedures.

In-river survival between release and capture at juvenile collection traps will be measured using indices and estimates of juvenile emigrant abundance at arrival in Shasta Lake as a ratio of total estimated numbers of emigrant juvenile salmon to total numbers released. If tagged fish are released, the ratio of release to recaptured fish will help determine the level of survival.

Timing Monitoring of the timing of ontogenetic development and migratory behaviors of juvenile salmon during the Pilot Program will improve understanding of habitat use, limiting factors for juvenile production, environmental cues for downstream migration, and design considerations for juvenile fish passage facilities and operations. The combination of regular spatial fish distribution surveys throughout the length of the rearing area and emigrant trapping in the lowermost reach of the Sacramento River near Shasta Lake, in the vicinity of the Fenders Ferry Road Bridge at Dog Creek, will provide data to develop an understanding of the progression of rearing and downstream migration relative to a number of important environmental correlates. Key water quality parameters, including temperature, dissolved oxygen, pH, and turbidity, and be measured daily during routine trap maintenance procedures and at upstream distribution survey sites during each fish survey. This data along with continuous flow and water temperature records at the U.S. Geological Survey gage at Delta, flow records at the Siskiyou County gage below Box Canyon Dam, and Reclamation’s thermograph array along the study reach will provide data and information for evaluating juvenile salmon migration patterns in association with environmental correlates.

Patterns of occurrence and size of juvenile salmon emigrants that can be monitored using the juvenile collection systems may be enhanced (e.g. by periodic releases of test fish) to evaluate relative abundance of the emigrants if trap efficiencies can be periodically measured over range of flow, weather, water quality and fish size conditions that occur during the monitoring season. Because relatively large numbers of juvenile salmon are required to conduct mark-recapture experiments to measure trap efficiencies over the course of a season, it is not certain at this point in the pilot study planning process whether sufficient numbers of fish will be available for trap efficiency tests. Therefore, a target of at least five trap efficiency tests using juvenile winter-run captured in the collection traps has been identified as an initial goal. Trap efficiency for abundance estimations will be supplemented by collection efficiency calibration data obtained from tests conducted with triploid Chinook Salmon.

Size Distribution The size and growth of juvenile salmon over the course of the rearing season will be tracked using the size (length and weight) data collected during distribution and habitat use surveys and at the juvenile collectors. Initial sizes of outplanted juvenile salmon and the size of fish captured in the traps will provide an overall integrated measure of growth potential throughout the river over the rearing season. Seasonal progression in size of fish observed and measured at the distribution survey sites and among habitat types will provide an indication of any size segregation of fish along the length of the rearing reach and among habitat types. An important consideration for the design of downstream fish passage facilities and operations will be the patterns and environmental associations of sizes of juvenile salmon captured at the downstream end of the rearing reach in the traps.

If tagged fish are released, growth rates can be determined for each individual fish given that the lengths at release and capture are recorded.

McCloud River – Metrics 1 Through 5 For the Pilot Program, monitoring for the juvenile salmon life stage on the McCloud River will be restricted to the reach from McCloud Dam downstream for five to six miles through USFS-owned land and the McCloud River Preserve and from Shasta Lake upstream to permitted areas on private land to just downstream from the McCloud River bridge on Gilman Road. Outplanting of hatchery-reared juveniles will be restricted to the accessible property in the upper six miles of the McCloud River. Juveniles from all three methods of colonization are expected to distribute downstream throughout the McCloud River as they rear and begin to emigrate; however, the duration that juvenile salmon will occur in any of the accessible study reaches is uncertain. Consequently, the amount of information on movement, habitat use and growth during the rearing period is expected to be limited. For purposes of the Pilot Program, juvenile life stage studies may be limited to transport and handling survival of outplanted juvenile salmon and monitoring the size and emigration timing of juveniles in the lowermost reach of the McCloud River.

Movement Monitoring the movements of juvenile salmon in the McCloud River will be confined to the vicinity of the release site of outplanted hatchery-reared juvenile salmon in the upper five to six miles and in the lower four miles of the river. Similar to the Upper Sacramento River, one to two survey stations can be established in each of these two sections of the McCloud River and surveyed at biweekly intervals from late July through November to monitor the occurrence and relative abundance of juvenile salmon. Although little will be known of the movement and habitat use of fish in the middle inaccessible reach of the river, some understanding of relative period of occupation of the three reaches could be developed and inferred from presence and duration of occupation of the uppermost and lowermost reaches.

Habitat Use Monitoring of habitat use would be limited to the uppermost and lowermost reaches of the river, and would provide similar information as described for the Upper Sacramento River.

Survival Methods used would be the same as described for the Upper Sacramento River.

Timing Methods used would be the same as for the Upper Sacramento River; however, specific progression of juvenile salmon distribution through the middle inaccessible reach would be unknown. General inference of the timing of juvenile movement through the middle reach would be possible based on the progression of relative abundances observed in the uppermost and lowermost reaches. Patterns of occurrence and size of juvenile salmon emigrants and associations with environmental correlates that can be monitored using the juvenile collection traps would be similar to that described for the Upper Sacramento River.

Size Distribution Evaluation of size and growth patterns of juvenile salmon throughout the river would be restricted to information obtained from surveys of habitat in the uppermost and lowermost reaches and general inferences about the middle reach similar to above described limitations on information for movement and timing of juvenile salmon rearing in the McCloud River. Application of information on the patterns in sizes of juvenile salmon emigrants captured in the juvenile collectors, which would be installed in the McCloud River near Shasta Lake, in the vicinity of McCloud River Bridge, and at the head of the reservoir would be similar to that described for the Upper Sacramento River.

Sacramento River – Metrics 6 Through 9 Evaluations of resident fish spatiotemporal distributions, relative abundances, and habitat preferences and overlaps with reintroduced winter-run Chinook Salmon will be conducted concurrently at the same survey stations and using the same field techniques and analytical approach as described for the juvenile Chinook Salmon life stage. Similarly, movements of resident fishes toward Shasta Lake will be monitored at the trapping stations located in the lowermost section of the Sacramento River near the Fender's Ferry Road Bridge.

Movement/Timing The occurrence and relative abundance of resident fish species, including potential juvenile salmonid predators, at each survey station will be used to track the spatiotemporal patterns of distribution through the Study Area. The frequency of occurrence and timing of various life stages of resident fishes captured in the lower reach traps will be used to evaluate potential adfluvial movements and associations with environmental correlates, including migration of juvenile Chinook Salmon, between the river and Shasta Lake.

Ecological Interactions The potential for competitive and predation interactions between resident fishes and reintroduced juvenile Chinook Salmon will be evaluated, for the purposes of the Pilot Program, by initially examining overlaps in the spatial distributions and habitat use during the rearing season by species and life stage in the various survey reaches and habitat types. Analytical techniques for comparison of habitat use and preferences by resident species and juvenile Chinook Salmon will follow the standard guidance for evaluating ecological resource selection and preferences by animals provided by Johnson (1980), Manly et al. (2002), and others.

McCloud River – Metrics 6 Through 9 Evaluations of resident fish spatiotemporal distributions, relative abundances, and habitat preferences and overlaps with reintroduced Chinook Salmon will be conducted concurrently at the same survey stations and using the same field techniques and analytical approach as described for the juvenile anadromous salmonid life stage. Similar to that described for juvenile anadromous salmonid life stage studies, these surveys will likely be conducted in the uppermost and lowermost four to five miles of the McCloud River in the Study Area. Movements of resident fishes toward Shasta Lake will be monitored at the juvenile collection stations located in the lowermost section of the McCloud River near the McCloud River Bridge at Gilman Road. Currently occurring evaluations of nutrients in the spring fed and run-off dominated streams on Mount Shasta (Lusardi et al 2016) will be coordinated to help assess current productivity and potential new sources of marine derived nutrients from salmon.

Movement/Timing Same as for the Upper Sacramento River; however, specific progression of resident fish distribution through the middle inaccessible reach would be unknown.

Ecological Interactions Evaluation of ecological interactions between resident fish and reintroduced juvenile anadromous salmonid, based on habitat use data gathered during snorkel and electrofishing surveys, would be limited to the reaches of the river accessible by project personnel, but would provide similar information as described for the Upper Sacramento River in these reaches.

Chinook Salmon Movement Through Shasta Lake – Metric 10 Migration and survival of juveniles within Shasta Reservoir would be determined by tracking acoustically-tagged fish. Approximately 100 to 500 tagged juveniles of the minimum size that can be effectively tagged (currently approximately 75 to 80 mm) would be released in groups near the mouths of the study tributary. The fish would be tracked using a combination of roving surveys by boat outfitted with a mobile receiver and stationary receivers. The size of tags would limit the lifestage that can be tracked to advanced parr. This study would attempt to determine areas of aggregation for potential within-reservoir juvenile collection and survival from the tributary mouths over time and to specific locations in the reservoir. A finding of adequate survival to aggregation locations within the reservoir could open the possibility for collecting juveniles at a single reservoir location. This would provide opportunity for using both the McCloud and Upper Sacramento rivers for reintroduction with a single juvenile collector. If the fish survive well in the reservoir to grow and become larger, they could achieve a size advantage for higher survival to the ocean when they are released into the lower Sacramento River.

Controlled Cultured Colonization – Rearing Some fry and/or juveniles may also be reared in temporary rearing facilities using Upper Sacramento or McCloud river water so as to increase the survival and imprinting. This is meant to increase the likelihood of returning adults homing to the target river, and, because there would be a concentrated number of fish, these may be used for testing collection efficiencies.

On-channel temporary rearing would be installed and operated for up to 100,000 Chinook Salmon to be reared from fry to a range of sizes between 40 millimeters and 100 mm (approximately 900 pounds). To maximize the efficiency of the rearing for the study temporary raceways would be preferred over side channel rearing. Five to seven portable 1,080 gallon fiberglass raceways or similar fabricated troughs would be provided to rear fish to release size. A flat area about 40 wide 100 feet would be sufficient to provide stable foundation for raceways and provide access for monitoring. Water supply capacity of 150 gallons-per-minute (gpm) to 200 gpm would be required. Spring sources would be preferred but pumped supplies could be developed with simple screened pump systems. Small diameter piping would be routed for water supply, drain water and fish release from the incubators to the river. Temporary security fencing around the incubators and critical water supply features would be necessary.

Year 2

Pilot studies that would be conducted in Y2 may include follow ups from findings in Y1 and the following key evaluations for the egg and larval life stage.

Life Stage Key Questions

The following key questions are listed below for the egg life stage. Some or all of these questions may be addressed in Y2; however, some may need to be addressed in subsequent years of the Pilot Program, and depending on the outcomes of the pilot studies, some of the questions may be deemed no longer important enough to be addressed by the Pilot Program or even for the overall Reintroduction Program:

1. What is the best method for eggs transplant (Whitock-Vibert box, artificial redd, tube, hydraulic egg planting/injection, streamside incubation), and which stage of egg development is most successful?

2. Where are the most suitable (e.g., accessibility, habitat conditions) locations to incubate or plant eggs?

3. What kind of survival from planted egg to juvenile emigrant can we obtain?

4. How do the McCloud and Upper Sacramento rivers compare with respect to egg productivity (egg-to-fry survival)?

Pilot Studies

Objectives

The main objectives for the Y2 pilot studies are the same as defined in Y1 and to get newly emergent fry into the river in lieu of having adults spawning in the river. Monitoring of incubation survival of transplanted eggs in streamside or in-river incubation, and emergent fry condition will be key to Y2 studies.

The highest life-stage specific mortality rate in salmonids generally occurs during the incubation period and is often related to the characteristics of the spawning habitat. Studies on salmonid spawning habitat requirements have tended to focus on stream depth, velocity and physical properties such as water temperature, substrate size and composition. However, other physical and biological habitat features such as water quality, interspecies interactions, overhanging vegetation, woody debris and undercut banks affect spawning site selection (Quinn 2005, McRae et al. 2012). Cover features have the potential to provide protection from predators as well as protection from adverse stream conditions, such as high stream velocity.

Egg-to-fry survival is an important vital rate as a high mortality in these early life stages can often result in subsequent low adult returns and a reduced likelihood of Reintroduction Program success.

The primary goal of controlled egg introduction is to get known numbers of newly emergent Chinook Salmon into the river so that an accurate estimate of survival of the fish down the river to the collection locations can be obtained.

Primary Metrics

The first 10 metrics are described under Y1

11. *Number of emergent fry entering river* – in-river survival rate to hatch should range between 10 and 50 percent survival to hatch. Incubation facility survival rate to hatch should range between 70 and 95 percent survival.

12. *Water quality and flow* – time for salmon egg development is temperature dependent and can be calculated using the accumulated thermal unit (ATU), a unit of measurement describing the cumulative effect of temperature over time. One ATU is equal to 1°C for 1 day. One ATU estimate for Chinook Salmon egg development is 476 degree days (dd) for hatching and 724 dd for emergence (Beachum and Murray 1990). Optimal intragravel dissolved oxygen levels in the redds should average around 10 or 11 milligrams/liter with water temperatures between 41°F and 54°F (5°C and 12°C). Surface flow velocities should range between 0.5 and 2 meters-per-second.

General Approach and Methodologies

Decisions about the availability and appropriateness of various life stage(s) to use for winter-run and spring-run Chinook Salmon recolonization of tributaries above

Shasta Dam have not been finalized by Federal and State fishery management agencies. To address some of the uncertainties concerning the amount and suitability of habitat for the early freshwater life stages of Chinook Salmon in these tributaries, Pilot Program studies can examine several questions related to egg and embryo life stage considerations, namely incubation survival of transplanted eggs and the conditions of the intragravel environment of suitable spawning habitat. Incubating eggs in or alongside the river will allow more natural emergence to occur under the environmental conditions of the target river. These emergent fry could be used to get a better idea of in-river productivity before adults are available to be used in the project. The fishery agencies will collaborate to determine distribution of Chinook salmon between the lower Sacramento River, above Shasta, and Battle Creek reintroduction areas.

If eggs are transplanted to the Upper Sacramento and McCloud rivers, they will be obtained from Chinook Salmon spawned at the hatchery and the eggs will be initially incubated there or at another location under standardized hatchery protocols. Eyed eggs would be the expected stage of embryo development for outplanting either in egg boxes or streamside incubators or injected into the gravel. Instream incubation boxes can be buried in streambed gravels at suitable locations for egg incubation, typically in pool tailouts, at the head of riffles, or as floating or anchored boxes located in portions of the stream with appropriate depths and flow velocities.

Although design specifications for transplanting of eggs has yet to be completed for the Pilot Program, most of the typical streamside and within-stream gravel box incubators, based on the Whitlock-Vibert Box design, can beadapted to evaluate survival of incubating embryos. The egg incubators consist of perforated polypropylene boxes, with two internal chambers for incubating eyed eggs and pre-emergent larvae. Eggs are placed in the upper chamber and as eggs hatch, fry drop through a perforated egg chamber floor, into the bottom chamber. When the pre-emergent fry absorb their yolk sac, they are then able to pass through slots in the bottom chamber as swim-up fry. This type of in-stream incubator could be modified to screen the bottom chamber to prevent fry from passing out of the chamber until the incubators are inspected to count numbers of unhatched (dead) eggs and swim-up fry.

Individually identifiable incubation boxes will be loaded with a known number of eyed eggs at the beginning of the study. The incubation temperature record from the originating hatchery will be used to compute the cumulative temperature units (TU) experienced by each batch of eggs received, to date. Water temperature at each egg incubation site will be continuously monitored with a datalogging thermograph and measured by handheld thermometer daily during site maintenance. When the cumulative thermal experience of each batch of eggs reaches 900 to 1,000 degree Celsius TUs, typical range for fry emergence in Central Valley Chinook Salmon (USFWS 1999), incubation boxes will be inspected and counts will be recorded for surviving fry and dead fry and eggs.

Depending on the availability of the eggs from Livingston Stone NFH, a portion may be incubated in streamside egg and fry incubation facilities using water from the Upper Sacramento or McCloud rivers to increase survival through hatching or injected into the gravel. On stream incubation within the watershed would be conducted at temporary sites that are provided with a stable water supply and security. Portable streamside incubators or other methods capable of incubating up to 350,000 Chinook Salmon eggs can be provided with limited site developments. A reasonably flat area of 200 to 400 square feet should be sufficient to provide stable foundation and access for monitoring. Two to four box incubators could be assembled on a flat stable area. Water supply capacity of 50 to 100 gpm would be required. Spring sources would be preferred but pumped supplies could be developed with simple screened pump systems. Small diameter piping would be routed for water supply, drain water and fish release from the incubators to the river. Temporary security fencing around the incubators and critical water supply features would be necessary.

When adult salmon are transported and released in the Sacramento and McCloud rivers and spawning locations for these fish are determined, measurements of spawning habitat and intragravel habitat conditions could be obtained at these sites. Gravel-bed permeability and water quality will be measured at up to five points located in the downstream edge of the egg pockets of redds and five points located adjacent to but outside the influence of redd excavations, in undisturbed streambed gravels. Data to be recorded for all measurement point locations include: (1) GPS coordinates; (2) site photographs; (3) river discharge at the nearest gage; (4) atmospheric conditions and other relevant physical conditions; (5) dominant surface sediment using Wentworth classifications (Platts et al. 1979); (6) fluvial habitat type; (7) total water depth; and (8) water velocities at depths of 0.2, 0.6, and 0.8 of the total depth.

Streambed permeability and gravel-bed water samples will be obtained using a modified, Terhune Mark VI standpipe. At each measurement location, the standpipe will be driven into the streambed to three, successive, pre-specified depths below the bed (6, 12, and 18 inches) and intergravel recharge, dissolved oxygen, and water temperature measurements will be made at each depth following the procedures and conventions adopted by similar studies (Terhune 1958, Barnard and McBain 1994, Saiki and Martin 1996, Stillwater Sciences 2002, Merz and Setka 2004, Horner 2005). Young et al. (1989) reported that when using a Mark VI standpipe there were significant differences in permeability determinations made by different people; therefore, efforts to minimize the variability due to operator bias and standardized effort must be used.

Specific technical and analytic considerations for each study objective and river is described in the following subsections.

Sacramento River – Metrics 1 and 2 Pilot studies on egg incubation and spawning habitat conditions will largely be confined, at least initially, to the nine mile thermally optimal reach for egg incubation during winter-run Chinook spawning season (late-April to mid-August) on the Upper Sacramento River from RM 28 (near the Dunsmuir wastewater treatment facility) to Box Canyon Dam (RM 37) (Reclamation 2014b).

Egg-to-Fry Survival Egg incubation box studies can be conducted at one or more locations, where security can be provided and public access is limited to minimize disturbance of incubators. If buried incubators are used, the incubators and associated thermographs can be camouflaged to prevent disturbance and positions recorded using GPS for later relocation. Incubator boxes can be installed in artificially excavated redds and buried or can be secured in an anchored or floating frame in the water column at suitable depths and current speeds. Unburied incubator boxes will need to be protected from direct sunlight.

Descriptive statistical summaries of results can be compared to hatchery survival and literature values for incubator boxes and naturally incubated eggs.

McCloud River – Metrics 1 and 2 Although the thermally optimal reach for egg incubation during the winter-run Chinook Salmon spawning season on the McCloud River extends for approximately 10 miles from McCloud Dam to near Squaw Valley Creek, pilot studies will likely be restricted to the upper five to six miles on USFS lands and the McCloud River Preserve (Reclamation 2014b).

Egg-to-Fry Survival Methods used would be the same as for the Upper Sacramento River.

Controlled Cultured Colonization – Streamside Incubation Some of the eggs from Livingston Stone NFH may be incubated outside of the Upper Sacramento or McCloud rivers to increase the likelihood of hatching, but within the system waters.

On stream incubation within the watershed would be conducted at temporary sites that are provided with a stable water supply and security. Portable streamside incubators or other methods capable of incubating up to 350,000 Chinook Salmon eggs can be provided with limited site developments. A reasonably flat area of 200 to 400 square feet should be sufficient to provide stabile foundation and access for monitoring. Two to 4 box incubators could be assembled on a flat stable area. Water supply capacity of 50 gpm to 100 gpm would be required. Spring sources would be preferred but pumped supplies could be developed with simple screened pump systems. Small diameter piping would be routed for water supply, drain water and fish release from the incubators to the river. Temporary security fencing around the incubators and critical water supply features would be necessary.

Year 3

Pilot studies that would be conducted in Y3 may include follow ups from findings in Y1 and Y2 and the following key evaluations for the adult life stage.

Life Stage Key Questions

The following key questions are listed below for the adult life stage. Some or all of these questions may be addressed in Y3; however, some may need to be addressed in subsequent years of the Pilot Program, and depending on the outcomes of the pilot studies, some of the questions may be deemed no longer important enough to be addressed by the Pilot Program or even for the overall Reintroduction Program:

1. What is the prespawn mortality rate of transported fish, and will the fish successfully spawn after being transported?
2. What are the best release locations for adults?
3. What is the recruit ratio of juveniles that make it to Shasta Lake to adult females released in the Study Area?
4. How do the McCloud and Sacramento rivers compare with respect to productivity (recruit-per-spawner)?
5. Where are the adults distributing in the Sacramento and McCloud rivers?
6. Is there sufficient holding and spawning habitat; are they located in close enough proximity to each other?
7. What effect does adult transportation have on Chinook Salmon egg viability?
8. How many smolts per each adult transported upstream must make it downstream from Keswick in order for the project to not have a demographic and genetic mining effect on the existing source population?
9. Can we eliminate juvenile and egg supplementation to reach the targeted numbers of returning adults and rely strictly on productivity from adult transport alone?

Pilot Studies

Objectives

The main objectives for the Y3 pilot studies are the same as defined in Y1 and Y2 and to determine adult prespawning survival, movement, and spawning distribution.

Understanding the prespawn survival rates of reintroduced Chinook Salmon is important, particularly if, as found in other studies (Keefer et al. 2010, USFWS

2011), the prespawn survival rate decreases relative to the natural population. Adult fish that are transported upstream experience additional stressors that increase their risk of mortality before spawning. If the prespawn mortality rates are underestimated, it could be assumed that reintroduction is not feasible, and the program could be terminated prematurely even though prespawn mortality could potentially decrease over time as transport methods improve and the fish adapt to the recolonized habitat.

Adult Chinook Salmon are expected to migrate to and distribute throughout the reintroduction rivers, where suitable spawning habitat occurs. The habitat assessment conducted in 2013 (Reclamation 2014b) identified the potential amount of available spawning and holding habitat for both the Upper Sacramento and McCloud rivers (See Chapter 3).

Primary Metrics

The first 12 primary metrics are described under Y1 and Y2

13. *Post-transport/handling survival (48 hour post-release mortality)* – several factors related to transportation may trigger prespawn mortality. These factors include, but are not limited to stress from transportation, unsuitable water temperatures, unsuitable water quality parameters, and overcrowding.

    Collecting and transporting adult Chinook Salmon is used around large dams where volitional passage is not logistically or biologically possible. Collection and transport of adult fish is used in numerous systems now, and methods and protocols are well established to minimize stress and mortality of the fish. Adult fish transported should not be physiologically ready to spawn. Therefore, the number of adult Chinook Salmon surviving transport should be at least 95 percent. A ratio of the number of adults surviving for 48 hours after transport and release to the total number released will be used for this metric.

14. *Survival to spawning (number of confirmed spawners)* – during the early stages of reintroduction programs, prespawn mortality rates are often higher than desired. However, the prespawn mortality rate in the McCloud River may be lower than would occur in the Upper Sacramento River because lower water temperatures are likely to occur at the time of release. The number of salmon carcasses with unshed gametes and the ratio of these carcasses to the total number of adults released will serve as the primary metric.

15. *Frequency and distance upstream or downstream from release site* – because the holding habitat capacity of both the Upper Sacramento and McCloud rivers is greater than the number of fish available for the Pilot Program, the expectation of holding adult distribution will likely be confined to the areas closest to the release site(s) that have suitable depths, spawning material and temperature. Fish could also emigrate from the

area in search of waters more similar to that in the area where they reared as fry or juveniles. The number and locations of pools in the Study Area, where adult salmon are found to hold before spawning, will serve as this metric.

At lower flows, adult fish passage could be restricted by natural barriers or impediments to fish passage. The habitat assessment determined that no complete fish passage barriers occur in the mainstem Upper Sacramento and McCloud rivers; however, Mears Creek Falls on the Upper Sacramento River and Tuna Creek Falls on the McCloud River may form seasonal passage impediments under some, as yet uncertain, flow levels. Adult passage rates and holding durations at each of these features, and others that may be determined during the Pilot Studies, will be used as metrics for this parameter.

Tributaries can provide valuable habitat for both rearing and spawning, particularly if habitat in a mainstem river is limiting. This, however, is not a factor in the reintroduced habitat, although it does not preclude the value of tributary habitat. Identifying the use of tributaries in the Pilot Program would involve recording Chinook Salmon use of the tributaries. The primary metric will be occurrence and number of redds counted in tributary mouths and farther upstream. If the fish regularly use these tributaries, then a habitat assessment of the tributaries should be conducted.

16. *Distances and direction of spawning locations from release site* – because the spawning habitat capacity of both the Upper Sacramento and McCloud rivers is greater than the number of fish available for the Pilot Program, the expectation of redd distribution could be confined to the areas closest to the release site(s). Depending on the prespawn mortality rates, the number of redds anticipated should be consistent with the remaining survivors. Additionally, the redds should occur in suitable spawning gravels. The number and locations of redds in the Study Area, where adult Chinook Salmon are found to spawn, will serve as this metric.

17. *Distribution of spawning sites relative to habitat suitability assessment* – See metric 15

18. *Frequency and duration in study reaches and/or specific habitat types (if possible)* – See metric 14

General approach and methodologies

To address the Pilot Program study objectives for adult salmon, fish telemetry will be the primary technique for obtaining information on adult salmon movement, habitat use, and survival. The general technical approach for both the Upper Sacramento River and McCloud River will be the same. Before transport from Livingstone Stone NFH, some adult salmon will be fitted with radio-only or combined acoustic-radio transmitter (CART) tags, with pressure/motion sensors (to detect potential mortality) configured to provide at least 100 days of transmitter life. Use of CART tags may be necessary if it is anticipated, or determined early in the Pilot Program, that adult salmon move downstream from release sites and enter Shasta Lake, and that it is desirable to track these fish in the reservoir environs, where depths and water quality can limit use of radio transmitter tags. To monitor the locations and movement of tagged salmon, fixed-station radio and acoustic datalogging receivers can be located strategically along the study reaches of the rivers and within portions of the Sacramento and McCloud arms of Shasta Lake. Mobile telemetry tracking can be periodically performed by land and air along the river channels and by boat in Shasta Lake. The frequency and type of mobile tracking and downloading of fixed station dataloggers will be dictated by access restrictions specific to each river, and to some degree by fish specific movements and responses in any one river and year.

The ultimate spatiotemporal patterns of spawning salmon will be monitored using a combination of ground and aerial surveys to plot locations of salmon redds. Telemetry surveys can be conducted concurrently with these spawning survey flights. Weekly or biweekly aerial surveys will be conducted from May through September to identify and locate salmon redds. Redd locations will be recorded as Universal Transverse Mercator (UTM) coordinates using GPS, in a standard datum, and include date and time, and plotted on aerial photographs of the survey reaches.

Specific technical and analytic considerations for each study objective and river is described in the following subsections.

Sacramento River – Metrics 12 Through 17 Fixed-station radio-telemetry datalogging receivers can be installed at four to five locations between five and ten miles apart along the Upper Sacramento River. Sites in the vicinity of Fenders Ferry Bridge (RM 1), Sims Road Bridge (RM 15), Riverside (Castella) Road Bridge (RM 20), Dunsmuir I-5 Bridge (RM 30), and Cantara Loop railroad bridge (RM 34.5) can be considered as preliminary sites (obtain access permission from counties, Caltrans, and Union Pacific Railroad, as necessary). Fixed-station radio and or acoustic datalogging receivers can be installed in the Sacramento arm of Shasta Lake near Antlers, Sugarloaf, and O'Brien marinas. This equipment can be installed and secured to bridges to avoid ground disturbing construction. Acoustic receiver installation in Shasta Lake will require applicable georeferencing and marking of receiver locations with buoys. Secure installations will need to be tailored for each site.

Coarse-scale movements of individual tagged salmon should be documented by querying and downloading fixed-stations, at least, weekly. Spatial and temporal patterns of movement at the scale of distances between stations can be determined weekly. This information can be used to restrict and focus mobile telemetry surveys to reaches between the fixed stations to determine finer scale locations of tagged fish. A combination of mobile telemetry surveys using road and land access, raft floats, and aerial flights will be conducted to obtain the finer-scale locations of tagged fish. All fish locations will be recorded in UTM coordinates using GPS, in a standard datum, and include date and time.

Movement Individual fish movements can be tracked spatially and temporally to analyze initial and subsequent directions and rates of movement from the release site, ultimate spawning disposition, and duration of occupation of reaches, habitats, and other sites of interest.

Habitat Use Habitat characteristics at locations, where tagged salmon are detected during mobile telemetry surveys, will be recorded using the same criteria used for the habitat assessment. The frequency and duration of use of various habitat types, duration of occupation of various study reaches, and the locations and conditions of habitat at the spawning locations will be analyzed and compared to the initial habitat assessment results. Aerial or ground redd distributions will be compared to spawning habitat suitabilities provided in the habitat assessment.

When adults have been translocated, released, and documented to have successfully spawned by telemetry tracking studies and redd surveys, measurements of spawning habitat and intragravel habitat conditions will be obtained at these sites following the general approach and methodology described above.

Descriptive statistical summaries of results can be compared to other regional studies of spawning habitat conditions for the Sacramento River below Keswick Dam (Stillwater Sciences 2007, NSR 2012) and to spawning and egg incubation suitability criteria from the scientific literature (e.g., Tappel and Bjornn 1983, Bjornn and Reiser 1991, Kondolf et al. 2008).

Survival Post-transport and pre-spawning mortality can be evaluated using the telemetry tags with motion sensors to detect abrupt and protracted cessation of motion of tagged fish. Mortality shortly after release, within a pre-determined time period, may be attributed to transport and handling-induced stress or direct injury. Recovery of tagged fish indicating mortality will allow for necropsy and disease screening if recovered within a day or two of death. Data on the frequency of post-release and pre-spawning fish mortality, necropsy examination of general tissue and organ conditions, and pathogen loads will be collected in coordination with Federal and State fish health specialists.

McCloud River – Metrics 12 Through 17 Access to the McCloud River for installing fixed-station telemetry receivers and conducting land-based mobile telemetry is limited. Consequently, the level of information that could currently be obtained, particularly on adult salmon survival and habitat use, would be less than for the Upper Sacramento River. Access to the McCloud River is potentially available through lands owned by the U.S. Forest Service and The Nature Conservancy's McCloud River Preserve in the upper five to six miles of the river below McCloud Dam and through the Bollibokka Club in the lower three to four miles of the river near its confluence with Shasta Lake.

Accordingly, up to three fixed telemetry stations could be installed on the McCloud River, with one near Shasta Lake (RM 0), one at the upstream end of the Bollibokka Club near Tuna Creek (RM 5), and one at the downstream end of the McCloud River Preserve near Ladybug Creek (RM 18). Fixed-station radio and or acoustic datalogging receivers can be installed in the McCloud arm of Shasta Lake near Ellery Creek, Jennings Creek, and Hirz Bay campgrounds. Similar to the Upper Sacramento River, this equipment can be installed using hand tools and in a manner to avoid ground disturbing construction. Acoustic receiver installation in Shasta Lake will require applicable georeferencing and marking of receiver locations with buoys.

Spatial and temporal patterns of individual tagged salmon movement in the McCloud River using the fixed stations would be limited to very coarse-scale indications of time of passage in the lower- and upper-most reaches of the river, but it would provide for isolating general reach locations and direction of movement of fish, which could be confirmed with follow-up mobile telemetry surveys. Mobile telemetry surveys would require periodic helicopter flights over the entire length of the McCloud to track positions of tagged fish and in concert with weekly or biweekly redd surveys later in the season; however, aerial surveys would preclude locating exact positions and measuring specific habitat conditions at tagged fish locations. All tagged fish locations will be recorded as UTM coordinates using GPS, in a standard datum, and include date and time.

Movement In general, information from the limited set of fixed telemetry stations and weekly aerial telemetry surveys of individual tagged adult salmon would allow for spatial and temporal analysis of movement and spawning disposition, but at a lower resolution than for the Sacramento River. Determination of ultimate spawning disposition, duration of occupation of reaches, habitats, and other sites of interest would not be possible except in those reaches where access is currently available.

Habitat Use Collection of data on habitat characteristics at tagged fish locations would be limited to only those areas with current land access at the uppermost and lowermost study reaches. Although incomplete for the entire river length, habitat use of tagged salmon in the survey-accessible reaches could be compared to the habitat suitability provided in the habitat assessment, which was similarly limited. Detected redd distributions will be compared to spawning habitat suitabilities provided in the habitat assessment.

When adults have been translocated, released, and documented to have successfully spawned by telemetry tracking studies and redd surveys, measurements of spawning habitat and intragravel habitat conditions can be obtained at these sites following the general approach and methodology described above.

Descriptive statistical summaries of results can be compared to other regional studies of spawning habitat conditions for the lower Sacramento River (Stillwater Sciences 2007, NSR 2012) and to spawning and egg incubation suitability criteria from the scientific literature (e.g., Tappel and Bjornn 1983, Bjornn and Reiser 1991, Kondolf et al. 2008).

Survival Post-release and pre-spawning mortality would be evaluated using telemetry techniques similar to that described for the Upper Sacramento River. Recovery of tagged fish, necropsy and disease screening would be limited to tagged fish mortalities that could be recovered in the land accessible uppermost and lowermost study reaches.

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Chapter 8 Timeline

This chapter presents the anticipated schedule for implementing the Pilot Program. No specific year has been identified for the start of the Pilot Program because the availability of Chinook Salmon will be determined on a year-to-year basis. The captive breeding program at Livingston Stone NFH, which began in 2015, may have fish available for release starting in 2017. NMFS and CDFW will determine whether the Livingston Stone NFH winter-run Chinook Salmon or spring-run Chinook Salmon will be used for the Pilot Program, depending on the condition of the natural population downstream from Keswick Dam and other factors. NMFS is developing an experimental population designation covering the area upstream of Shasta Dam.

The following timeline presents the proposed schedule for the first three years of the Pilot Program. The fish passage engineering studies are not included in the timeline because it is expected that these efforts will continue year-round during all three years. If a passage option is identified as infeasible, it will be removed. Additionally, following each year of studies, the Steering Committee and appropriate technical subcommittees will review the results of the pilot studies to adjust subsequent studies as needed.

Table 8-1. Pilot Program Timeline for Year 1

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry/Juvenile Colonization												
Fry/Juvenile release to tributaries												
• Transport survival study								■	■	■		
Movement, Habitat Use, Size and Growth Studies												
• Direct observation/electrofishing								■	■	■	■	■
• Document baseline of condition of resident fish species (desktop with limited field work)	■	■	■	■	■	■	■	■	■	■	■	■
Streamside controlled cultured colonization - rearing								■	■	■		
Emigration Timing and Survival Studies												
• Trap efficiency tests		■	■	■	■							
• Juvenile emigrant trapping[1]	■							■	■	■	■	■
• Captured emigrant release to Sacramento River below Shasta[1]	■							■	■	■	■	■
• Discrete water quality sampling[1]	■							■	■	■	■	■
• Reservoir Tracking Study[1]	■										■	■
Field data analysis and reporting[1]	■	■	■					■	■	■	■	■

Note:
[1] Emigration Timing and Survival Studies and the data analysis and reporting would carry into the early months of the following year. Stakeholder meetings would occur after each year of study and may occur at anytime needed throughout the year.

Table 8-2. Pilot Program Timeline for Year 2

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry/Juvenile Colonization												
Fry/Juvenile release to tributaries												
• Transport survival study								■	■	■		
Movement, Habitat Use, Size and Growth Studies												
• Direct observation/electrofishing								■	■	■	■	■
Streamside controlled cultured colonization - rearing								■	■	■		
Emigration Timing and Survival Studies												
• Trap efficiency tests		■	■	■	■							
• Juvenile emigrant trapping[1]	■							■	■	■	■	■
• Captured emigrant release to Sacramento River below Shasta[1]	■							■	■	■	■	■
• Discrete water quality sampling[1]	■							■	■	■	■	■
• Reservoir Tracking Study[1]	■										■	■
Egg Colonization												
Egg-to-Fry Survival Studies												
• Egg collection				■	■	■	■					
• Incubation studies (Whitlock-Vibert box)				■	■	■	■	■	■			
• Water quality at spawning sites				■	■	■	■	■	■			
Streamside controlled cultured colonization - incubation				■	■	■	■	■	■			
Field data analysis and reporting[1]	■	■	■					■	■	■	■	■

Note:

[1] Emigration Timing and Survival Studies and the data analysis and reporting would carry into the early months of the following year. Stakeholder meetings would occur after each year of study and may occur at anytime needed throughout the year.

Table 8-3. Pilot Program Timeline for Year 3

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry/Juvenile Colonization												
Fry/Juvenile release to tributaries												
• Transport survival study								■	■	■		
Movement, Habitat Use, Size and Growth Studies												
• Direct observation/electrofishing								■	■	■	■	■
Streamside controlled cultured colonization - rearing								■	■	■		
Emigration Timing and Survival Studies												
• Trap efficiency tests		■	■	■	■							
• Juvenile emigrant trapping[1]	■							■	■	■	■	■
• Captured emigrant release to Sacramento River below Shasta[1]	■							■	■	■	■	■
• Discrete water quality sampling[1]	■							■	■	■	■	■
Egg Colonization												
Egg-to-Fry Survival Studies												
• Egg collection				■	■	■	■					
• Incubation studies (Whitlock-Vibert box)				■	■	■	■	■	■			
• Water quality at spawning sites				■	■	■	■	■	■			
Streamside controlled cultured colonization - incubation				■	■	■	■	■	■			

Table 8-3. Pilot Program Timeline for Year 3 (contd.)

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Colonization												
Adult Translocation, Movement, and Habitat Use Studies												
• Adult transport survival	■	■	■	■	■							
• Prespawn survival	■	■	■	■	■	■	■	■				
• Adult distribution (telemetry and redd surveys)	■	■	■	■	■	■	■	■				
Field data analysis and reporting[1]	■	■	■	■								

Note:

[1] Emigration Timing and Survival Studies and the data analysis and reporting would carry into the early months of the following year. Stakeholder meetings would occur after each year of study and may occur at anytime needed throughout the year.

Timing for any activities past three years would follow the same general schedule for the activities as listed above.

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Chapter 9
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