Hatchery and Genetic Management Plan for Feather River Hatchery Spring-run Chinook Salmon Program

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The Resources Agency

DEPARTMENT OF WATER RESOURCES

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Prepared for:

California Department of Water Resources

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HATCHERY AND GENETIC MANAGEMENT PLAN

Feather River Fish Hatchery
Spring-run Chinook Salmon Program

Hatchery Program:	Feather River Spring-run Chinook salmon
Species or Hatchery Stock:	Central Valley Spring-run Chinook salmon (*Oncorhynchus tshawytscha)*
Agency/Operator:	California Department Fish and Game (Operator)/ California Department Water Resources (Contractor)
Watershed and Region:	Feather River, Sacramento River drainage
Date Submitted:	
Date Last Updated:	

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LIST OF ABBREVIATIONS

AFRP	Anadromous Fish Restoration Plan
BO	Biological Opinion
BY	Brood Year
CALFED	California (Water Policy Council) and Federal (Ecosystem Directorate)
CEQA California	Environmental Quality Act
CNFH	Coleman National Fish Hatchery
Commission	California Fish and Game Commission
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
D-893	Decision 893
CDFG	California Department of Fish and Game
Division	American River Division (of CVP)
DPC	Delta Protection Commission
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FMS	Flow Management Standard
FRH	Feather River Hatchery
IEP	Interagency Ecological Program
NFH	Nimbus Fish Hatchery
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OCAP	Operations, Criteria, and Plan
Reclamation	United States Department of the Interior, Bureau of Reclamation
RMG	River Management Group
ROD	Record of Decision
SEPWT	Salmonid Escapement Project Work Team
State	State of California
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USRFRHMP	Upper Sacramento River Fisheries and Riparian Habitat Management Plan
WCB	Wildlife Conservation Board
WQCB	Water Quality Control Board
WRA-EIR	Water Forum Agreement Environmental Impact Review

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INTRODUCTION

Section 7 of the Endangered Species Act (ESA) provides that agencies are obligated to consult with National Marine Fisheries Service (NMFS) on any activities that may affect a listed anadromous fish species, including hatchery programs (16 USC 1531. 2002). Hatchery and Genetic Management Plans (HGMPs) are described in the final salmon and steelhead 4(d) rule (NOAA 2005a) as a mechanism for addressing the take of certain listed species that may occur as a result of artificial propagation activities. The NMFS uses the information provided by HGMPs to evaluate impacts on anadromous salmon and steelhead listed under the ESA, and in certain situations, the HGMPs will apply to the evaluation and issuance of Section 10 take permits. Completed HGMPs may also be used for regional fish production and management planning by federal, state, and tribal resource managers. The primary goal of the HGMP is to devise biologically-based artificial propagation management strategies that ensure the conservation and recovery of listed Evolutionarily Significant Units (ESUs).

The California Department of Water Resources (DWR) constructed the Feather River Hatchery (FRH) in the mid 1960s to mitigate for Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* spawning habitat made inaccessible due to construction of Oroville Dam on the Feather River near the City of Oroville. The Oroville Dam and reservoir are key features of the State Water Project (SWP) and provide flood protection, water storage, hydropower production, recreation, and other benefits. Contracts are established with DWR and the California Department of Fish and Game (CDFG) to support operation and maintenance of FRH. On 22 October 2004, DWR received a Biological Opinion (BO) following formal consultation with the NMFS pursuant to Section 7 of the ESA on the effects of the proposed long-term operations, criteria, and plan (OCAP) for the SWP on threatened and endangered fish species. The OCAP BO issued by NMFS did not address the effects of hatchery operations, but it did highlight the requirement for DWR to enter into consultations on the effects of the hatchery operations on potentially affected listed species. A primary prerequisite to completing the required consultation is a description of fish production management practices used by CDFG and directed by DWR in order meet mitigation requirements.

This HGMP for the FRH spring-run Chinook salmon program describes hatchery operations and addresses impacts on anadromous salmonids listed under the ESA that are related to the production of fish required by DWR to meet mitigation goals.

1. PROJECT DESCRIPTION

1.1 Name of Hatchery or Program

Feather River Hatchery spring-run Chinook salmon program

1.2 Species and Populations (or Stock) in Propagation and ESA Status

Hatchery and natural-origin Feather River spring-run Chinook salmon are listed as "threatened" as part of the Central Valley spring-run Chinook salmon ESU, which includes spring-run Chinook salmon from Deer, Mill and Butte creeks and all other naturally spawning Central Valley spring-run Chinook (NOAA 2005a).

1.3 Responsible or Organization and Individual

The FRH is operated by the CDFG under contract with the DWR. The following individuals are key personnel for FRH operations.

DWR Contract Manager:
Pete Scheele, California Department of Water Resources, Chief Oroville Field Division
460 Glenn Drive, Oroville, CA 95966
(530) 534-2323 P
(530) 534-2302 F
pscheele@water.ca.gov

Department Regional Manager:
Sandra Morey, Regional Manager
1701 Nimbus Road, Rancho Cordova, CA 95670
(916) 358-2900 P
(916) 358-2912 F
smorey@dfg.ca.gov

CDFG Regional Hatcheries Supervisor:
Armando Quinones, Senior Hatchery Supervisor
1701 Nimbus Road, Rancho Cordova, CA 95670
(916) 358-2900 P
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aquinones@dfg.ca.gov

CDFG Hatchery Manager:
Anna Kastner, California Department of Fish and Game, Hatchery Manager II
5 Table Mountain Road, Oroville, CA 95695
(530) 538-2222 P
(530) 532-0573 F
akastner@dfg.ca.gov

Although there are no other agencies, tribes or co-operators directly involved in operating FRH, one advisory group provides guidance. The Feather River Technical Team advises FRH personnel to help integrate the hatchery operations into management of the Feather River below Oroville Dam, the upstream limit of fish migration.

1.4 Funding, Staff Level, and Annual FRH Program Operational Costs

The FRH staff currently includes 13 full-time, permanent employees (Table 1-1). The annual operating budget is approximately $1.9 million and includes $125,000 for temporary help personnel. In addition, FRH receives approximately $350,000 in annual service and facility maintenance from the DWR Oroville Field Division.

Table 1-1. Annual FRH staff by classification title. .

Position Title	Personnel Years
Hatchery Manager II	1
Hatchery Manager I	1
Personnel Services Spec 1	1
Fish and Wildlife Technician A/B	9
Office Technician –Typing	1

Note, this annual FRH budget includes operations at the Thermalito Annex facility and production of fall-run Chinook salmon, steelhead, and coldwater fisheries enhancement stocking for Lake Oroville. Costs of fish tagging, marking, and other monitoring programs are not included.

1.5 Location(s) of Hatchery and Associated Facilities

The FRH main facility is located at river kilometer 107 on the Feather River in the town of Oroville, California (Figure 1-1). Additionally, a separate FRH Annex facility is located downstream adjacent to the Thermalito Afterbay and Highway 99. The Feather River enters the Sacramento River at river kilometer 129. The Sacramento River flows through the Sacramento-San Joaquin Delta and into San Francisco Bay. Anadromous salmonids leave the Sacramento River watershed and enter the Pacific Ocean at the Golden Gate.

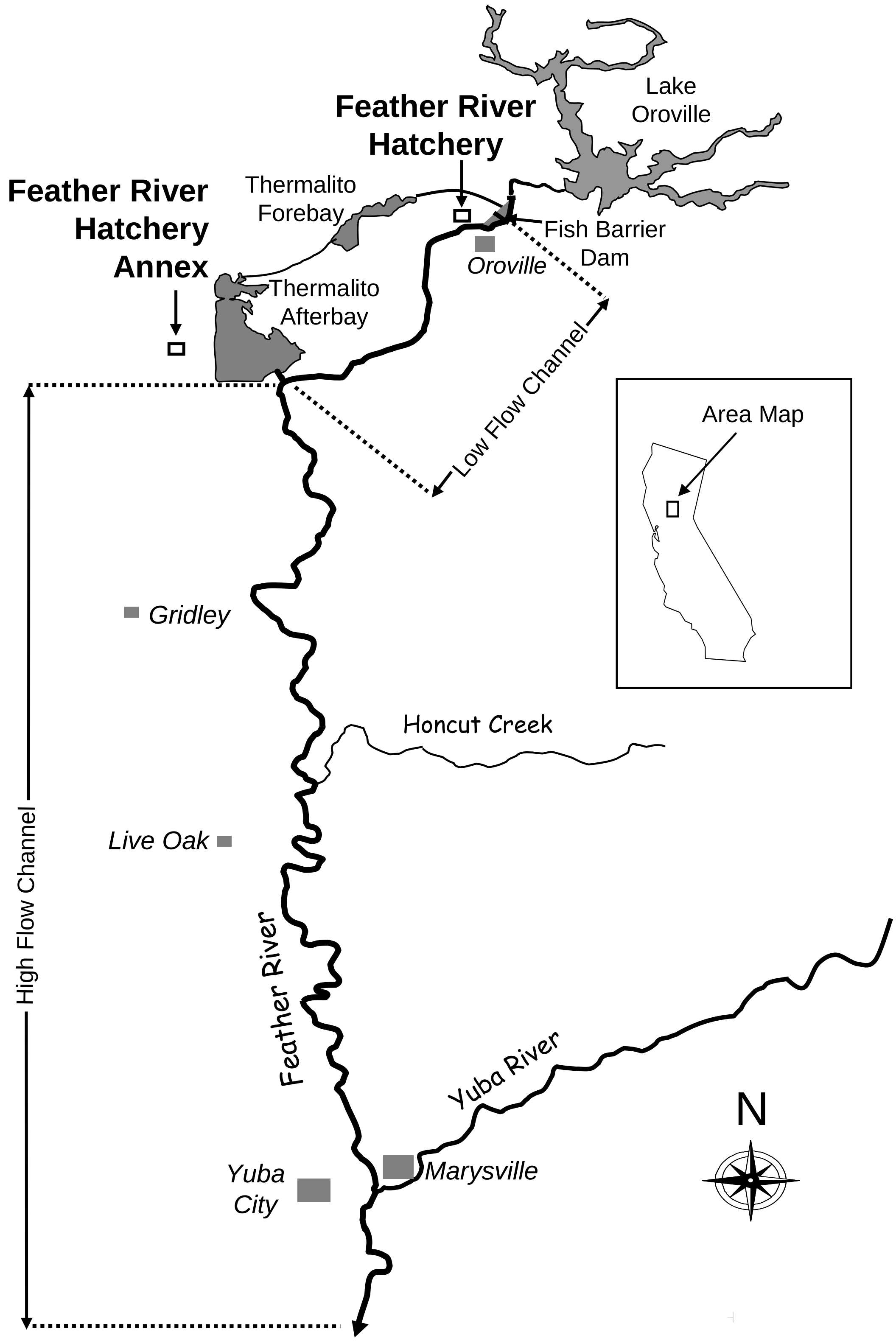

Figure 1-1. Feather River Hatchery facility and area map.

The latitude and longitude of the FRH is:

39°31'4.44"N

121°33'13.47"W

The latitude and longitude of the FRH annex is:

39°28'39.88"N

121°41'17.44"W

The Pacific States Marine Fisheries Commission's (PSMFC) Regional Mark Information System code for the FRH is:

6FCSAFEA FRH

1.6 Type of Program

The spring-run Chinook program at FRH is an Integrated Recovery Program which seeks to aid in the recovery and conservation of Central Valley spring-run Chinook. Fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population as FRH broodstock (adapted from NPCC 2003).

1.7 Purpose (Goal) of Program

The primary purpose of the program is to supplement and preserve the phenotypic/ genotypic characteristics of Feather River spring-run[1] Chinook salmon, a sub-population of the Central Valley spring-run Chinook salmon ESU. The program also mitigates for spawning and rearing habitat lost due to construction of Oroville Dam in the early 1960s. The program seeks to provide for ocean and freshwater harvest, while also sustaining adequate stock for in-river and hatchery spawning.

1.8 Justification for the Program

In 1960, California voters authorized construction and operation of the SWP. Oroville Dam and reservoir on the Feather River were essential project components providing water storage, hydroelectric power, flood control, and recreational benefits. In the years immediately prior to construction of Oroville Dam, CDFG estimated from a few hundred to about two thousand spring-run Chinook salmon made their way past the dam site to spawning and rearing habitat in the upper watershed (Fry and Petrovich 1970, Painter et al. 1977). Although the dam blocked access to historic spawning grounds, access to hypolimnetic coldwater in Oroville Reservoir provided suitable holding, spawning and rearing habitat below the dam and propagation of spring-run Chinook salmon was included in the original Oroville Dam mitigation plan.

[1] In this HGMP, adult spring-run Chinook salmon are defined as age-2 and older upstream migrants which express phenotypic spring-run behavior by entering the Feather River during the months of April, May, and June and which do not have a wire tag or other marker representative of other hatchery programs.-

The spring-run Chinook salmon mitigation program commenced with initial operation of the FRH in 1967; thus has been in operation for more than three decades. Until 2004, separation of spring-run and fall-run Chinook at FRH was based solely on arrival timing. Generally, fish arriving at FRH in September were spawned as spring-run, those arriving in October were spawned as fall-run. Subsequently, DWR studies documented there had been considerable mixing of fall- and spring-run Chinook salmon stocks in the hatchery (DWR 2004a). At about the same time, the ladder to the FRH began to be opened during the spring months to determine when steelhead and spring-run Chinook salmon might be holding in the Feather River. Investigators found substantial numbers of phenotypic spring-run Chinook salmon ascended the fish ladder in May and June (DWR 2004a). The possibility of enumerating and tagging Chinook salmon led to a novel approach to collecting broodstock and minimizing introgression between spring-run and fall-run Chinook at FRH. The Feather River spring-run Chinook salmon population is among the largest of remaining spring-run Chinook salmon populations in the Central Valley, with the other major runs being to Deer, Mill and Butte creeks, all Sacramento River tributaries.

The new spring-run Chinook salmon hatchery operations,went into effect with the 2004 brood year, and is designed to protect this important component of the Sacramento Valley spring-run Chinook salmon as defined by National Oceanic and Atmospheric Administration (NOAA) Fisheries.

1.9 Species and Population (or Stock) in Propagation, and ESA Status

Spring-run Chinook salmon reared at FRH are considered to be part of the threatened Central Valley spring-run ESU (NOAA 2005a).

1.10 Program "Performance Standards"

The goals of the FRH spring-run Chinook salmon program are accomplished through carefully planned trapping, artificial spawning, rearing, and release of spring-run Chinook salmon. Spring-run Chinook salmon reared at FRH contribute to major sport and commercial fisheries in the Pacific Ocean, primarily off the California and Oregon coasts (DWR 2004a). FRH spring-run Chinook salmon also support popular sport fisheries in San Francisco Bay, the Sacramento and Feather rivers.

FRH spring-run Chinook salmon broodstock are composed fish known to have entered the FRH ladder before July 1 and which do not possess a wire tag or otolith indicating other than FRH spring-run origin. Fish entering FRH prior to July 1 receive an external tag. Only these externally-tagged fish are used as spring-run Chinook salmon broodstock at FRH.

Production goals for FRH currently specify the annual release of 2 million spring-run Chinook salmon smolts (i.e., at 60 fish per pound). On the other side of the life cycle, contribution of adult Feather River spring-run Chinook salmon to spawning escapement provides a useful metric for compliance to pre-project conditions defining mitigation goals. In the decade prior to the construction of Oroville Dam, the spring Chinook salmon run averaged 1,700 fish (Painter et al. 1977). Methods for assessing spring-run specific adult returns to the Feather River have changed in the last decade, but have ranged from roughly 1,800 – 17,000 spring-run Chinook salmon depending on the year and methodology (Figure 1-2).

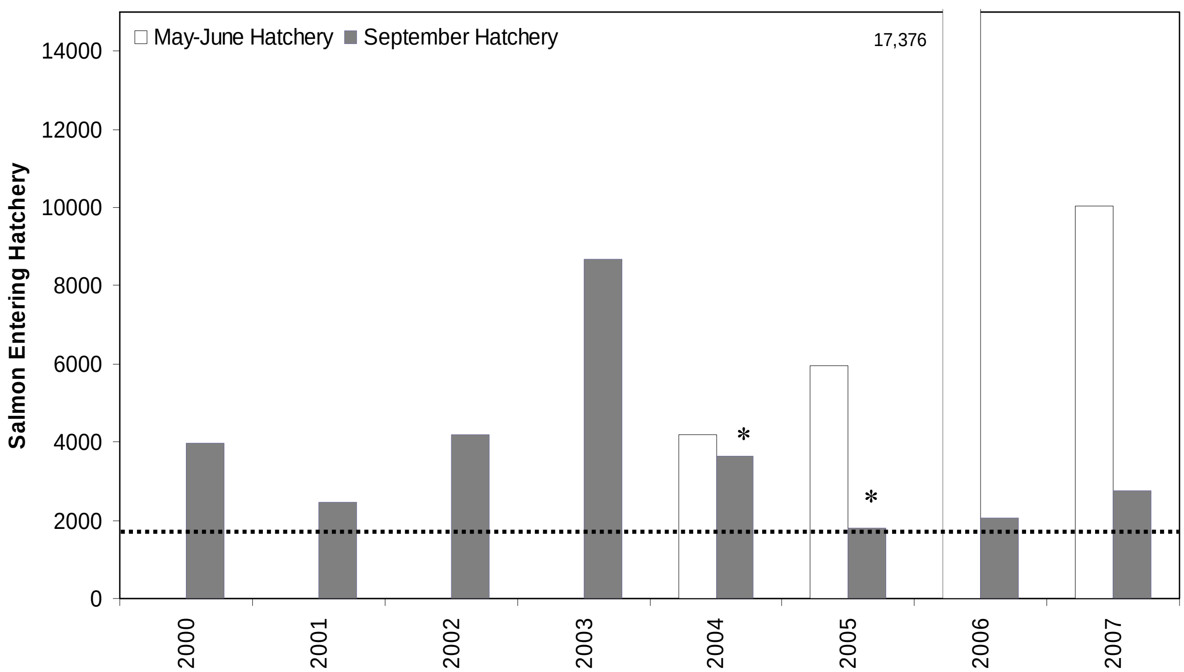

Figure 1-2. Annual abundance of FRH spring-run Chinook salmon by two methods: number of fish trapped at FRH in September (classified by date), and fish ascending the FRH ladder from April-June. Dotted line indicates pre-project average abundance. (Note, " * " indicates years when a complete count was not possible due to permit constraints)

Performance Standards: Juvenile Salmon

Standard 1: Program will attempt to meet, but neverexceed, production goals.

Indicator 1.1*:* Annual reports indicate that up to 4 million spring-run Chinook salmon eggs are taken annually.

Indicator 1.2*:* Annual reports indicate a quantity of up to 2 million spring-run Chinook salmon smolts (i.e., at 60 per pound or larger) are reared and released annually.

Standard 2: All (100%) hatchery-produced juvenile spring-run Chinook salmon will receive an adipose fin clip and a coded wire tag.

Indicator 2.1*:* Consistency between hatchery annual reports and tagged fish release reports indicating that 100% of spring-run Chinook smolts have been adipose fin clipped and coded wire tagged. .

Indicator 2.2*:* Pre-release quality checks indicate a 99.9% mark rate and a greater than 95% tag retention rate 21 days or more after tagging.

Standard 3: All (100%) FRH spring-run juvenile Chinook salmon will be released into the Feather River between the Fish Barrier Dam and the Yuba River confluence.

Indicator 3.1*:* Reported release locations for FRH spring-run Chinook smolts.

Standard 4: Survival of FRH spring-run Chinook salmon releases are maximized while minimizing adverse interactions with natural-origin salmonids; including competition, predation, straying, and genetic introgression.

Indicator 4.1*:* Reported locations, dates, and sizes of juvenile FRH spring-run Chinook salmon and rationale for how these releases are expected to maximize survival while minimizing adverse interactions.

Indicator 4.2*:* Report describing experimental program to evaluate effectiveness of various in-river release strategies. Specifically, experimental program should quantify how release methods (boat ramps, volitional, release chutes), release times (day vs. night), flow coordinated releases (pulse flows, turbidity), and release locations influence the survival, behavior and stray rates of hatchery salmon.

Performance Standards: Adult Salmon

Standard 5: Adult (age-2 and older) hatchery spring-run Chinook salmon are provided for commercial and recreational harvest such that impacts on ESA listed and natural origin salmon can be minimized w ar and incidental impacts from angling on other listed species will be minimized during the recreational fishery.

Indicator 5.1*:* Report describing number of hatchery adult spring-run Chinook salmon caught and harvested.

Indicator 5.2*:* Report describing estimated number of listed and natural origin Chinook caught and harvested, estimated number of listed species surviving catch and release, and estimated number of listed species not surviving catch and release. Harvest related mortality will be considered minimized when analyses indicate harvest activities do not inhibit the recovery of natural origin or ESA listed Chinook stocks.

Standard 6: Spring-run Chinook salmon broodstock are collected in a manner that minimizes introgression with fall-run Chinook salmon, and also approximates the distribution in age and size of natural-origin fish.

> ***Indicator 6.1**:* Analysis and report demonstrating fall-run Chinook (as determined by wire tags or otolith analysis) represent less than 5% of FRH spring-run Chinook broodstock.
>
> ***Indicator 6.2:*** Report describing evaluation of carrying capacity of the Feather River to support self-sustaining in-river spawning spring- and fall-run Chinook populations. This information is essential for FRH management actions including planning placement of the segregation weir, egg taking stations, and to inform future changes to FRH production goals which may be necessary to meet improved broodstock management practices.
>
> ***Indicator 6.3**:* Annual reports demonstrating that age and size of hatchery broodstock mimics that observed among naturally spawning phenotypic spring-run as determined by tagging and/or otolith analysis.

Standard 7: In order to minimize any domestication traits associated with hatchery practices, the percentage of first generation hatchery fish used for spawning should be minimized. Though a proportion of hatchery origin fish less than 15% is desirable (Lindley 2007), the current stock composition is not known, and is presumed to be predominately composed of hatchery-origin fish. *Note, this action cannot be fully implemented or assessed until all Feather River hatchery-origin Chinook salmon are externally marked by an adipose fin clip.*

> ***Indicator 7.1**:* Annual reports providing estimated proportion of natural origin and hatchery origin known fish among FRH spring-run broodstock and among fish spawning in the Feather River.
>
> ***Indicator 7.2**:* DWR will develop and implement a plan for increasing proportion of natural origin in FRH spring-run Chinook broodstock.
>
> ***Indicator 7.3**:* Annual reports showing increasing proportion of known natural-origin fish among spring-run Chinook salmon broodstock as indicated by tagging and/or otolith analysis.

Standard 8: The FRH adult spring-run Chinook salmon broodstock will be spawned to mimic natural conditions where salmon pair with similar-sized mates. Jacks will make up no more than 2% of males spawned unless necessary to meet mitigation goals.

Indicator 8.1*:* Data in annual reports indicating number of males, females and jacks spawned consistent with Standard 8.

Indicator 8.2*:* Data in annual reports indicating sex and fork length for mating pairs consistent with Standard 8.

Standard 9: Straying and related genetic introgression with natural origin Chinook salmon is minimized.

Indicator 9.1*:* Studies conducted by DWR or other entities indicate FRH spring-run Chinook salmon compose less than 5% of the natural origin spawning population in each tributary evaluated.

Indicator 9.2*:* DWR will develop and implement a plan for decreasing proportion of hatchery origin salmon spawning in the Feather River.

Indicator 9.2*:* Studies conducted by DWR demonstrate a decreasing proportion of hatchery origin salmon among the in-river spawning population

Standard 10: Genetic composition of Feather River Chinook salmon will be consistent with HGMP goals.

Indicator 10.1*:* Genetic analysis of Feather River Chinook salmon populations status conducted a minimum of every three years.

Indicator 10.2*:* Reports describing genetic analyses indicate natural and hatchery-origin fish are genetically similar and shows increasing divergence between FRH spring- and fall-run Chinook salmon.

Indicator 10.3: In addition, fitness of naturally reproducing fish found to be sufficient to produce self-sustaining in-river spawning and rearing population. This study will make it possible to evaluate effectiveness of improved broodstock management practices.

Standard 11: All Chinook entering the FRH fish ladder are processed in a manner that minimizes pre-spawning mortality of fish needed for broodstock, and also reduces the number of hatchery origin Chinook occurring on the spawning grounds..

Indicator 11.1*:* Date, fork length, sex, adipose clip status, presence of other tags or marks are recorded for each pre-spawning mortality (not including culled fish or fish used as broodstock).

Indicator 11.2*:* Dates of ladder operation dates of FRH fish processing, and related number of fish spawned, culled, or returned to round tanks (for holding).

Performance Standards: General

Standard 12: FRH spring-run Chinook salmon eggs, fry or juvenile fish in excess of production needs (as defined in Standard 1) are disposed of in a manner identified by CDFG and never released in California anadromous waters.

Indicator 13.1: Number and method of disposal of excess FRH spring-run juvenile Chinook salmon eggs, fry, or juvenile fish.

Indicator 13.2: No excess eggs, fry or juvenile salmon are released, placed, or planted in anadromous waters.

Standard 13: FRH spring-run Chinook salmon program is operated in compliance with CDFG fish health policies and guidelines.

Indicator 13.1: Number of broodstock sampled for pathogens. Types and frequencies of observed infections.

Indicator 13.2: Rearing survival rates: 1) egg to fry; and, 2) fry to juvenile fish released.

Indicator 13.3: Results of fish health examinations.

Indicator 13.4: Number of juveniles sampled and pathogens observed immediately prior to release.

Standard 14: FRH effluent complies with the conditions and water quality limitations identified in the current National Pollutant Discharge Elimination System (NPDES) permit.

Indicator 14.1: Reported dates, locations and number of water samples collected.

Indicator 14.2: Samples analyzed and results reported.

Indicator 14.3: Sampling and results consistent with NDPES permit.

Standard 15: FRH spring-run Chinook salmon carcass are disposed of in a manner identified in the HGMP and complies with CDFG and NMFS criteria.

Indicator 15.1: Reported method of carcass disposal consistent with CDFG and NMFS criteria.

Standard 16: Data on FRH operations will be collected, reviewed and reported in a consistent and scientifically-rigorous manner, and in a manner consistent with reporting requirements specified in this HGMP.

Indicator 16.1: FRH reports are produced, reviewed, and finalized by August each year. For example, annual report for 2011-2012 season is due by August 2012.

Indicator 16.2: Reports will follow the format and provide all necessary data and information as described in Appendix F.

2. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

Spring-run Chinook salmon produced by FRH are affected by a variety of other programs and policies related to fisheries or water resource management. The following are brief descriptions of some of the institutions which influence FRH and the fish it produces through management policies or by modifying environmental conditions,

2.1 Alignment of the Hatchery with Other Central Valley Plans or Policies

The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1998 has been incorporated into Section 6902 of the Fish and Game Code:

"The Legislature, for purposes of this chapter, declares as follows:

> (a) It is the policy of the state to significantly increase the natural production of salmon and steelhead trout by the end of this century. The department shall develop a plan and a program that strives to double the current natural production of salmon and steelhead trout resources.
>
> (b) It is the policy of the state to recognize and encourage the participation of the public in privately and publicly funded mitigation, restoration, and enhancement programs in order to protect and increase naturally spawning salmon and steelhead trout resources.
>
> (c) It is the policy of the state that existing natural salmon and steelhead trout habitat shall not be diminished further without offsetting the impacts of the lost habitat."

Other than Fish and Game Code, there is currently no Central Valley-wide hatchery plan in place. Overall coordination of hatcheries is provided by CDFG, but to date operations of Central Valley anadromous salmonid hatcheries have not been coordinated with regard to operational, or ecological guidelines or concerns. Though, this situation may improve with the 2007 formation of the Central Valley Hatchery Project Work Team under auspices of the Interagency Ecological Program (IEP). The work group provides a forum for exchanging ideas on how to operate the hatcheries in a way that provides balanced consideration for fisheries and impacts of hatchery operations on naturally-spawning Chinook salmon and steelhead.

In 2001, CDFG and NOAA Fisheries completed a joint review of anadromous salmonid hatcheries. Their recommendations are designed to help manage the hatcheries in an ecologically-sound manner, and have been considered in preparing this HGMP. The following were recommended in the joint review:

1. Feather River spring-run Chinook salmon should be released "in-river" and not be trucked to distant downstream sites.
2. The production of fall-run Chinook salmon at FRH and Nimbus hatcheries should be considered for "in-river" releases instead of being trucked downstream.
3. Hatchery "in-river" releases and water management practices (including water exports from the Sacramento-San Joaquin Delta) should be coordinated so that emigration survival is maximized.
4. A formal process should be identified for the periodic review and assessment (e.g., every 6 – 9 years, or 2 – 3 broodyears) of hatchery production levels.
5. All agencies should pursue efforts to establish a constant fractional marking program at all hatcheries.
6. All agencies should pursue efforts to develop adequate sampling programs to recover marked and tagged fish in the Central Valley.
7. An HGMP should be prepared for each hatchery.

2.1.1 U.S. Corps of Engineers Section 10 of the Rivers and Harbors Act of 1899 – Section 404 of the Clean Water Act (CWA)

In 1972, amendments to the Federal Water Pollution Control Act added what is commonly called Section 404 authority (33 U.S.C. 1344) to the program. The Secretary of the Army, acting through the Chief of Engineers, is authorized to issue permits, after notice and opportunity for public hearings, for the discharge of dredged or fill material into waters of the United States at specified disposal sites. Selection of such sites must be in accordance with guidelines developed by the Environmental Protection Agency (EPA) in conjunction with the Secretary of the Army. These guidelines are known as the 404(b)(1) Guidelines. The discharge of all other pollutants into waters of the U.S. is regulated under Section 402 of the Clean Water Act (CWA) which supersedes Section 13 permitting authority mentioned above. The Federal Water Pollution Control Act was further amended in 1977, and given the common name of "Clean Water Act". The Act was again amended in 1987 to modify criminal and civil penalty provisions and to add an administrative penalty provision. The FRH complies with all appropriate regulations of the CWA.

2.1.2 Upper Sacramento River Fisheries and Riparian Habitat Management Plan (USRFRHMP).

The USRFRHMP, also known as the "1086 Plan" after California Senate Bill (SB) 1086, was enacted into state law in 1986. The bill did not specifically identify the Feather River, but required the Wildlife Conservation Board to inventory the lands along the upper Sacramento River and describe and prioritize those lands of value to fish and wildlife. The SB 1086 also created an advisory council composed of specified members, and required the advisory council to develop, for submission to the Legislature, the USRFRHMP to provide for the protection, restoration, and enhancement of fish and riparian habitat and associated wildlife for the area between the Feather River and Keswick Dam. The bill provided for an action team with specified members to develop proposed plan elements. The provisions of this bill were repealed on 1 January 1989.

2.1.3 Central Valley Salmon and Steelhead Restoration Plans and Monitoring Programs

Pursuant to the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1998, the Central Valley Salmon and Steelhead Restoration and Enhancement Plan (CDFG 1990) and Restoring Central Valley Streams: A Plan for Action (CDFG 1993) outline restoration and enhancement goals by CDFG for salmon and steelhead in the Sacramento and San Joaquin river systems, and provide management direction for the programs.

Since the mid-1960s, CDFG (and more recently DWR), have conducted annual mark-recapture carcass surveys to estimate the fall-/spring-run Chinook salmon spawning escapement in the Feather River. Fall- and spring-run Chinook salmon cannot be distinguished by these carcass surveys, nor can hatchery and natural-origin salmon be differentiated. Carcass surveys also serve to sample for and recover coded wire tags, scales, otoliths, and tissue samples.

In response to the need to coordinate and improve escapement monitoring programs in the Central Valley, the IEP Salmonid Escapement Project Work Team (SEPWT) was formed in 2001. The team, which includes biologists assigned to various agencies and departments, works on salmon escapement monitoring surveys throughout the Central Valley. The group is a satellite team of the IEP Central Valley Salmonid Project Work Team (CVSPWT). In 2004, the SEPWT completed a proposal for the development of a comprehensive monitoring plan for Central Valley adult Chinook salmon escapement. The goal of the plan is to improve monitoring survey data for use in assessing the success of restoration activities, evaluating progress toward recovery of listed stocks, and sustainable management of ocean and inland fisheries.

In 2005, CDFG and PSMFC were awarded California Bay-Delta Authority (CALFED) Ecosystem Restoration Program (ERP) Directed Action support for development of Central Valley salmon monitoring plans (Available:

http://www.delta.dfg.ca.gov/erp/grants_2005_grants.asp) which were intended to resolve challenges with study design, coordination, and reporting. The CDFG expects this plan to be completed by approximately 2010.

FRH staff actively participates in efforts to reform and improve spring-run Chinook salmon monitoring programs throughout the Central Valley.

2.1.4 Central Valley Project Improvement Act (CVPIA)

Congress passed the CVPIA in 1992, with the purpose of adding fish and wildlife protection as specific features of the U.S. Bureau of Reclamation's (USBR) Central Valley Project, and included two components of particular interest to the FRH spring-run Chinook salmon program:

Anadromous Fish Restoration Program (AFRP). One goal of the AFRP is to double the naturally spawning populations of five anadromous fish species, including all Central Valley races of Chinook salmon and steelhead. As part of the AFRP, the U.S. Fish and Wildlife Service (USFWS) described the runs of anadromous fish in the Central Valley, their status and factors that may have caused observed declines and which may be bottlenecks towards recovery. The AFRP also included annual funding for research and monitoring (e.g., USFWS and USBR 1999) and for restoration of salmon habitat. These actions are designed to help achieve the goal of doubling naturally spawning populations and to acquire the data necessary to know when the goal had been achieved. With respect to the impact of hatcheries, the AFRP specifically developed an analysis of a constant fractional marking program intended to help determine the proportion of hatchery fish in spawning Chinook salmon populations. The AFRP has proposed certain environmental conditions (e.g., flow) of many Central Valley streams, including the Feather River, that may help achieve the doubling goal.

Anadromous Fish Screen Program (AFSP). The AFSP provided funding to improve and screen water intakes in the Sacramento and San Joaquin valleys that may entrain juvenile Chinook salmon and steelhead. To the extent that the more than 700 significant diversions along the Sacramento and San Joaquin rivers (Herren and Kawasaki 2001) are entraining juvenile Chinook salmon and steelhead, and these losses have population-level impacts, screening the diversions should benefit naturally spawning salmonid populations. It should be noted that in recent years, the AFRP and AFSP elements of the CVPIA have been brought together with other restoration efforts (e.g., CALFED and 4-Pumps projects) under the "single blueprint" concept to evaluate and fund projects that have the maximum chance of improving conditions for salmonids.

2.1.5 The Delta Accord

In 1994, many of the environmental and water interests joined with the water and fisheries agencies to sign the "historic" Delta Accord. The basic intent of the Accord was to establish interim protection for listed species, including winter- and spring-run Chinook salmon, steelhead and delta smelt. The interim protection was to be followed by long-term measures that would not only result in more favorable conditions for listed fish species (with eventual delisting), but would also help achieve water supply reliability. With respect to the fate of emigrating Chinook salmon and steelhead, there were three important outcomes of the Accord:

A ***SWRCB 1995 Water Quality Control Plan*** that codified the fish protection measures.

The ***California Bay-Delta Program (now called the California Bay-Delta Authority)***. This important entity is discussed in more detail below.

The ***Vernalis Adaptive Management Plan (VAMP).*** The VAMP is a series of experiments over a 12-year period designed to evaluate the effects of San Joaquin River flow and water project pumping on survival of fall-run Chinook salmon emigrating from the San Joaquin River system. Officially, the experiments began in 2000, but pilot studies were conducted in 1998 and 1999. From a FRH perspective, VAMP is particularly important in that the study protocol calls for combined SWP and CVP pumping to be held to a range of 1,500–3,000 cubic feet per second (cfs) from April 15 through May 15 each spring, depending on the exact protocol for each year. In reality the VAMP period pumping reduction is often extended to June 1st each spring to provide additional protection for San Joaquin River basin Chinook salmon and delta smelt, the so-called "shoulders on VAMP". Since many Sacramento Valley Chinook salmon emigrate during this period, reduced pumping should increase the survival of salmon smolts through the Delta. The VAMP also annually releases tens of thousands of tagged study fall-run Chinook salmon in the Delta. These fish are from the Merced Fish Hatchery and tend to stray to other streams when they return as adults.

2.1.6 The California Bay-Delta Authority (CALFED)

CALFED is a comprehensive, multi-agency, long-term effort with the goal of restoring ecological systems in the Central Valley and the San Francisco Estuary, while maintaining the reliability of water supplies. The four major CALFED program areas are ecosystem restoration, levee system integrity (along the rivers and in the Sacramento-San Joaquin Delta), water quality, and water supply reliability. Information on this complex, proposed multi-billion dollar program is available at http://calwater.ca.gov/.

Several CALFED efforts not only affect the quality of the Delta as salmonid habitat and a migratory pathway, but also the overall quality of salmonid habitat in the Central Valley. The results of CALFED programs will influence future decisions on where hatchery production should be released, and the overall role of hatcheries in Central Valley salmon restoration and management. A few key CALFED programs affecting salmon distribution and abundance and recovery are:

The ***Ecosystem Restoration Program (ERP)***. Over the past five years, the ERP has awarded more than 450 million dollars in contracts to restore ecosystem functions, screen irrigation and other water intakes, improve fish ladders, and fund research and monitoring needed to understand the effects of these efforts. One of the overall ERP goals is to restore essential fish habitat to promote recovery of naturally spawning salmonid populations. As mentioned earlier, the ERP works in conjunction with the CVPIA and DWR staff implementing the 4-pumps mitigation program to cooperatively fund those projects that have maximum ecosystem values (i.e., the "single blueprint" concept). Restoration of Butte Creek, one of three Central Valley streams with significant natural spring Chinook salmon runs, provides an excellent example of how such restoration actions (e.g., removing barriers) can improve the ability of a stream to support a listed salmon run. As shown in Figure 5 (Plate C), recent spring Chinook salmon runs to Butte Creek have increased, but it is not clear how much of the recovery is due to good ocean conditions versus restoration measures on Butte Creek.

The ***Environmental Water Account (EWA)***. The CALFED Record of Decision included the EWA, a new concept in fish protection in the Delta. Basically the EWA acquires water, mostly from willing sellers above the Delta, and stores the water until needed for fish protection. Through an integrated process of data collection, posting, and evaluation, biologists from the fish agencies keep track of fish abundance and distribution, hydrology, and water project operations. When it appears that water project operations, mainly pumping in the Delta, may impact Chinook salmon, steelhead or delta smelt, the fish biologists can recommend that Delta pumping be curtailed for one to several days. Any water costs to project customers are made up from the EWA water in storage, thus promoting the CALFED goals of fish protection and improving water supply reliability. A more complete description of the EWA and salmon can be found in Brown and Kimmerer (2003). The EWA can be expected to benefit Sacramento and San Joaquin Valley emigrating salmon and steelhead by reducing entrainment.

The ***South Delta Fish Facilities Forum (Forum)***. The Forum is to help CALFED, member agencies and stakeholders sort out the issues associated with fish protection at the screened south Delta intakes to the state and federal water projects. The fish protective facilities in the south Delta are based on designs from the 1950s and should be upgraded. At both facilities, fish salvaged during the screening process are held in collecting tanks and periodically trucked several miles for release. There is considerable mortality at several steps in the screening, collection, and hauling process. The Forum is charged with finding ways to reduce fish losses, and in turn, to make the Delta less stressful to migrating salmon and other fish.

Decisions on whether or not to release Feather River production in the river would be influenced in the case of a less stressful Delta.

2.1.7 California Fish and Game Code

California Law consists of 29 codes that include the Fish and Game Code. The Fish and Game Code includes various chapters dealing with fish and wildlife.

The FRH complies with all applicable code sections and regulations.

2.1.8 California Fish and Game Commission Policies

The California Fish and Game Commission (Commission) is composed of up to five members, appointed by the Governor and confirmed by the Senate. The Commission meets publicly to discuss various proposed regulations, permits, licenses, management policies, and other subjects within its areas of responsibility. It also holds a variety of special meetings to obtain public input on items of a more localized nature, requests for use permits on certain streams, or establishment of new ecological reserves. The Commission is responsible for the formulation of general policies for the conduct of CDFG. Several of those policies are relevant to FRH and are found in the Fish and Game Code (Appendix A). The Commission also has general regulatory powers under which it decides seasons, bag limits, and methods of take for game animals and sport fish.

The FRH complies with all applicable Commission policies.

2.1.9 California Department of Fish and Game Operations Manual

The CDFG Operations Manual contains sections that provide direction and guidance to the Department for anadromous fish management, and fish production and distribution, including fish health policies and procedures (Appendix B).

Staff at FRH comply with all applicable sections of the CDFG Operations Manual.

2.2 Existing Cooperative Agreements, Memoranda of Understanding, Memoranda of Agreement, or other Management Plans or Court Orders under which the Hatchery Operates

The FRH is operated pursuant to an annual contract between DWR and CDFG in which DWR funds hatchery costs. There is also a contract between CDFG and the Salmon Trollers Association that funds the enhancement component of FRH operation. Neither contract contains biological constraints or goals.

A 1983 agreement between CDFG and DWR specifies the degree to which flows can be changed due to operational needs. Among other things, this agreement is to minimize redd stranding and subsequent losses of production from redds exposed by flows lower than were present during spawning.

The SWP's Oroville Complex is operated by DWR under a Federal Energy Regulatory Commission (FERC) license. The FRH is part of the Oroville Complex. The Oroville Facilities FERC license expired in 2007, and a new long-term license has not yet been issued (though a settlement agreement was achieved in March 2006). The settlement agreement includes the "Feather River Fish Hatchery Improvement Program". Under this program, DWR in cooperation with CDFG, would ensure the continued operation of the FRH for the production of anadromous salmonids. The Feather River Fish Hatchery Improvement Program includes a Feather River Hatchery Management Program, an approach to facility assessment, and a strategy to evaluate facility, and/or operational modifications to achieve FRH water temperature targets in coordination with riverine flow and temperature requirements.

Under the proposed program, DWR would prepare a comprehensive Feather River Fish Hatchery Management Plan within two years of license issuance. The plan would include production goals for the FRH, and describe protocols necessary to meet these goals. The anadromous fish production goals, such as number of fish, size of fish, and release location (including in-river releases), and future program changes such as the current spring-run Chinook salmon (phenotypic) program, would be determined by the Licensee and CDFG, in consultation with the Feather River Technical Team, the resource agencies, and an advisory Ecological Committee (EC), as a component of the FRH Adaptive Management Program.

Feather River Fish Hatchery Improvement Program details specify that if anadromous salmonids are passed upstream of the FRH, the Proposed Action would also include the installation of a water disinfection system for the FRH water supply prior to such passage.

The program also requires changes in FRH water temperature requirements. The FRH temperatures must be suitable for all life stages, including holding, spawning, incubating, hatching, and rearing. If necessary, project operations and/or facilities would be modified to meet the temperature objectives.

The temperatures in the first column of Table 2-1 are the interim maximum daily mean temperature targets, which would take effect upon issuance of the new FERC license. At no instance will the hourly maximum temperatures depicted in the second column of Table 2-1 be exceeded during the term of the new license. There would be no minimum temperature except between April and June 1, during that time the temperatures must not fall below 51°F. If DWR cannot achieve these criteria, DWR and resource agencies will conference to determine an agreeable temperature management strategy.

Table 2-1. Proposed water temperature objectives for the Feather River Fish Hatchery.

Time Period	Interim Daily Mean Maximum (°Fahrenheit)	Hourly Mean Maximum (°Fahrenheit)
September	56°	56°
October - November	55°	55°
December – March	55°	55°
April – May 15	55°	55°
May 16 – May 31	55°	59°
June 1 – June 15	60°	60°
June 16 – August 15	60°	64°
August 16 – August 31	60°	62°

Source: DWR 2006, FERC Project 2100 Settlment Agreement

The DWR and CDFG annually collect a variety of data appropriate for evaluating the effectiveness of the Feather River Fish Hatchery Improvement Program and progress towards program objectives. Information collected in these studies would include annual data from both river and hatchery data collection efforts. Detailed study needs are described in Recommendations (Section 11). These annual reports are to be compiled and presented every five years in the Lower Feather River Habitat Improvement Plan Report. In addition, the FRH program would be reevaluated every five years. A comprehensive facility assessment of the FRH, at least once every five years, would be conducted. This would be used to identify whether changes need to be made to the facilities to support operations and management at the hatchery.

Over the life of the license DWR and CDFG will work towards meeting these conditions, or modifying them through an adaptive management process.

2.2.1 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 U.S.C. 661-667e; the Act of 10 March 1934; Ch. 55; 48 Stat. 401), as amended by the Act of 24 June 24 1936, Ch. 764, 49 Stat. 913; the Act of 14 August 1946, Ch. 965, 60 Stat. 1080; the Act of 5 August 1947, Ch. 489, 61 Stat. 770; the Act of 19 May 1948, Ch. 310, 62 Stat. 240; P.L. 325, 6 October 1949, 63 Stat. 708; P.L. 85-624, 12 August 1958, 72 Stat. 563; and P.L. 89-72, 79 Stat. 216, 9 July 1965, authorizes the Secretaries of Agriculture and Commerce to provide assistance to and cooperate with federal and state agencies to protect, rear, stock, and increase the supply of game and fur-bearing animals, as well as to study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife.

The Act also directs the Bureau of Fisheries to use impounded waters for fish-culture stations and migratory-bird resting and nesting areas and requires consultation with the

Bureau of Fisheries prior to the construction of any new dams to provide for fish migration. In addition, this Act authorizes the preparation of plans to protect wildlife resources, the completion of wildlife surveys on public lands, and the acceptance by the federal agencies of funds or lands for related purposes provided that land donations received the consent of the state in which they are located.

Central Valley-wide plans for anadromous fish generally include two economically important native species, Chinook salmon and steelhead; and in the past, plans usually emphasized Chinook salmon.

2.2.2 NOAA Fisheries Formal and Early Section 7 ESA Consultation on the Coordinated Operations of the CVP and SWP and Operational Criteria and Plan (OCAP 2004)

This consultation included actions for the Feather River including: established temperature objectives for the Feather River in the low flow channel.

> "DWR shall maintain daily average water temperatures in the Feather River, between the Fish Barrier Dam and Robinson's Riffle (RM 61.6) from June 1 through September 30 less than or equal to 65°F to protect over-summering steelhead. This term is not intended to preclude pump-back operations at the Oroville Facilities that are needed to assist the State of California with supplying energy during periods when the California Independent System Operator has anticipated Stage 2 or higher alerts."

These temperature criteria affect the operation of Lake Oroville stop-logs (i.e., temperature control device) and could potentially affect the availability of cold water needed to rear salmonids at FRH. No such conflict has occurred to date however, and generally Feather River temperature requirements seem to compliment FRH requirements. New FRH temperature requirements related to the FERC relicensing agreement (see Section 2.2) may create more potential for conflicts between FRH and river requirements.

2.3 Relationship to Harvest Objectives

Mitigation hatcheries are not only intended to produce salmon to offset losses of habitat lost due to dam construction or other projects, they are to produce adult salmon for harvest. In the case of the Central Valley Chinook salmon, the fish may be harvested in the ocean commercial and recreational fisheries and in the inland recreational fisheries. It is important to understand the fisheries and their harvest because: 1) harvest contributes a socio-economic benefit to society; 2) harvest of abundant hatchery fish may lead to incidental harvest of naturally spawning stocks; and, 3) trends in harvest, including effort, should be considered when setting or adjusting hatchery production goals. Two organizations are of particular importance in following harvest and setting regulations to allocate harvest in a manner that protects the overall fisheries resources and, in particular, salmon stocks and species that are at risk.

Pacific Fishery Management Council (PFMC). The PFMC is one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976 for the purpose of managing fisheries three to 200 miles offshore of the U.S. coastline. The PFMC is responsible for salmon and other fisheries off the coasts of California, Oregon, and Washington.

The PFMC's Salmon Fishery Management Plan describes the goals and methods for salmon management. Management tools such as season length, quotas, and bag limits vary depending on how many salmon are present. There are two central parts of the Plan: 1) an annual goal for the number of spawners of the major salmon stocks (i.e., spawner escapement goals of 122,000 – 180,000 fall-run Chinook salmon returning to the Central Valley); and, 2) allocation of the harvest among different groups of fishers (commercial, recreational, tribal, various ports, ocean, and inland). The PFMC must also comply with laws such as the ESA. In recent years the PFMC has adjusted the ocean fisheries to help ensure that Klamath River escapement goals have been met. The ESA and fishery season, gear and location-related adjustments to protect specific stocks have affected the numbers of salmon that escape to the Feather River and other Central Valley streams.

The ***California Fish and Game Commission***. The Commission has the general regulatory function to set seasons, bag limits, and methods of take for game animals and sport fish. In adopting hunting (biennially, even-numbered years) and sport fishing regulations (biennially, odd-numbered years), the Commission, in each case, holds a series of open public meetings (three for hunting and four for sport fishing) located in various parts of the state. Individual and group input can be received and considered prior to adoption of new or changed regulations. The Commission can decide to increase the catch of salmon by increasing the bag limit for example in the Feather River sport fishery, and to limit the take of listed species, such as early returning spring-run Chinook salmon on the Feather River. Estimated numbers of Central Valley spring-run Chinook salmon harvested in ocean fisheries have varied since 1995 (Table 2-2). FRH spring-run Chinook salmon are undoubtedly a major component of this harvest, but specific harvest rates are currently unknown. Ocean commercial, ocean sport, and inland sport fisheries benefit from spring-run Chinook salmon reared and released by FRH.

Table 2-2. Estimated ocean landings (harvest) of Central Valley spring-run Chinook salmon by brood year and age (calculated from Cramer et al. 2005).

Brood	Ocean Landings				
Year	Age 2	Age 3	Age 4	Age 5	Total

1995	1,571	6,785	196	8,552
1996	816	3,599	258	4,674
1997	1,318	5,796	378	7,491
1998	1,379	4,998	445	6,822
1999	769	3,456	562	4,786
2000	802	3,559	321	4,681
2001	486	2,236	756	3,478
2002	718	3,271	710	4,700
2003	610	2,782	633	4,025
2004	1,021	4,490	292	5,803
2005	3,624	4,751	323	8,698
2006	3,914	5,131	349	9,393
Totals	17,028	50,854	5223	73,103
Means	1,419	4,238	435	6,092

2.4 Relationship to Habitat Protection and Recovery Strategies

There are many factors that may affect the natural production of Feather River spring-run Chinook salmon and the effects of these factors are not completely understood. The following are some of the more important factors and restoration measures.

Feather River

Water Temperature – June through mid-October is the primary period during which water temperature could potentially limit natural production. Temperatures above 68°F are likely detrimental to spring-run Chinook salmon holding in the Feather River (see review, DWR 2007). Water temperature in the Feather River for the first 12 km below the fish barrier dam can be controlled to a large degree by releasing water from various levels in Oroville Reservoir. Below the Thermalito outlet (Figure 2-1), discharge of warmed water from the Thermalito Afterbay can increase ambient river temperatures.

Flow – Although flow must be adequate to provide sufficient depth so that deposited eggs do not become stranded as flows recede, Healey (1991) found that Chinook salmon do well in a variety of flows and depths. In the Feather River, flow in the first 12 km below the fish barrier dam is typically held near 625 cfs except during very high flow years when Oroville Reservoir spills or when additional flows are necessary to meet water temperature objectives. A 1983 agreement between CDFG and DWR limits flow fluctuations to minimize redd dewatering and juvenile stranding. The FERC Project 2100 settlement agreement specifies a new base flow of 800 cfs during the Chinook salmon spawning season (i.e., September 9 through March 31), and 700 cfs during the remainder of the year and additional flow as necessary to meet new temperature requirements.

Gravel Quality – Chinook salmon production is dependent in part on the presence of gravel of the optimal size distribution. The presence of dams and regulated flows tends to reduce gravel quality, both in terms of size distribution and interstitial flow and this pattern is also apparent for the Feather River (DWR 2005b. Problems with Feather River gravel quality will be addressed as a condition of the FERC Project 2100 settlement agreement which requires gravel supplementation designed and conducted in coordination with the EC and fishery resource agencies.

Competition for Spawning Territory – In the Feather River, during the September through mid-October period, spring- and fall-run Chinook salmon may seek spawning sites in the river below the fish barrier dam. For much of the spawning season, fall-run Chinook salmon may re-dig spring-run Chinook salmon redds, destroying incubating eggs or exposing the developing embryos to predation and other mortality sources (super-imposition, Sommer et al. 2001). In addition, the presence of spring-run and fall-run Chinook salmon on the spawning grounds simultaneously probably results in some hybridization between the two races.

Emigration Corridor

The Sacramento-San Joaquin Delta (Figure 2-2) is most often mentioned as the area in the emigration route having the greatest impact on naturally emigrating Central Valley Chinook salmon (OCAP BO 2004). However, juvenile spring-run Chinook salmon must migrate through 112 river kilometers of the lower Feather River, and additional distance in the Sacramento River before reaching the Delta. Little is known about pre-Delta habitat suitability or predation losses, but when flows are low and waters clear, predation losses in the Feather and Sacramento rivers are likely significant (Williams 2006). The SWP and CVP operate large pumping and fish protection facilities in the southern Delta with a combined capacity of more than 8,000 cfs. The CVP also operates a controllable set of gates on the Sacramento River near Walnut Grove (the Delta Cross Channel) that is used to move Sacramento River through the interior Delta towards the project pumps.

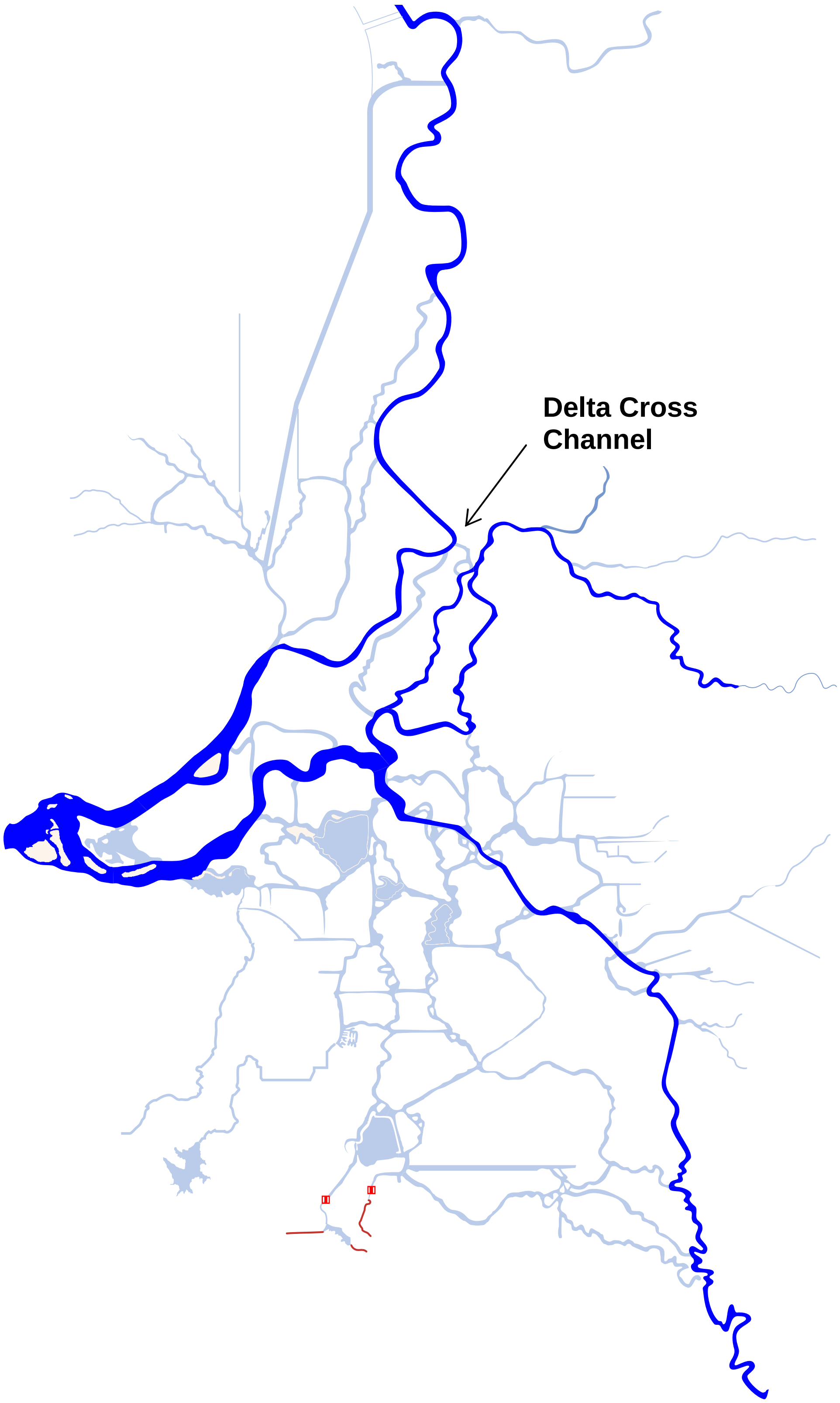

Figure 2-2. The Sacramento-San Joaquin River Delta

Recovery/Restoration Activities

In recent years there have been many programs and actions designed to help protect and restore Central Valley listed and candidate salmonid populations.

Specific to the Feather River spring-run, the recent FERC settlement agreement (DWR 2006) proposes a suite of actions designed to improve and expand salmonid habitat in the Feather River. Although these actions will not be formally adopted until FERC issues the new license, improvements will likely begin during the five year life of this HGMP and must be considered as DWR and CDFG adaptively manage the naturally spawning and hatchery stocks of the threatened Feather River spring-run Chinook salmon.

At this time there is no clear understanding of what controls spring-run Chinook salmon abundance on the Feather River, or the impact of proposed restoration and recovery actions on that abundance. The presence of several thousand phenotypic spring-run Chinook salmon during the past four decades indicates that whatever the conditions are, they have been adequate to support one of the largest spring Chinook salmon runs in the Sacramento Valley. The FRH production undoubtedly has a profound influence on patterns of Feather River spring-run Chinook salmon abundance.

2.4.1 U.S. Fish and Wildlife Service Biological Opinion on the CVP-Operation Criteria and Plan

On 30 July 2004, the USFWS released their Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the CVP and SWP and the OCAP (Appendix C). The BO includes an effects determination and take statements and also objectives that may affect operation of FRH.

2.4.2 Delta Protection Commission

The Delta Protection Commission (DPC) produced a strategic plan for 2006-2011 (DPC 2006). Strategies are limited to the Sacramento-San Joaquin Delta, but habitat improvements may enhance recovery of listed species. The mission of the DPC is to protect, maintain, and where possible, enhance and restore the overall quality of the Delta environment consistent with the Delta Protection Act and the Regional Plan, including, but not limited to agriculture, wildlife habitat, and recreational activities, to ensure orderly, balanced conservation and development of Delta land resources and improved flood protection. The DPC has no authority regarding operation of the FRH.

2.4.3 U.S. Fish and Wildlife Service Anadromous Fish Restoration Program

The USFWS Anadromous Fish Restoration Program is tasked by the CVPIA to make “all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis”. Since 1992, the AFRP has provided several million dollars of funding for habitat projects to restore Central Valley salmon and steelhead populations.

Though AFRP does not currently have any active programs on the Feather River, FRH certainly has the potential to effect and be affected by AFRP actions.

2.5 Ecological Interactions

Concern has been expressed over the effects of hatchery fish on wild fish populations (e.g., Kostow 2004). Some authors have reported ecological interactions and risks to wild populations (Nickelson et al. 1986; Chilcote 2003; Kostow and Zhou 2006) while other have described genetic risks (e.g., Reisenbichler and McIntyre 1977; Weitkamp et al. 1995; Currens et al. 1997; Reisenbichler and Rubin 1999). Ecological interactions may include competition, predation, parasitism and disease transfers, and behavioral influences, while genetic interactions may occur from interbreeding between hatchery and wild fish. Interbreeding may affect the fitness of wild fish and result in the loss of genetic diversity. Adverse impacts are not necessarily inherent to hatchery programs, but poorly understood management objectives can exacerbate impacts, or perceived impacts (Campton 1995; Brannon et al. 2004). Though less often emphasized, hatcheries have many positive effects: supplementing natural populations; protecting genetic resources; and, provide for stream nutrient enrichment (Steward and Bjornn 1990; Cuenco et al. 1993). Some biologists feel that properly managed hatchery programs can provide for fisheries as well as supplement numbers of fish that spawn naturally, thus increasing natural production, while acceptably reducing biological risks; others doubt that this is achievable.

2.5.1 Competition

In ecology, competition is the interaction between two or more organisms, or groups of organisms, that use a common resource in short supply. There can be competition between members of the same species and competition between members of different species. Investigations have shown that most of the spring-run (as well as fall-run) Chinook salmon naturally-produced in the lower Feather River emerge in large numbers in January and continue to emerge through April, and initiate migration from the river shortly after emerging, with emigration peaking in February (Seesholtz et al 2003). FRH-produced spring Chinook salmon are currently released in equal proportions: half in the Feather River in the vicinity of Live Oak at river kilometer 64; and, the other half directly into San Francisco Bay. Spring-run Chinook salmon release generally occurs during Apirl or May, when most natural-origin Chinook salmon have already emigrated. Thus, competition with naturally-produced Chinook salmon would primarily occur during migration and rearing in the lower Feather River, the Sacramento River, the Delta, San Francisco Bay, and eventually the Pacific Ocean.

Hatchery fish co-occurring with wild fish can compete for habitat and food (e.g., McMichael et al. 1999). McMichael et al. (1997) investigated the effects of non-migrant (residual) juvenile hatchery steelhead on growth of wild rainbow trout *O. mykiss* and juvenile spring-run Chinook salmon to examine how increased densities of residual hatchery steelhead might affect wild rainbow trout and Chinook salmon growth. Experiments using screened enclosures in a natural stream found that hatchery steelhead negatively impacted growth of wild rainbow trout, but did not impact growth of spring Chinook salmon. These findings illustrate that adverse impacts to wild fish may result when overall densities are increased by hatchery releases. However, Weber and Faush (2003) observed that such studies (e.g., McMichael et al. 1997) illustrate the effect of increased fish density in general, rather than the specific competitive effect of hatchery fish. Competition from juvenile FRH spring-run Chinook salmon may be more intense because of their large size relative to natural origin conspecifics.

Competition between naturally-produced and hatchery-produced salmon is not restricted to freshwater rearing. Indeed, mounting evidence shows that carrying capacity for ocean salmonids is finite, and density dependent impacts may occur with the addition of large numbers of hatchery salmon (Beamish et al. 1997; Ruggerone and Nielsen 2004). Ruggerone and Goetz (2004) evaluated offshore competition between Asian pink salmon and Bristol Bay (Alaska) sockeye salmon, which intermingle in the North Pacific Ocean and Bering Sea, using the unique biennial abundance cycle of Asian pink salmon from 1955 to 2000. The interaction with odd-year pink salmon led to significantly smaller size-at-age of adult sockeye salmon, especially among younger female salmon. They concluded this evidence for interspecific competition highlighted the need for multi-species, international management of salmon production, including salmon released from hatcheries into the ocean.

Competition for spawning and rearing habitat for anadromous salmonids below the Fish Barrier Dam has been affected by changes to the geomorphic processes caused by several factors, including hydraulic mining, land use practices, construction of flood management levees, regulated flow regimes, and operation of Oroville Dam and other upstream dams. Further, Oroville Dam and other dams upstream of Lake Oroville have blocked gravel, sediment, and large woody debris recruitment from the upstream areas of the watershed, resulting in continued degradation of spawning and rearing habitat in the lower Feather River. In addition, the Oroville Facilities and other projects (e.g., Poe Dam) block the upstream migration of spring-run Chinook salmon into historic spawning habitat in the upper Feather River. Continued FRH production of spring-run Chinook salmon contributes to competition for spawning and rearing habitat relative to existing conditions.

The increased intensity of competition for habitat likely contributes to adult pre-spawning mortality as well as redd superimposition. Pre-spawn mortality estimates in the lower Feather River from 2000 through 2003 were high when compared to reported estimates from some other systems (DWR 2004c). From 2000 through 2003, the pre-spawn mortality estimate ranged between 42.5% and 39.7%. The average pre-spawn mortality rate combining all study years and both reaches was approximately 41.1%.

Given available data, it is not possible at this time to estimate the proportion of pre-spawn mortality accounted for by natural origin (as opposed to FRH-produced) spring-run Chinook salmon in the lower Feather River.

Spring-run Chinook salmon in the lower Feather River are particularly susceptible to redd superimposition as their redds are disturbed by later arriving fall-run Chinook salmon, leading to reduced egg survival (Fukushima et al. 1998). Superimposition of redds may result in poor egg-to-fry survival rates due to disruption of previously constructed redds (Litchfield and Willete 2002). Redd disruption can also result in increased egg and alevin mortality leading to reduced production. Redd surveys show that spawning occurred in twice as much area below the Thermalito Afterbay Outlet relative to the LFC (Sommer et al. 2001). Yet, based on 2000 to 2003 escapement data, nearly 80% of the Chinook salmon adults spawn in the LFC (DWR 2004c). Assuming an average redd area of 55 ft^2, the LFC provides sufficient spawning area approximately 14,100 spawning pairs of Chinook salmon (Sommer et al. 2001; DWR 2004c). Spawning escapement surveys in the LFC indicate that spawning pairs have exceeded this number by a factor of 3.6 to 1.3 every year between 2000 and 2006. Redd superimposition rates may decline as suitable spawning habitat in the LFC is expanded through gravel supplementation efforts.

2.5.2 Predation

Although predation is part of salmonid natural ecology, it can become more significant as a result of hatchery practices. High rates of predation can be especially problematic when prey populations are extremely low because of Allee effects (Gascoigne and Lipcius 2007). Predation by FRH juvenile salmon on natural-origin salmonids may occur, but is unlikely to be significant because juvenile Chinook salmon feed primarily on invertebrates, and are not highly piscivorous. However, hatchery releases can also have significant indirect effects (negative or positive) on natural-origin fish by either attracting predators, worsening predation (Brown and Mate 1983; Collis et al. 2001), or by swamping predators thereby reducing predation on natural-origin salmon (Marnell 1986; White et al 1995). Predator attraction or swamping effects can be compounded when hatchery salmon induce natural-origin juveniles to leave their normal habitat and join the school of hatchery fish migrating downstream (Hansen and Jonsson 1985; Hillman and Mullan 1989).

2.5.3 Parasitism and Disease Transfers

Several viruses, bacteria, external and internal parasites can cause clinical infections in hatchery and naturally spawning Chinook salmon salmonid populations in the Central Valley. Many of the disease vectors are routinely present in hatcheries and enter via surface water supplies, in the adult fish coming into hatcheries, or are transmitted by birds and other vectors.

Parasites and pathogens may be transmitted between fish, and fish held in hatcheries are more susceptible to this transfer because of the higher densities in which they are held. The primary disease concern at the FRH has been infectious hematopoietic necrosis virus (IHNV), and the concern has been primarily focused on transfer of disease between hatchery fish released above the hatchery to fish in the hatchery. As implied by its name, IHNV causes severe necropsis of hematopoeitic (blood forming) tissues, especially in the anterior kidney, spleen, and pancreas. The virus has been most troublesome in hatchery situations where culture conditions may increase stress, transmission, and move rapidly from infection to clinical disease. Culture operations that have been affected by IHNV outbreaks include net pen Atlantic salmon growing facilities in the Pacific Northwest and commercial rainbow trout operations in Idaho to Coleman National Fish Hatchery and the FRH in the Central Valley. During serious outbreaks, mortalities of juvenile salmon can reach 70 – 80% in infected raceways. Virus sensitivity generally varies inversely with fish size, thus juvenile Chinook salmon are most vulnerable between the yolk sac fry stage to about two months of age. The IHNV is spread mostly through the water with two most likely routes: 1) in the water itself; or, 2) horizontal transmission from fish to fish. The virus may also be transmitted vertically from parents to progeny through gametes (Noga 2000).

Although there appear to be Central Valley reservoirs of IHNV that can infect hatchery populations, it is unclear how they function. For example resident rainbow trout may carry the virus and provide a source of infection to those hatcheries receiving a surface water supply. Another potential source of contamination comes from returning adult Chinook salmon. Early spawners may be IHNV free, but later spawners may essentially all be carriers, implying a local source for this rapid spread of the virus (Brown and Kimmerer 2004).

Personal communications (2004) with Bill Wingfield (retired CDFG fish virologist) and Bill Cox (CDFG, Statewide Fish Health Coordinator) yield the following bulleted Central Valley IHNV summary:

- Epizootics of IHNV were noted when Coleman National Fish Hatchery (CNFH) began operation in the 1940s. The early days of FRH and Nimbus Hatchery operations also saw IHNV outbreaks, with juvenile mortalities exceeding 90% in some cases. Such hatchery practices as feeding Alaskan sockeye salmon *O. nerka* viscera (possibly carrying IHNV), and Coleman's rearing and planting an infected strain of rainbow trout (Kamloops) in Shasta Reservoir may have contributed to the IHNV problem in the Valley. Movement of infected juveniles from place to place may have led to spread of different strains of the virus. For example, almost one million infected juvenile Chinook salmon were moved from CNFH to the Mad River Hatchery, where they were reared and then hauled back to the Sacramento River system for eventual release. There have also been some anomalous situations that puzzled fish pathologists (i.e., IHNV was a problem in the Trinity River, but not at the Iron Gate Hatchery on the Klamath River).

- In recent years IHNV has been less of a problem in Central Valley hatcheries. Although Coleman had epizootics in the mid-1990s, installation of an ozone treatment system on the water intake has apparently eliminated the problem at this facility. For several years before 1998, IHNV had not been a significant problem at FRH. Epizootics in juvenile hatchery Chinook salmon then occurred in 1998, 2000 and 2001, and 2002 with significant fish losses. In 2002, steelhead mortality due to IHNV occurred at the FRH.
- Although the virus had been detected in stream salmonids, there have been no reported epizootics of IHNV in Central Valley stream populations (i.e., the virus was detected but the fish themselves were asymptomatic of the disease).

Hatchery related disease studies were described, conducted and summarized as part of the Oroville Facilities FERC (DWR 2004a). Their review concluded that:

- Sacramento Valley strains of IHNV have continued to evolve, with particular activity in the Feather River and the FRH, but the continuing evolution of the virus does not seem to be resulting in strains that are more virulent than early ones. This of course, does not imply that future strains will also not increase in virulence.
- In recent years IHNV has caused epizootics in the CNFH and the FRH. In the case of CNFH, IHNV has been a recurring problem over the years. In the Feather River system, IHNV was a problem early on but, until 1998, had not caused epizootics.
- There is a general pool of the IHNV in the Central Valley that appears to be affecting returning adults. There is some possibility that the pool is maintained in part by the presence of adults in the system during all seasons of the year.
- Laboratory infection studies demonstrate that adults can be infected horizontally by exposure through the water. This helps explain the observation that the degree of infection is generally higher later in the run as compared to earlier (e.g., Wingfield and Chan 1970). This transmissibility could lead to different strains being carried from stream to stream as fish enter one or more streams before moving on to their spawning stream. This concern may be alleviated somewhat by the observation that green (immature) fish do not seem as susceptible to infection.
- Under many circumstances, infected juveniles can be released from the hatchery without affecting juveniles from naturally spawning salmonids. This conclusion is based on laboratory studies of fish with relatively low IHNV titers. Information on the effects of clinically diseased fish (not just those infected) on naturally occurring salmonids is not known. Free and Foott (1998) did show that infected juveniles released from CNFH were still infected when collected about 180 miles

below the hatchery. Another study of CNFH juvenile released showed that infected juveniles could survive for several days. In fact, the release group with the highest infection rate, had the highest survival to the Sacramento-San Joaquin Delta (and were also the largest fish). Thus, infected fish do survive after release, and exhibit at least the potential for disease transmission.

- The combination of conditions in the hatcheries that cause the disease to move from infection to epizootic is unknown. Free and Foott (1998) suggest that if 7-day mortality exceeds 0.5%, hatchery managers should be concerned that infection rates may be significant, exceeding 10%.
- The absence of IHNV in juvenile salmonids in the Yuba and Feather rivers suggests that transmission from the hatchery to riverine fish, including salmonids, may not be a major concern. However, note these data are limited in both time and space.

Although data are limited, there is substantial documentation of pathogen transfers from wild to hatchery fish, but virtually none for pathogen transfer from hatchery fish to wild fish (personal communication, W. T. Cox, Program Manager, Fish Production and Distribution, CDFG). Thus, it appears that IHNV is not readily transmitted from hatchery fish to salmon and other fish in streams, estuary or the ocean. However, this concern may be increased if more hatchery production is released on-site. The IHNV is ubiquitous in the Central Valley watershed and there is no indication that FRH production has resulted in distributing the Feather River strain of the virus to other streams. Additionally, hatchery management practices at FRH minimize the release of fish infected with pathogens, and transfer of fish to saltwater is also a control measure for any freshwater parasites that may remain when the fish are released.

2.5.4 Behavioral Differences and Influences

Hatchery salmon are known to exhibit a variety of behaviors distinct from those of natural origin fish. Hatchery salmon in natural streams tend to occur at higher densities, select lower current velocities, exhibit different feeding regimes, and generally may create differences in learning, behavior, phenotypic expression, and genotypic selection (Fleming and Gross 1989; Irvine and Bailey 1992). Additionally, hatchery fish may not be as successful at spawning as their wild counterparts (Chebanov and Riddell 1998).

Many hatchery fish behaviors, while harmless in a hatchery setting, are maladaptive in natural streams. Natural origin fish which mimic behavior of hatchery fish may suffer increased mortality. For example, hatchery salmon are known to induce natural-origin juveniles to leave their normal habitat and join the school of hatchery fish migrating downstream (Hansen and Jonsson 1985; Hillman and Mullan 1989).

Presently, half of FRH spring-run Chinook salmon are planted directly into the Feather River (downstream of Live Oak), while the other half are released in San Francisco Bay. Fish released in the bay are unlikely to influence juvenile emigration behavior, but fish released in the Feather River may influence natural origin Chinook salmon. The extent to which hatchery fish may influence natural origin Chinook salmon behavior is unknown.

2.5.5 Interbreeding

There are many concerns about how hatcheries may genetically affect naturally spawning salmonids including hybridization between runs on the same stream, spawning with salmonids from other streams, and changes in the genetic structure as a result of fish culture practices. The fundamental issue underlying all of these problems is that fish produced in hatcheries are different from fish completing their life cycle naturally. In other words, hatchery fish are domesticated. Domestication has been shown to result in the rapid loss of fitness for natural spawning and rearing (Reisenbichler and McIntyre 1977; Arkush et al. 2002; Weber and Fausch 2003; Kostow and Zhou 2006) and domestication of a hatchery population may also lead to problems when hatchery fish interbreed with wild fish either accidentally or as the intended result of supplementation programs (Waples 1999; Kostow and Zhou 2006).

The most important Chinook salmon genetic question on the Feather River involves the genetic integrity of the nominal spring Chinook salmon run. Unfortunately, pre-Oroville Dam genetic data is not available as a genetic baseline; thus only data collected in the 1990s or later can be compared. Since 1995, there have been extensive studies of the genetics of Central Valley Chinook salmon which included samples from the nominal Feather River spring and fall-runs. These studies help shed light on the any genetic separation of the two runs. Since they do not include any samples before Oroville Dam was constructed, they do not help determine if any recently observed differences in genetic structure between the runs has been caused by the Oroville Facilities.

For this examination of Feather River salmon genetics we rely mainly on the work of Dennis Hedgecock and Michael Banks conducted at the Univeristy of California at Davis Bodega Marine Laboratory. (Note, Michael Banks is now with Oregon State University's Hatfield Marine Science Center, Newport, Oregon.) Briefly these genetic efforts began in 1995 with the goal of determining the genetic structure of Central Valley Chinook salmon. Although the original study focused on winter-run Chinook salmon, the study design called for an examination of several Central Valley Chinook salmon populations to determine if winter-run Chinook salmon could be readily separated from the other three races through use of genetic techniques. The study was funded by DWR, along with accompanying efforts by CDFG to collect, archive, and distribute tissue samples from Central Valley Chinook salmon runs. Microsatellite markers were selected as the method used to determine if the runs could be genetically sorted. Banks et al. (2000) and Hedgecock et al. (2002) describe the procedures and present many of the results from these studies. For purposes of this evaluation, the neighbor-joining tree that resulted from this work is of particular interest (Figure 2-3 from Banks et al. 2000).

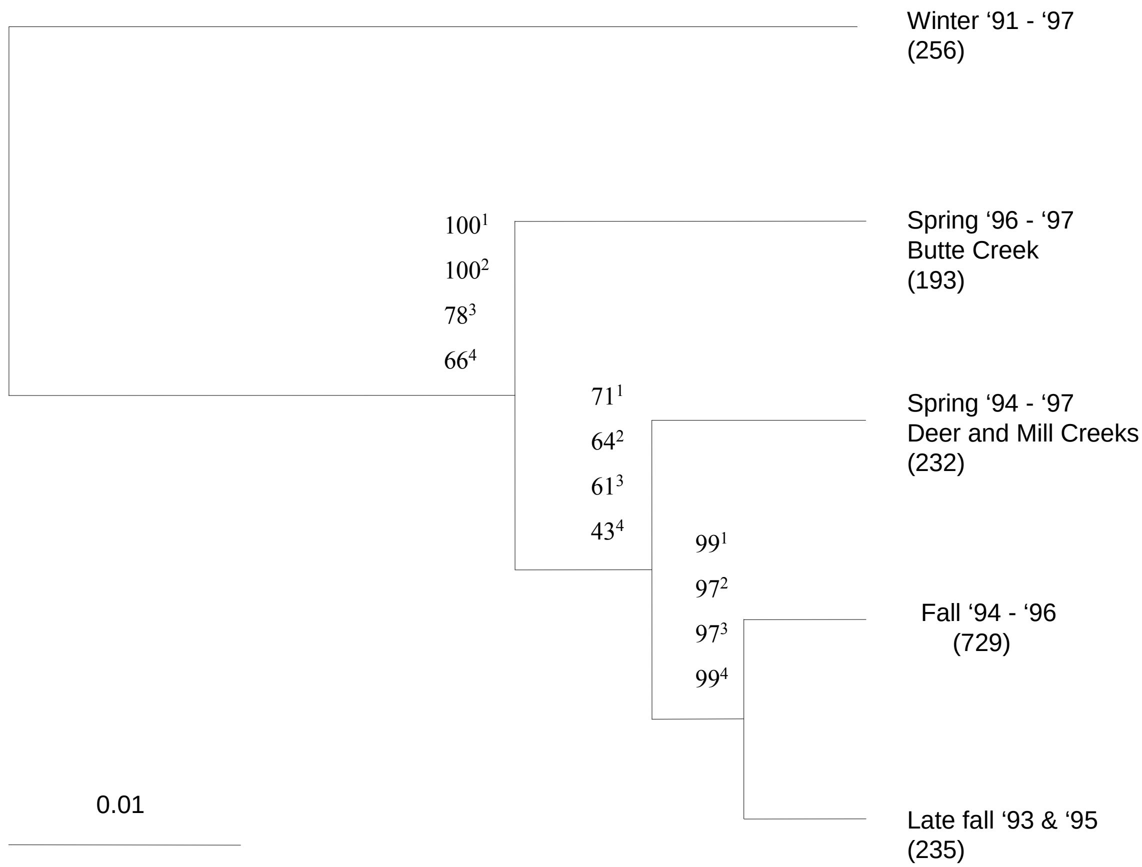

Figure 2-3. Genetic distance between Central Valley salmon stocks as defined by UPGMA phenogram derived from the Cavalli-Sforza chord measure using adjusted data from ten microsatellite loci (Banks et al. 2000). Numbers in parenthesis indicate samples size.

In this genetic tree, runs on the same limb are the most similar. Some important points from these data relative to the Feather River spring-run Chinook salmon are:

- There are two major branches on the tree: one that contains winter-run Chinook salmon; and, one that contains the other three races. This separation seems to support the hypothesis that the winter-run was long isolated from the other three races. Historically, winter-run Chinook salmon spawned during the summer in the spring-fed streams on the slopes of Mt. Lassen.

- There are genetically distinct spring Chinook salmon runs on Butte Creek (separate branch point), and on Mill and Deer creeks (sharing a common branch point).
- All Central Valley fall-run Chinook salmon populations are on one limb (i.e., the microsatellite markers used in this study could not distinguish among fall-run stocks in the Sacramento and San Joaquin drainages, or in individual streams within these drainages).
- Genetic data from tissues collected from nominal Feather River spring-run samples were included in this analysis and cluster on the fall-run limb of Figure 2-3, thus indicating these fish were most closely related to fall-run, but there was a slight difference. These nominal spring-run Chinook samples for this study were collected mostly in the late 1990s, and came from a variety of sources including fish captured in river by anglers and early arrivals to the FRH.

At the request of DWR, Hedgecock (2002) expanded the earlier work on genetic separation of Feather River Chinook salmon by increasing the number of microsatellite markers used (i.e., from 7-8 loci to 12 in these samples) to examine samples collected from 1994 through 2000 (Table 2-3). These samples were provided by CDFG. The 1994 samples are of particular importance as CDFG opened the hatchery ladder in June 1994, and the samples are from 25 fish that ascended the ladder (i.e., fish that exhibit the spring-run adult run timing characteristic). The unknowns likely include nominal spring-run Chinook salmon and fall-run Chinook salmon (e.g., FRH adults tissue collected from 23 September to 4 October 1999). Many of these samples could be more properly described as Feather River "early".

Table 2-3. Samples of adult, potential spring-run Chinook salmon provided to Bodega Marine Laboratory for genetic analysis.

Year	Race	Location	Date	Life Stage	N
1994	Spring-run	FRH	6/6/94	Adult, spawning	25
1995	Unknown	FRH	10/2/95	Adult, spawning	95
1996	Unknown	FR [1]	6/3/96-21/96	Adult	17
1996	Unknown	FR	10/3/96-9/96	Adult, carcass	78
1996	Unknown	FRH	9/30/96	Adult, spawning	95
1999	Unknown	FRH	9/23/96-10/4/96	Adult, spawning	115
2000	Unknown	FR [1]	5/6/00-6/12/00	Adult	50

[1] *Tissue collected angler caught fish.*

Based on the 12 microsatellite loci used, the samples analyzed formed a cohesive set of genetically similar populations that is somewhat different, but still most closely related to Central Valley fall populations. There was some indication of genetically distinct sub-populations in the Feather River, as well as indications that all the samples may not have contained genetically homogenous fish (e.g., in 1999 the 23 September fish seemed genetically distinct from the latter two sets of fish samples collected during the September/early-October period).

Hedgecock et al. (2002) confirmed that phenotypic Feather River early fish are distinct from Butte, Mill and Deer creeks spring-run, and were most similar to Central Valley fall-run Chinook salmon (Figure 2-4). These data did indicate there may be subpopulations of Chinook salmon on the Feather River and the existing populations are relatively close genetically, but still distinguishable.

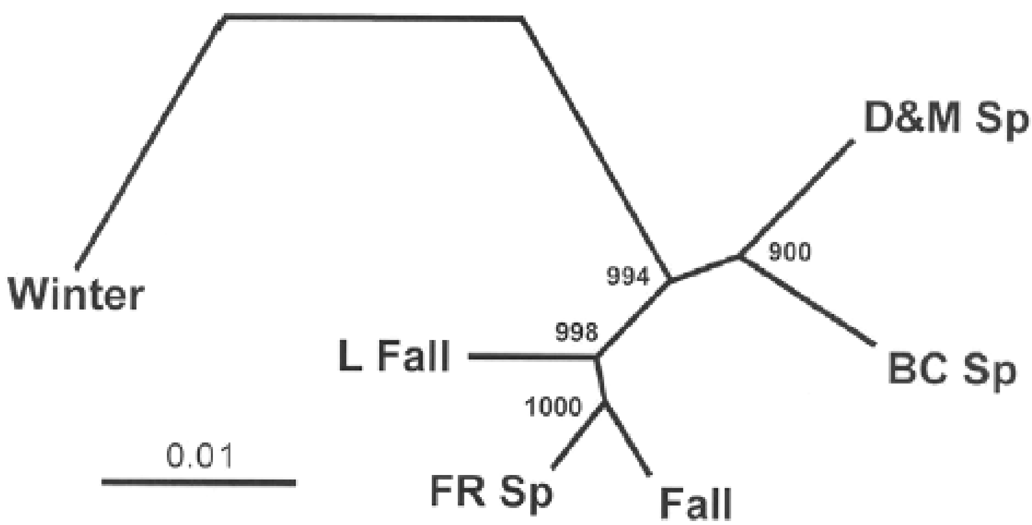

Figure 2-4. Genetic distance among Central Valley Chinook salmon runs. Note, L Fall = late fall, D&M Sp = Deer and Mill Creek springs, BC Sp = Butte Creek springs, FR Sp = Feather River Springs. (Hedgecock et al. 2002).

Michael Banks at Oregon State University analyzed about 100 tissue samples collected on Memorial Day weekend in 2003. His results and genetic tree demonstrated a similar pattern - i.e. the Feather River spring-run is genetically closer to Central Valley fall Chinook salmon than spring-runs on Deer and Mill creeks (Figure 2-5). Carlos Garza (NOAA Fisheries, personal communication) also examined about 70 of these samples and concluded that Feather River springs were most similar to Central Valley fall-run Chinook salmon, but that there may be variants within the Feather River Chinook salmon population that segregate by run timing.

Lastly, O'Malley et al. (2007) found homogeneity in netural microsatellite loci. They also showed Feather River spring-run Chinook salmon possess adaptive genes related to timing of migratory behavior (i.e., the "clock gene") whereas Central Valley fall-run Chinook salmon do not.

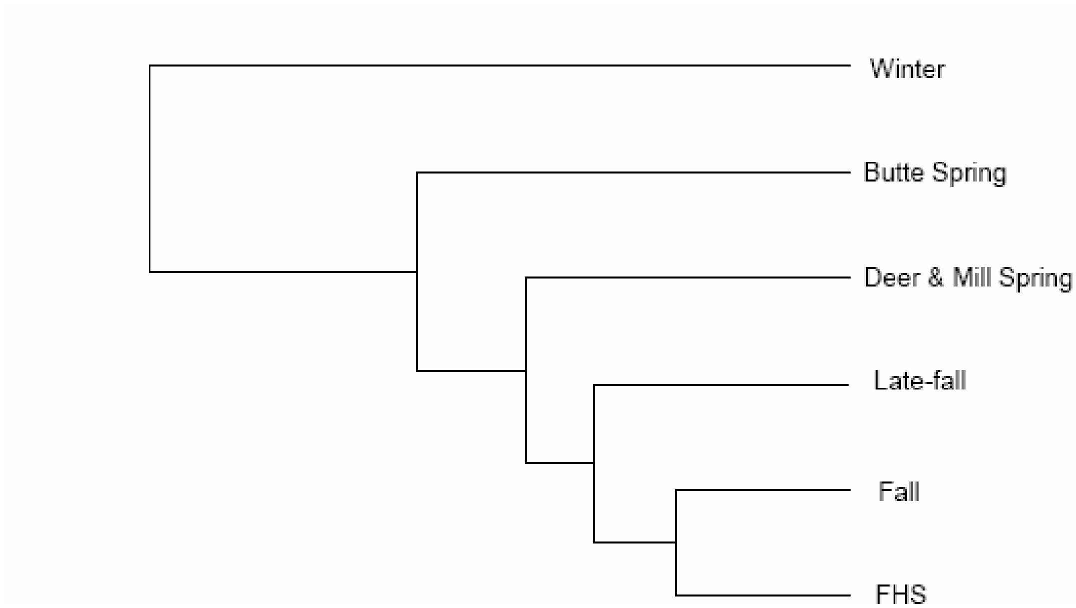

Figure 2-5. Genetic tree for Central Valley Chinook salmon based on 2003 Feather River early returns. Note, FHS are samples from fish that entered the hatchery on Memorial Day, 2003 (Preliminary data from M. Banks, OSU).

Hatchery fish straying rates in relation to release location has been the subject of farily intense study in the Central Valley. Early studies by Dettman and Kelley (1987) and Cramer (1990) attempted to examine the FRH contribution to the fisheries and escapement (including straying to other Central Valley streams), but their analyses and conclusions were constrained by insufficient data (i.e., mainly by the lack of a consistent tagging and tag recovery program at the Feather River and other Central Valley streams and hatcheries). Their results did indicate the FRH made a significant contribution to the ocean fisheries and a high proportion of adult Chinook salmon returning to the Feather River each year were of direct FRH origin. These data also suggested a significant degree of straying to other Central Valley streams from hatchery releases.

Mark and recapture data (coded wire tag recoveries) were used by CDFG in the ocean fisheries, Central Valley streams, and hatcheries to reconstruct the 1998 and 1999 fall Chinook salmon cohort from the FRH (Palmer-Zwahlen et al. 2004). One of the products of this analysis was an estimate of the rate at which fish released in the estuary return to the Feather River and to other streams (the stray rate). California Derpartment of Fish and Game staff estimated that of the estimated numbers of fall- and spring-run FRH Chinook salmon that returned to the Central Valley, about 90% returned to the Feather River (including the FRH), and about 10% strayed outside the Feather River basin. By comparison, about 6% of the in-basin releases strayed to streams other than the Feather River. The findings from the cohort analysis are in line with those from tag recoveries in Central Valley hatcheries and streams. Although tags from FRH fish were collected in most Central Valley streams sampled, about 96% of the 12,438 tags recovered during the 1997–2002 period were collected in the Feather River or at the hatchery. Compared to Bay releases, a lower percentage of in-basin releases survived to reenter the estuary as adults (0.3% vs. 0.9%), however these fish returned to the Feather River with greater fidelity (around 95% as compared to around 90% for Bay releases).

Beginning in 2002, FRH begain releasing half of all spring-run Chinook salmon production in-river and releasing the other half in the Bay. Though full recovery data are available only for 2002 and 2003 release years, several key insights are germane to this HGMP. Similar to previous studies, survival of in-river releases is roughly 1/3 that of fish released directly into the Bay (Table 2-4). Also as expected, straying rates for Bay releases were substantially higher than stray rates for in-river releases (Table 2-4), but as a percentage of fish recovered, straying rates were relatively low for both Bay and in-river releases (2.9% and 0.1%, respectively). The proportion of recoveries from sport and commercial fisheries was comparable, but returns to FRH and Feather River spawning grounds differed markedly between release locations (Figure 2-6). In-river releases were more likely recovered at FRH and appeared less likely to be recovered on the Feather River spawning grounds relative to Bay releases.

Table 2-4. Number of recoveries per million released of FRH spring-run Chinook salmon for Feather River (In-river) and Bay releases for brood years 1998-2002.

	Overall	Commercial	Hatchery	Spawning Ground	Sport	Strays
In-river Release	6,123	2,292	1,928	264	1,635	7
Bay Release	16,680	6,457	2,315	2,573	4,844	491

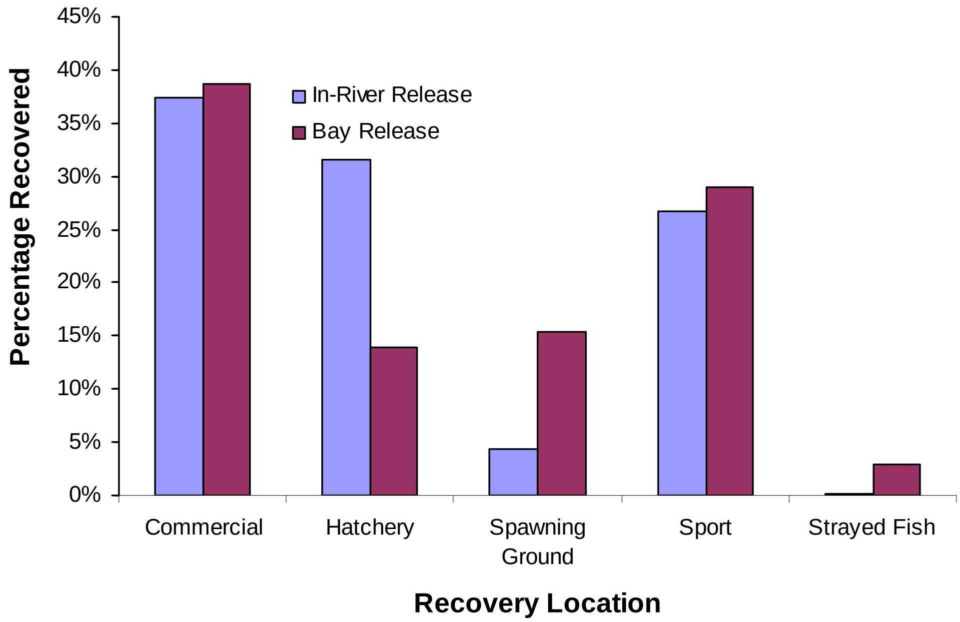

Figure 2-6. Recovery of coded wire tagged spring-run Chinook salmon released in the Feather River (In-river) or San Francisco or San Pablo Bay (Bay Release), reported as percentage of all tags recovered from various sources, including: in commercial fisheries (Commercial), FRH (Hatchery), Feather River spawning ground (Spawning Ground), recreational fisheries (Sport), or hatcheries or spawning grounds outside of the Feather River (Strays), for brood years 1998-2002. Note, recovery numbers are the estimated number of fish in the catch within each tag group, as estimated by the reporting agency.

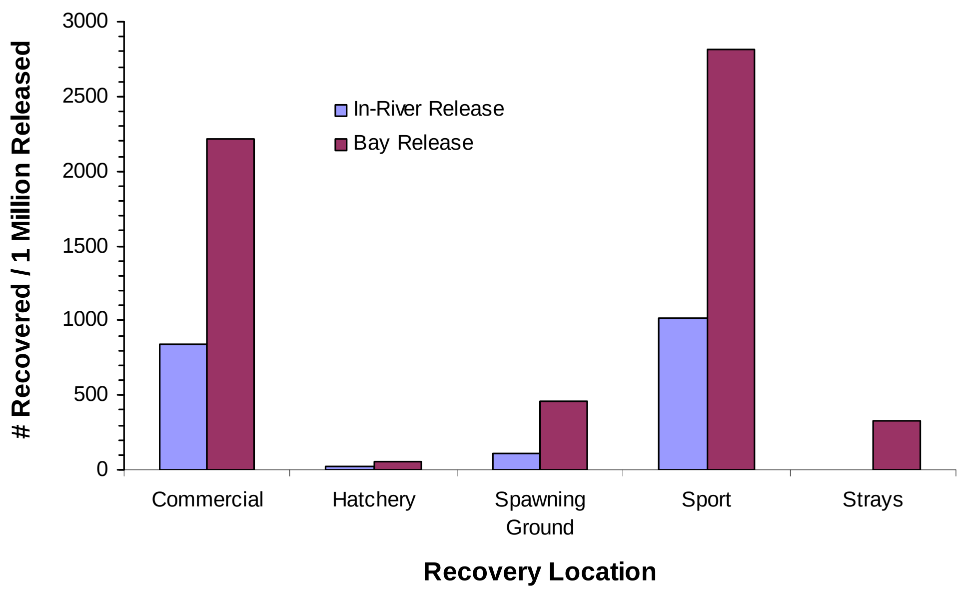

Figure 2-7. Recoveries per million released of coded wire tagged spring-run Chinook salmon released in the Feather River (In-River) or San Francisco/San Pablo Bay (Bay Release), and caught in commercial fisheries (Commercial), FRH (Hatchery), Feather River spawning ground (Spawning Ground), recreational fisheries (Sport), or hatcheries or spawning grounds outside of the Feather River (Strays), for brood years 1998-2002. Note, recovery numbers are the estimated number of fish in the catch within each tag group, as estimated by the reporting agency.

In summary, hybridization between Feather River fall and spring-runs has clearly occurred. However, it does not appear that hybridization between FRH fish and winter, spring and late-fall-runs on other streams has occurred. These findings are also consistent with the generally low straying rates estimated by recovery of coded wire tags. If FRH-origin fish have been straying extensively, the effect is not apparent in the genetic structure described by microsatellite markers for Central Valley spring Chinook salmon runs in Mill, Deer and Butte creeks, or on winter and late-fall-runs that spawn in the mainstem Sacramento River. However, better sampling for hatchery strays is still advisable to accurately estimate straying and hybridization threats from FRH production.

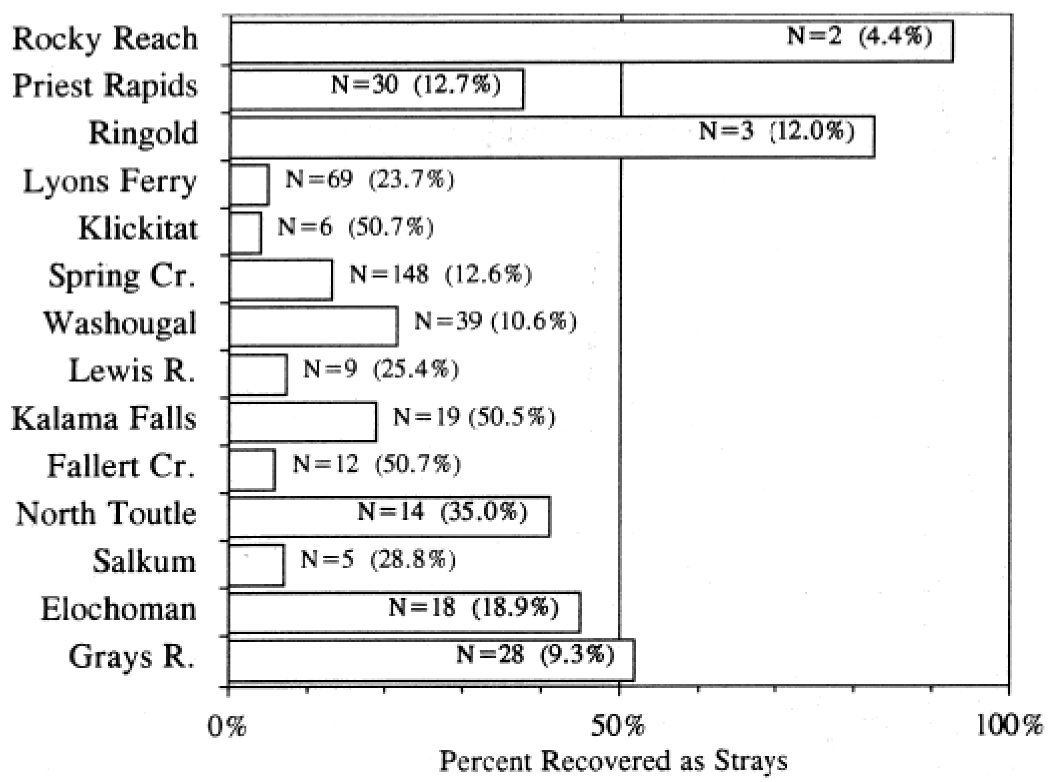

Figure 2-8. Percent of fall-run Chinook recovered as strays from on-station releases at Colombia River hatcheries. The hatcheries are arranged in the order they are encountered going up the Colombia River. Grays River Hatchery is closest to the estuary. N = number of tag groups used to estimate the percent recovered as strays. The number in brackets is the coefficient of variation among the tag groups originating at that hatchery. From Vander Haegen and Doty (1995).

Within the Central Valley fall-run population however, there has been extensive mixing among hatchery and natural origin fish through operation of FRH and other Central Valley salmon hatcheries. It is also likely that this excessive gene flow has caused the resulting populations to be less fit outside the hatchery environment. Fall-run Chinook salmon populations in the Central Valley have been found to have low genetic diversity as compared to Chinook salmon populations elsewhere (Banks et al. 2000; Williamson and May 2003). However, studies from Washington state (Vander Haegen and Doty 1995, Figure 2-8) show fall-run Chinook strayed more and with greater variability than straying observed among Coho salmon; even when fish are released at their hatchery of origin (i.e. on-station). For example, Vander Haegen and Doty (1995) found less than 3% of on station Coho releases strayed, whereas an average of 23.9% of all Colombia River fall run Chinook released on station strayed.

While loss of genetic diversity as a consequence of straying is well documented, fitness consequence of straying among Chinook salmon are less understood. Currently no studies have attempted to document the putative loss of fitness resulting from interbasin strays or more generally from interbreeding between hatchery and natural origin Central Valley Chinook salmon. Following Araki et al. (2007), full parental genotyping could be used to contrast reproductive fitness (i.e., number of progeny reaching adulthood) among spring-run Chinook from the Feather River and Butte Creek, for example.

2.5.6 Strategies to Reduce Ecological and Genetic Interactions

Release of hatchery salmon inevitably leads to some interaction with natural origin fishes. As already described, these interactions take many forms and can be either positive or negative (we concern ourselves primarily with the latter). Though we can easily describe potential interactions between hatchery and natural fish we often lack sufficient information to make well-founded judgments regarding the net effect of one approach relative to another. For example, salmon released in the Bay maximize survival, but also contribute to higher rates of straying and genetic introgression. Releases made in-river minimize straying risks, but lower production success and create new conflicts related to competition and behavioral influences on natural origin juveniles.

The practice of releasing 50% FRH spring-run Chinook salmon smolts in San Pablo Bay to encourage rapid out-migration and reduce competition with naturally-produced salmonids may be a reasonable, though imperfect, management strategy. Decreased survival and potentially significant (but unknown) interactions between hatchery and natural origin fish argue against in-river releases for all spring-run Chinook production. However, the performance of in-river releases could potentially be improved with corresponding flow pulses and by reducing predation losses at release locations. Continuing 50% in river releases for the term of this HGMP provides an opportunity to experimentally evaluate in-river survival and strategies for reducing adverse interactions with wild origin fish.

3. WATER SOURCE

3.1 Water Source, Water Quality Profile, and Natural Limitations to Production Attributable to the Water Source

FRH receives raw water from the Feather River at the Thermalito Diversion Dam and distributes it to the hatchery buildings and fish rearing areas. Overall raw water intake approximates 110 cfs. The raw water is gravity fed to an aeration tower where it is aerated and piped through the entire facility. Currently, more water is being gravity fed to the aeration tower than can be used. This is necessary to maintain sufficient water pressure. Thus, when the minimum discharge through the facility is estimated to be 40 cfs, approximately 69 cfs of aerated water is discharged directly back into the Feather River through the aeration overflow pipe. An estimated minimum 40 cfs and up to a maximum of 74 cfs is used. The Thermalito Annex, near the Thermalito Afterbay, uses about 12 cfs of well water that have percolated through Thermalito Afterbay soils.

The FRH has requested that DWR supply daily mean water temperatures during specific time periods (Table 3-1). However, as described previously temperatures provided to FRH are expected to change with implementation of the FERC licensing requirements for the Oroville Facilities.

Table 3-1. Current range of suitable water temperatures required for fish production at FRH.

Time Period	Daily Mean (Range ±4°F)
September	52 (48-56)
October - November	51 (47-55)
December – March	55 (51-59)
April – May 15	51 (47-55)
May 16 – May 31	55 (51-59)
June 1 – June 15	56 (52-60)
June 16 – August 15	60 (56-64)
August 16 – August 31	60 (54-62)

Studies indicate that average quality of the water entering the FRH has been quite good, with no constituents that are likely to adversely impact cold water fish culture or human health (DWR 2004d).

The discharge of FRH effluent is by percolation back to the Feather River from a large settling pond. Currently, much of this water re-enters the Feather River through a river side channel adjacent to FRH called "Hatchery Ditch". Quality of the discharge water is regulated by NPDES permit number CA0004570 issued by the California Regional

Water Quality Control Board. The permit regulates the discharge of constituents identified in Table 3-1. Discharged water has consistently met these requirements.

Table 3-1. FRH discharge effluent limitations.

Parameter	Units	Effluent Limitations			
		Average Monthly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
Flow[1]	mgd	--	47.3	--	--
pH	standard units	--	--	6.0	9.0
Total Suspended Solids[2]	mg/L	5	15	--	--
	lbs/day[3]	1,972	5,917	--	--
Settleable Solids[2,4]	ml/L	0.1	0.2	--	--
Copper (Total Recoverable)	µg/L	1.99	4.0	--	--
Formaldehyde	mg/L	0.1	--	--	--
Chloride	mg/L	106	--	--	--

[1]*Total of PND-001, PND-002 and EFF-003.*
[2]*Effluent limitations are net values (increase over source water).*
[3]*Based on a design flow of 47.3 mgd.*
[4]*Applicable to D001, D002 and D003 only.*

3.2 Measures to Minimize the Likelihood for the Take of Listed Natural Fish as a Result of Hatchery Water Withdrawal, Screening, or Effluent Discharge

Water used at FRH and FRH annex comes from sources that do not involve ESA issues. The Thermalito Diversion Pool and the Thermalito Afterbay are above fish barriers and no listed species are affected by water intake, and thus no risk aversion measures are necessary. As described previously, the area effluent discharge is located within critical habitat of Central Valley steelhead and Central Valley spring-run Chinook salmon. Present levels of operation allow FRH to meet federal effluent discharge water quality standards and minimize any take of this species. Since there are no plans to increase the level of operations at FRH, it is anticipated that FRH will continue to meet effluent discharge minimum standards.

3.3 Water Withdrawal and Screening

The Thermalito Diversion Dam Powerplant is a hydroelectric power plant located below the left abutment of the Thermalito Diversion Dam. Water flows through the power plant (or spills over the diversion dam) into the Feather River to maintain fish habitat between the Fish Barrier Dam and the Thermalito Afterbay Outlet. The FRH water comes from a subsurface intake pipe located in the Thermalito Diversion Dam. No fish screening is present on this intake, but due to its location no special status species are impacted.

3.4 Effluent Discharge

An estimated minimum 40 cfs and up to a maximum of 74 cfs of flow-through wastewater discharges to two settling basins (approximately 300 feet long by 30 feet wide and 15 feet deep) located near an embankment on the Feather River. The two settling basins are constructed with overflow pipes, which are capable of discharging directly to the Feather River (Figure 3-1) (discharge locations D001 and D002). However, no direct discharges have occurred from D001 or D002 since completion of the settling basins in 1984 because the basins are constructed in permeable gravels resulting in the percolation of wastewater through the settling basins into the Feather River via seepage. A main sump collects water from a majority of the facility, including eight of the ten rearing raceways, the rearing channel, and the hatchery buildings. Wastewater collected in the main sump is pumped (from the hatchery building) or gravity fed (from the raceways and rearing channel) into the two settling basins. If the main sump pumps are overwhelmed or fail, this wastewater will directly discharge to the Feather River via the sump overflow pipe (Figure 3-1, D003). Wastewater from the holding tanks adjacent to the Main Hatchery Building also discharges directly to the sump over flow pipe. Wastewater from the two newer raceways located on the western portion of the facility discharges directly to Settling Basin 002.

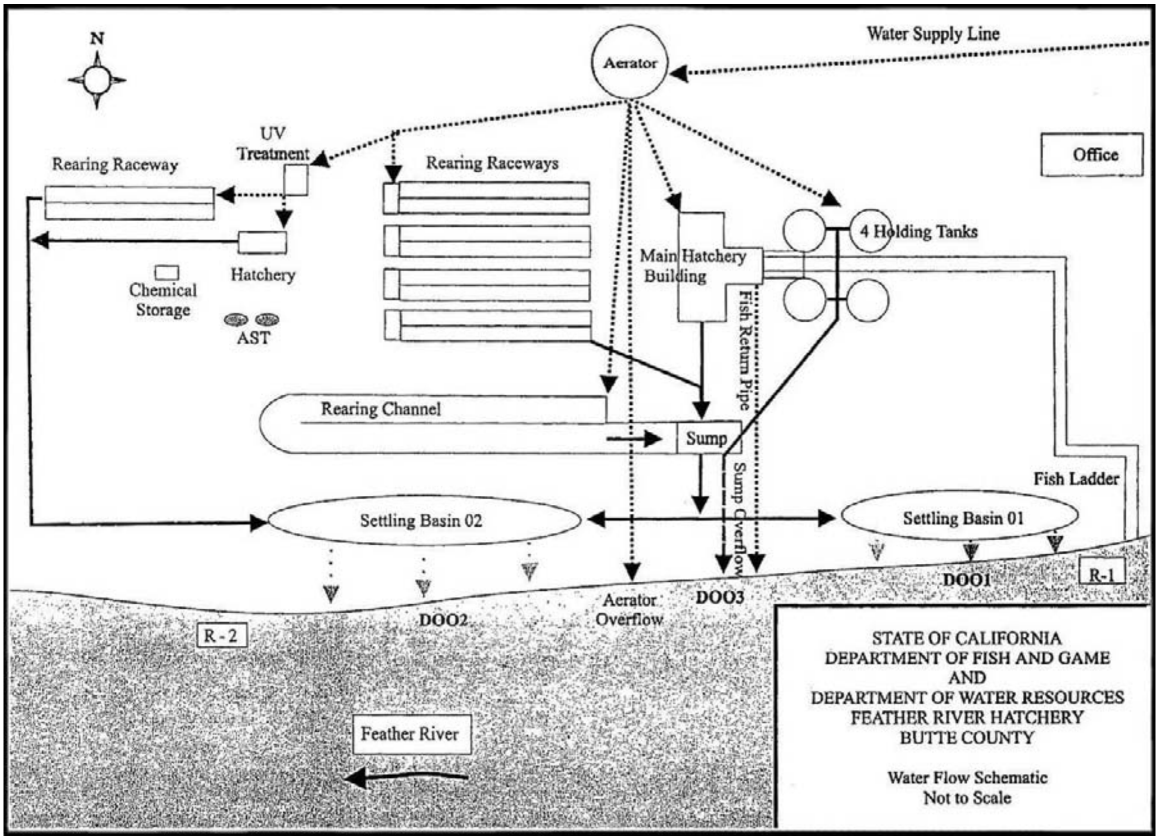

Figure 3-1. FRH water distribution and discharge

FRH has several raw water discharge points: the aerator overflow pipe; the fish ladder and gathering tank; the four holding tanks adjacent to the Main Hatchery Building; and, a fish return pipe located in the floor of the spawning room in the Main Hatchery Building. In order to pipe water to the two newer rearing raceways constructed on the western portion of the facility property, overall raw water intake flow to FRH increased to approximately 110 cfs. The raw water is gravity fed to an aeration tower where it is aerated and piped through the entire facility. Currently, more water is being gravity fed to the aeration tower than can be used. When the minimum discharge through FRH is estimated to be 40 cfs, approximately 69 cfs of aerated water is discharged directly back into the Feather River through the aeration overflow pipe. This discharge consists strictly of aerated water and contains no chemicals or hatchery wastes. When the fish ladder is in use during the migration and spawning season, raw water from the fish ladder, a gathering tank and four holding tanks located adjacent to the Main Hatchery Building, discharges directly to the Feather River. These direct discharges contain minimal quantities of fish fecal material, but no chemicals or unconsumed fish food is present, as the fish are not fed or treated in these locations.

4. DESCRIPTION OF THE FACILITY

4.1 Broodstock Collection Facilities and Methods

All upstream migrating Chinook salmon and steelhead are stopped at the Fish Barrier Dam (Figure 4-1). A 1/3-mile long gated fish ladder at the base of the dam allows fish to move up to the hatchery. The ladder gates are generally open from about September 15 through the following June to ensure that spring- and fall-run Chinook salmon and steelhead have an opportunity to enter the hatchery.

4.1.1 Fish Barrier Dam

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the FRH. Flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the Fish Barrier Dam and the Thermalito Afterbay Outlet. The dam diverts fish into a fish ladder that leads to the FRH. The Fish Barrier Dam is constructed of concrete, 600 feet wide, with a maximum height of 91 feet (from base of dam to tallest abutment).

Figure 4-1. Fish Barrier Dam, fish ladder entrance is located to the bottom left, off picture.

The Fish Barrier Dam divers fish into a ladder (Figure 4-2) that leads to the hatchery. The fish ladder is approximately 1/3-mile long and consists of a series of “steps” and pools. Pool length ranges from 8 – 1,000 feet, with a minimum width of six feet and a minimum water depth of two feet. Velocity of flow in the ladder ranges from two to five feet per second (fps), and the maximum drop between pools is one foot. Underwater passage of fish can be observed through 42-inch square viewing panels installed in the fish ladder wall.

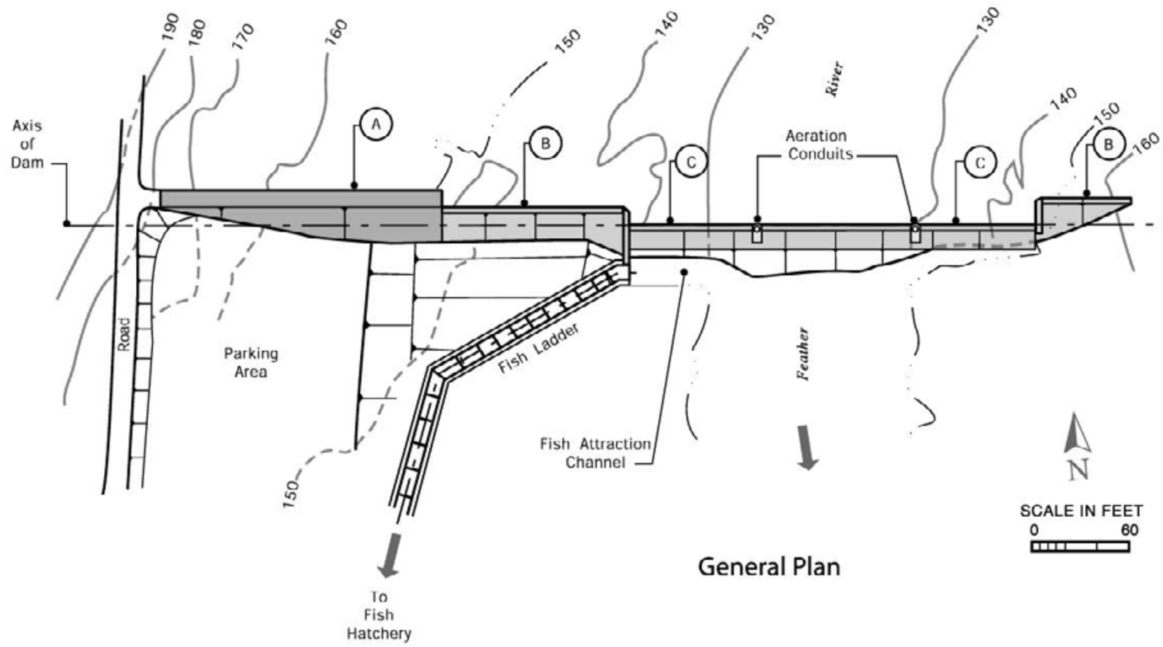

Figure 4-2. Schematic view of Fish Barrier Dam in relation to the fish ladder.

An enlarged section of the fish ladder at its upstream terminus functions as a gathering tank, entrapping fish ascending the ladder. A mechanical sweep gathers the fish and deposits them into the abutting spawning building. Four concrete circular tanks hold the fish until they are ready to spawn.

4.1.2 FRH Main Facility

The FRH Main Facility consists of an office and maintenance building, two hatchery buildings, ten concrete raceways, one concrete rearing channel, a gathering tank, four holding tanks, an aeration tower, an ultraviolet treatment building, several storage sheds, and the fish ladder (Figures 4-3 and 4-4). The main facility building houses the spawning operations and the egg incubators. As adult fish reach the end of the fish ladder, they are held in a gathering tank. A mechanical sweep moves the fish into the spawning room in the main building. Salmon and steelhead that are not ready to be artificially spawned are moved to one of four circular holding tanks. At the beginning of spawning operations, the fish are placed into a tranquilizing tank and are anesthetized with carbon dioxide. Fish can be returned to the river by a pipe in the floor of the spawning room. Viewing windows are located on either side of the spawning room where the public can observe the spawning operation.

The Hatchery Spawning Building is where the artificial spawning takes place. Milt is taken from the male and mixed with eggs taken from the female. The fertilized eggs are kept in incubators capable of holding up to 25 million eggs. The fry or young fish are held in incubators until they can be transferred to the rearing channels.

Young fish (i.e., fingerlings and yearlings) are held in rearing channels until they are ready for release. The rearing channels are concrete-lined raceways blocked off in intervals to form as many as 48 individual pools 100-ft long and 10-ft wide. Water flow and velocity in the raceways is 3–5 cfs at 0.1 fps. The raceways are covered with netting to protect the fish from predators such as hawks and herons. The raceways can be blocked at various intervals to provide holding space for special studies or for holding individual groups of marked and tagged fish.

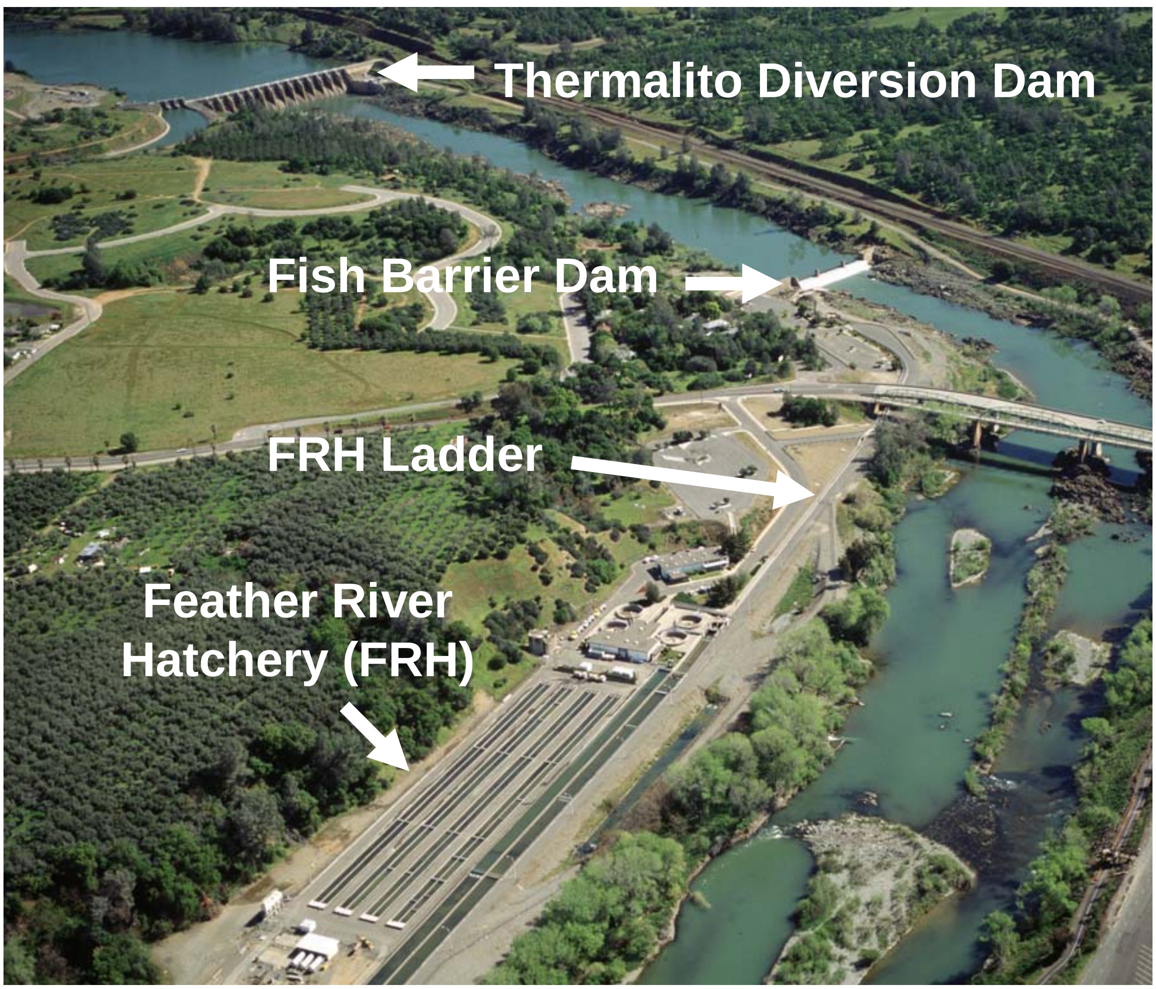

Figure 4-3. Aerial photograph of FRH main facility and related features.

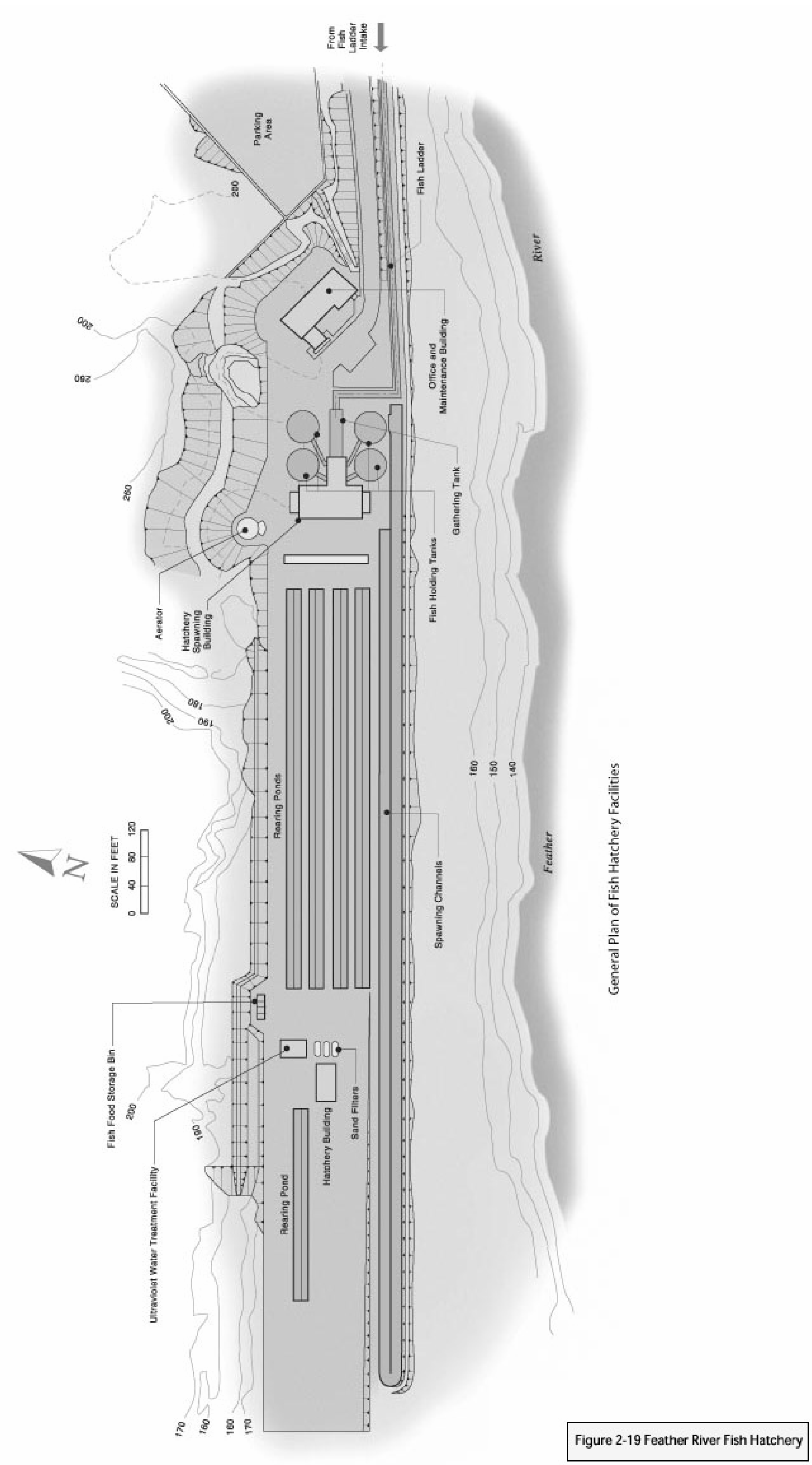

Figure 4-4. Schematic of main FRH facility.

4.1.3 FRH Thermalito Annex

The FRH Thermalito Annex (Annex) is located downstream from the FRH on the west side of the Thermalito Afterbay (Figure 1-1 and 4-5). The Annex provides additional rearing capacity for 2.5 million fingerling salmon. Temperature differences between FRH and the Annex (i.e., the Annex water is generally warmer during the rearing season) allow fish to be moved for faster growth, or to control diseases (IHNV, in particular). After growth had been achieved, or disease problems eliminated, the fish can be returned to the main hatchery. As of 1993, this practice of moving fish back and forth had been mostly discontinued and the Annex is being used almost exclusively for enhancement fish, although some mitigation fish may be reared there (A. Kastner, CDFG, personal communication).

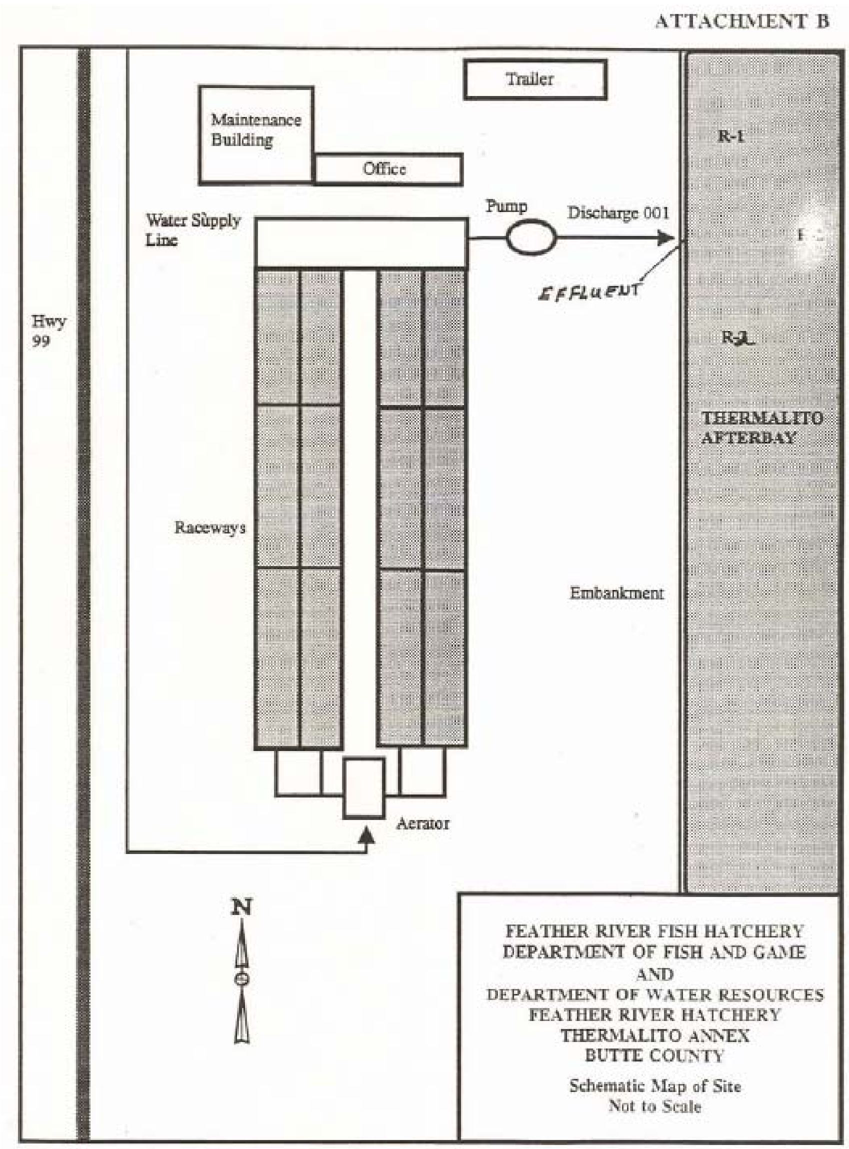

Figure 4-5. Schematic of the Thermalito Annex to FRH.

5. BROODSTOCK ORIGIN AND IDENTITY

5.1 Hatchery Broodstock Source

The spring-run Chinook salmon broodstock for the FRH is taken from adult phenotypic spring-run Chinook salmon entering the FRH during the period April through June. This selection is accomplished by opening the FRH ladder during these months. All Chinook salmon ascending the ladder and entering the hatchery are marked with two individually numbered Hallprint external tags and returned to the Feather River. The ladder is closed at the end of June, and not re-opened until approximately September 15. In instances where insufficient numbers of floy-tagged fish are available for spawning, spring-run Chinook salmon broodstock may be supplemented by spawning spring-run Chinook salmon identified by coded wire tag. No coded wire tagged fall-run Chinook will be used as spring-run Chinook broodstock.

Further details on protocols for identifying and spawning spring-run Chinook salmon at FRH can be found in Appendix D.

5.2 Supporting Information

Historic information on spring-run Chinook salmon is lacking. Yoshiyama et al. (2001) described the historic and present distribution of Chinook salmon in the Feather River while more recent information can be found in a variety of published papers, DWR reports and the annual report of the FRH.

5.2.1 History

The spring-run Chinook salmon broodstock for the FRH originated from native Feather River stocks. From 1967 to 2003, spring-run Chinook salmon broodstock were identified by the fall timing of adult entry to fish ladder and the hatchery. For example, fish processed by the hatchery by September 30 would be identified as spring-run Chinook salmon, and fish processed on or after October 1 were called fall-run Chinook salmon.

Since 2004, spring-run Chinook salmon have been identified by their entry into FRH between May and June (and through July 15 in 2008).

5.4 Annual Run Size

The estimated annual run size for Feather River spring-run Chinook salmon typically exceeds the number of individuals needed for spawning. Approximately 750 females and 750 males are needed annually to meet egg take and hatchery procedural goals.

5.5 Run Timing

Poor records are available related to the immigration timing of Feather River adult Chinook salmon. Chinook salmon trapping studies conducted prior to completion of

Oroville Dam (and FRH), show a distinct pulse of salmon entering March to June, peaking in May (Figure 5-1).

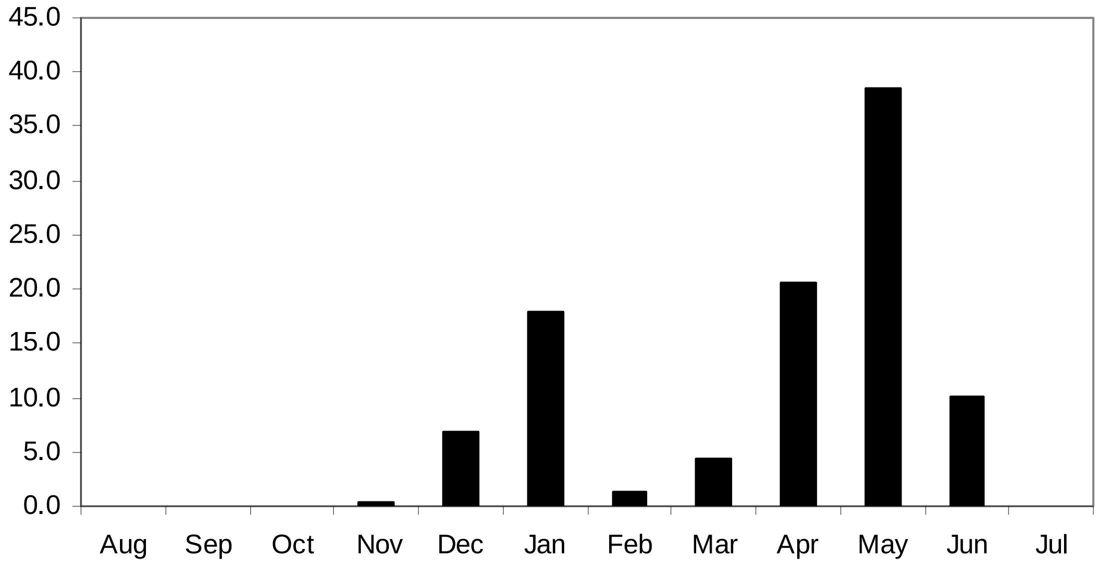

Figure 5-1. Timing of adult Chinook salmon captured at construction tunnel mouth passing Oroville Dam. Note, Y-axis represents numbers as average fraction of fish by month, 1963-1965.

More recent data on spring-run Chinook salmon timing are available beginning in 2004 with spring operations of the FRH ladder. Though data are incomplete for some years, a substantial May through June influx of phenotypic spring-run Chinook salmon is evident (Figure 5-2). The start and peak of the run appears to be about one month later than it was from 1965 to 1967. Since ladder operations do not extend beyond June (and have been cut short in some years due to permit constraints),we cannot evaluate Chinook salmon emigration timing in July and August. In making these comparisons however, it should be noted that in-river trapping from 1963 to 1965 may not be directly comparable to trapping at FRH.

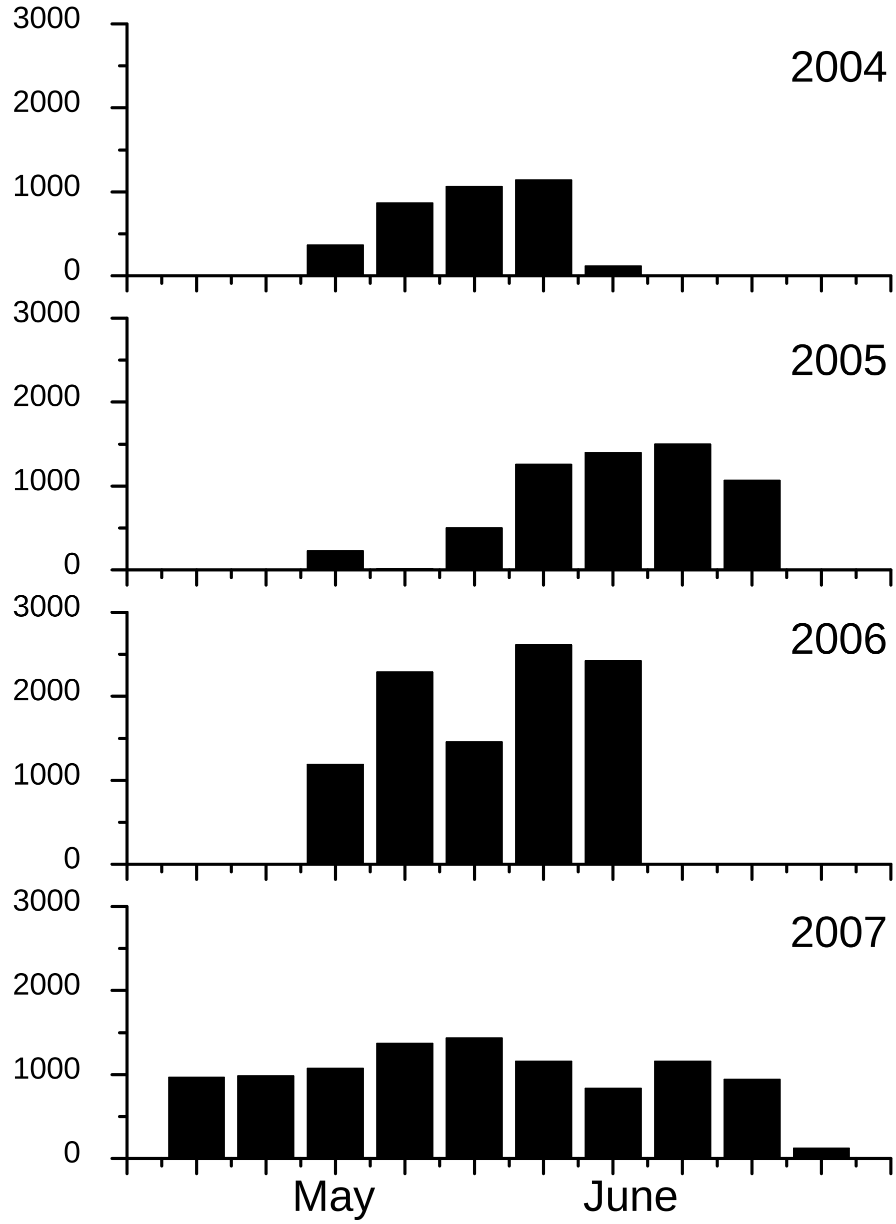

Figure 5-2. Timing of spring-run Chinook salmon entering FRH, 2004-2007.
Note, Y-axis numbers represent floy-tagged fish only, in some years tagging was stopped early due to sampling permit constraints.

5.6 Past and Proposed Level of Natural Fish in Broodstock.

The composition of wild origin fish in the FRH spring-run broodstock is largely unknown. Beginning in 2002, FRH has attempted to adipose fin clip and tag 100% of spring-run Chinook salmon smolts produced (Figure 5-3). As a result, adipose clips are increasingly prevalent among spring-run Chinook salmon adults entering FRH.

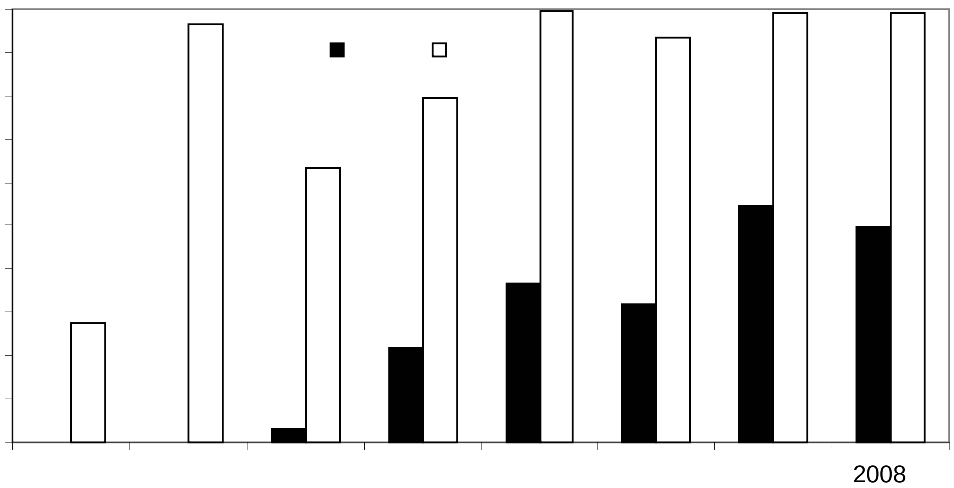

Figure 5-3. Proportion (Y-axis) of FRH spring-run Chinook salmon per year with adipose fin marks among broodstock adults at FRH, and among planted smolts.

The difference in adipose clip rates between returning adults and contributing smolt brood years would be one approach to assessing hatchery composition among broodstock. However, fall- and spring-run Chinook salmon are commonly misclassified at FRH (Figure 5-4). The tagging rate among fall-run Chinook salmon has been relatively low (5–10%) until 2006, when the 25% constant fractional marking program was implemented. Thus, efforts to estimate wild or hatchery origin among FRH broodstock can not be accurately assessed at this time. Marking of 100% of the hatchery fish by clipping the adipose fin, otolith thermal marking, or otolith isotope analysis will be necessary to definitively determine and manage hatchery composition among FRH broodstock.

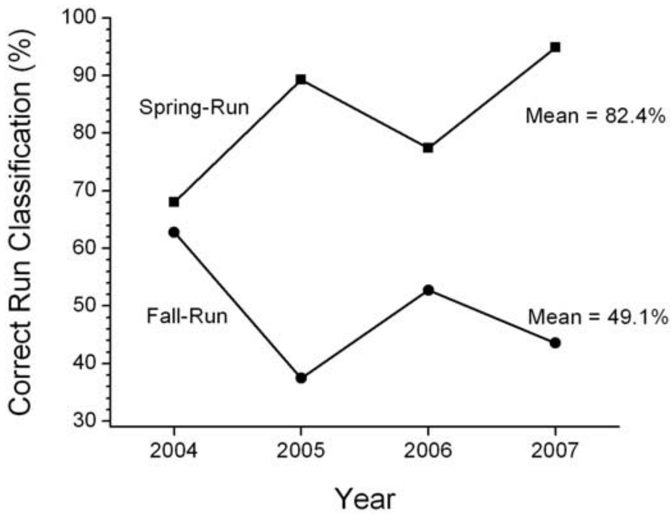

Figure 5-4. Percentages of spring and fall-run Chinook salmon correctly identified at FRH.
Note, run identification is from coded wire tag recoveries and is based on the run designation of the original spawners as compared to the run designation of the returning adults.

5.7 Genetic or Ecological Differences

There are no known genetic or phenological, or ecological differences between the hatchery and naturally spawning Chinook salmon runs in the Feather River. As described earlier in detail (Section 2.5.5, Interbreeding), Feather River spring-run Chinook salmon are genetically most similar to Central Valley fall-run. However, a recent study by O'Malley et al. (2007) found that Feather River phenotypic spring-run do exhibit a "clock gene" not found among phenotypic fall-run.

5.8 Age Structure, Fish Size, Fecundity, and Sex Ratio

Age Structure – Analysis of coded wire tags recovered from salmon entering FRH from 2000 through 2004 indicates that though variable, the population is primarily composed of Age-3 and Age-4 fish (Table 5-1).

Table 5-1. Age composition at FRH based upon recovery of coded wire tags and the proportion of fish tagged in each brood year (CDFG, unpublished data).

Percent by Age of Spawning Run to Returning to Hatchery				
Year	Age2	Age 3	Age4	Age 5
2000	10.4	48.0	41.5	0.01
2001	3.1	70.3	26.3	0.03
2002	4.9	48.8	45.5	0.05
2003	5.9	17.7	76.0	0.04
2004	30.2	49.7	16.9	3.3

Percent by Age of Spawning Run to Returning to Hatchery				
Year	Age2	Age 3	Age4	Age 5
Average	10.9	46.9	41.2	0.68

Similar patterns to FRH age composition are apparent among in-river spawning Chinook salmon in 2006, but differed substantially in 2007 when age-3 fish were under-represented (Figure 5-5). Additional years of in-river and hatchery age composition data will be necessary to assess trends and differences. Collectively, available data show that age composition is variable from year to year, but that three and four year olds compose the majority of the spawning run, with five years olds being relatively rare.

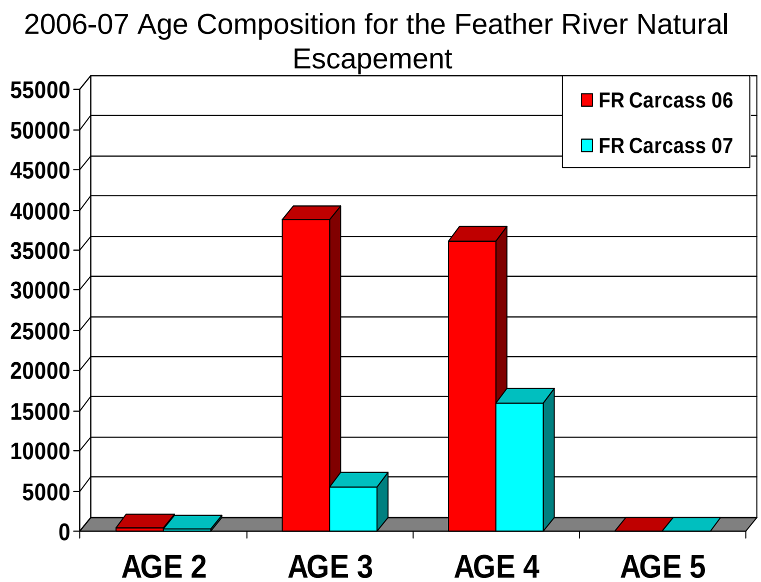

Figure 5-5. Age composition among in-river spawning Chinook salmon (spring- and fall-run) as determined by preliminary CDFG scale reading. Note, Y-axis represents escapement abundance estimate.

Fish Size – Total length observed among 2007 adult Chinook salmon in FRH and spawning in the Feather River are depicted in Figure 5-6. The explanation for larger sized fish observed during the river carcass surveys is uncertain, but may result from the mixture of spring- and fall-run Chinook on the spawning grounds. A contributing factor may be that smaller male salmon are known to swim downstream after spawning, and may therefore be under-represented in carcass surveys.

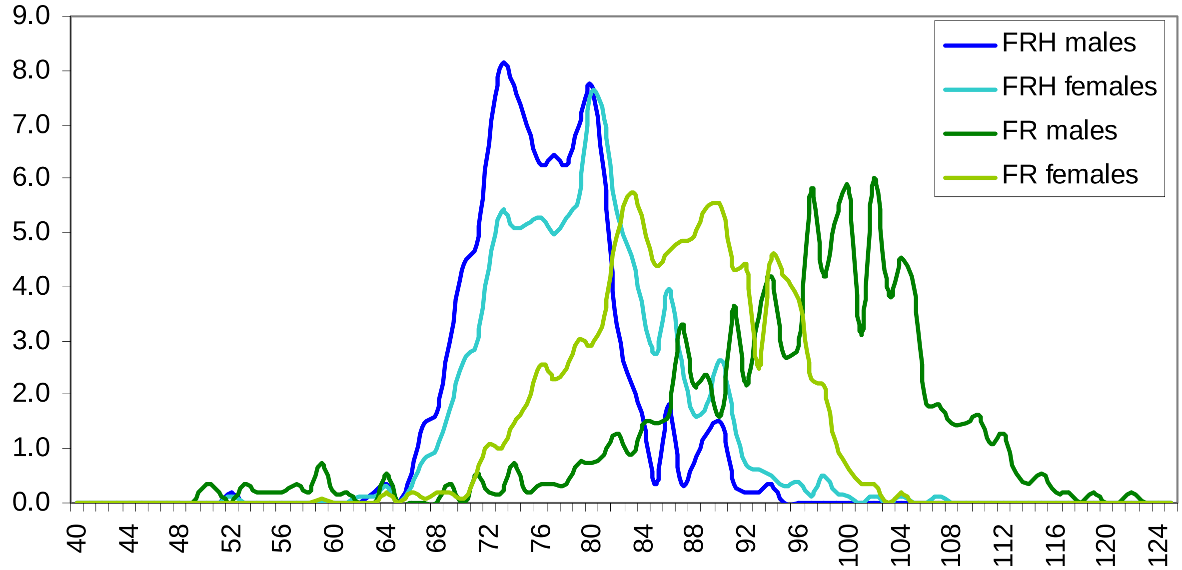

Figure 5-6. Length-frequency of Chinook salmon collected at FRH and from carcass surveys in 2007. Note, FR =Feather River, Y-axis respresents abundance in thousands, and the X-axis is carcass total length (cm)

Examining additional years of salmon length data collected from the Feather River carcass survey illustrates a relatively consistent size distribution among females, but considerable inter-annual variation among males (Figure 5-7).

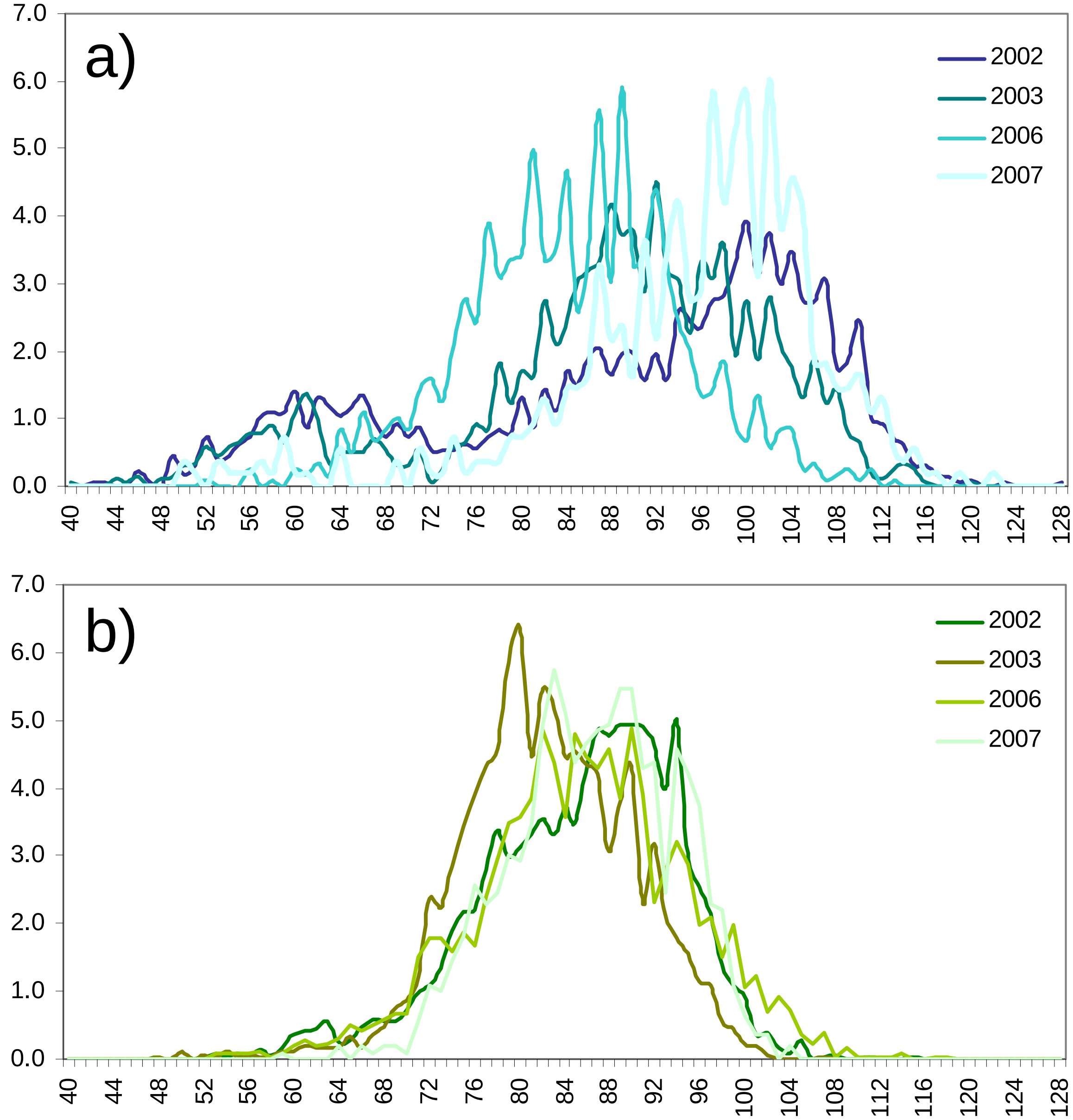

Figure 5-7. Length-frequency (in centimeters) among total length Chinook salmon sampled in Feather River carcass surveys: a) males; and, b) females. Note, Y-axis respresents abundance in thousands, and the X-axis is carcass total length (cm)

Fecundity – True estimates of fecundity for spring-run Chinook salmon spawned at FRH are not available because eggs per female are estimated by weight, not counted. However, since 1997, artificially spawned spring-run Chinook salmon have produced an average of 5,300 eggs per female spawned (Figure 5-8).

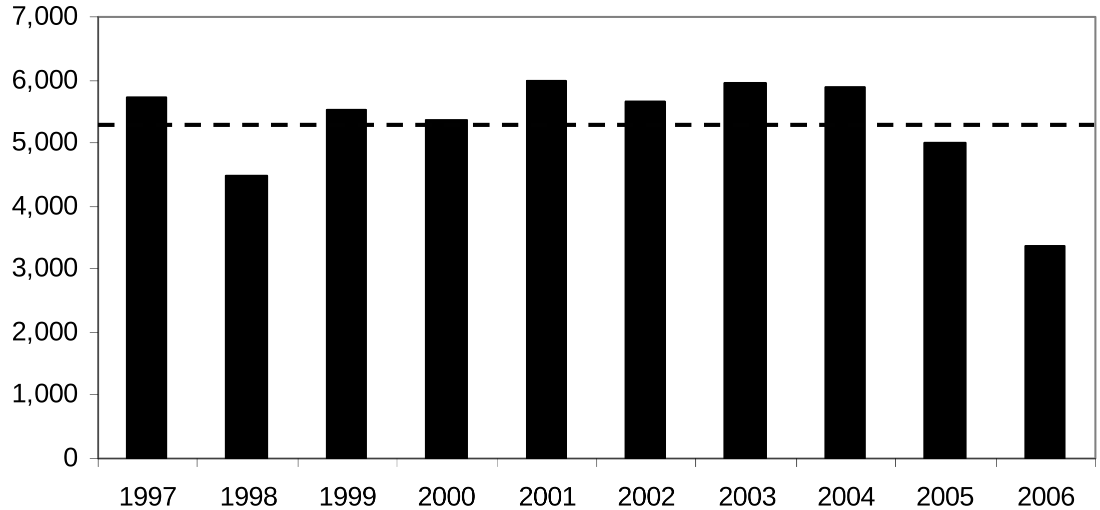

Figure 5-8. Average numbers of eggs collected from artificially spawned spring-run Chinook salmon at FRH. Note, dashed line represents ten year average, and Y-axis is average number of eggs.

Sex Ratio – During the last 10 years, there have been slightly more males than females (1.2:1, males-to-females). Nonetheless, the ratio has been variable and does not appear to demonstrate any trends (Figure 5-9).

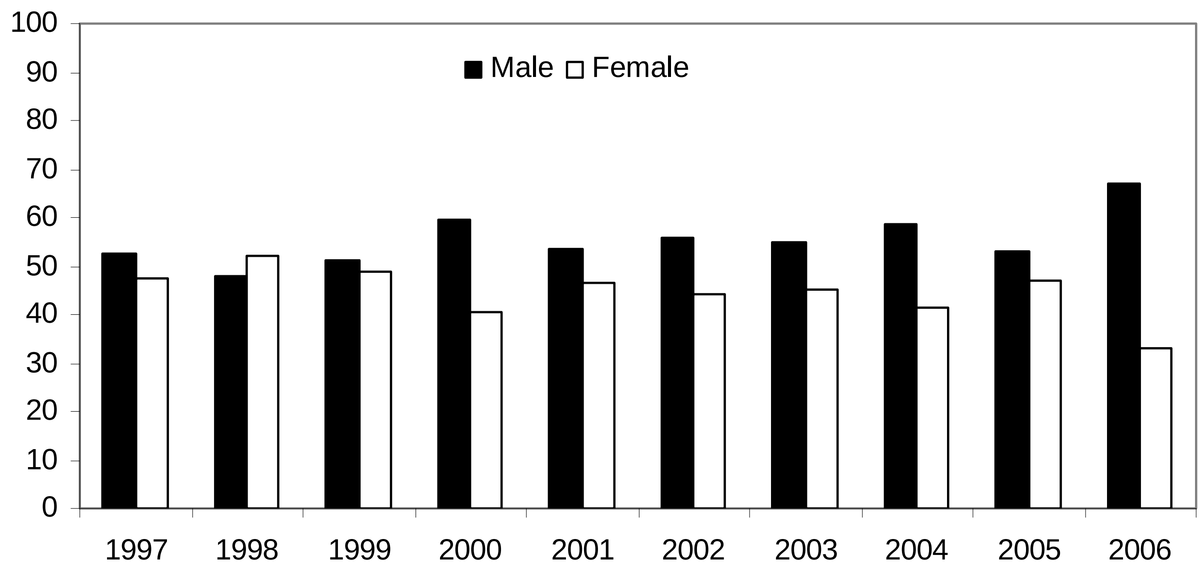

Figure 5-9. Proportion of male and female spring-run Chinook salmon entering FRH each year, 1997-2006.

5.9 Reasons for Choosing Broodstock

The spring-run Chinook salmon broodstock originated from Feather River stocks and are presumed representative of remaining spring-run Chinook salmon populations.

5.10 Measures to Minimize the Likelihood for Adverse Genetic or Ecological Effects to Listed Natural Fish that May Occur as a Result of Broodstock Selection Practices

Selecting only early arriving adult Chinook salmon minimizes the chances of interbreeding fall- and spring-run Chinook salmon at the hatchery. Since both FRH origin and natural origin spring-run Chinook salmon are listed, broodstock selection would not seem to adversely affect any ESA species except in as much as broodstock selection may influence subsequent straying rates. As previously described, straying rates of FRH salmon have been relatively low and have had no demonstrable effect on other Central Valley spring-run Chinook salmon populations; though, more thorough study is certainly warranted to better document straying to poorly sampled streams.

6. BROODSTOCK COLLECTION

6.1 Life History Stage to be Collected (Adults, Eggs, or Juveniles)

FRH collects adult spring-run Chinook salmon from the Feather River.

6.2 Collection or Sampling Design

Trapping for spring-run Chinook salmon generally occurs from April 1 through June 30 of each year. All Chinook salmon entering during this period are considered spring-run and are externally tagged and released back into the Feather River through the discharge tube in the spawning room. The following protocols will be followed for each salmon entering FRH during this period of timel:

- Each spring-run Chinook salmon will be double tagged with numbered Hallprint dart tags placed under dorsal fin. Tags should be sequential and the same color.
- Adipose fin clip status will be recorded.
- Record any recaptures or mortalities.

The ladder and trap remain open until June 30. At this time a barrier will be installed at the bottom of the ladder to prevent additional fish from coming up into the ladder. The remaining spring-run fish in the ladder will be allowed two weeks to ascend the ladder to be tagged and released back into the Feather River. At this point the ladder will be dewatered and cleaned. Fish that cannot be moved up the ladder into the hatchery will be herded back into the river and released unmarked.

The ladder will open on or near September 15 of each year to allow fish to return to the hatchery for spawning operations. Consistent with hatchery physical constraints and water quality, all returning fish shall be allowed free access to the hatchery after that date. In the event conditions develop creating potential for unacceptable fish loss, free access may be temporarily curtailed.

Spring-run (i.e., Chinook salmon that entered the FRH between April 1 and June 30) are identified by Hallprint tags. In years with sufficient broodstock, the following protocols will be used:

- Spring-run salmon will be paired 1 male:1 female with individuals paired with similar-sized mates. In this non-random mating scheme, jacks should not make up more than 2% of males spawned unless necessary to meet mitigation goals.
- If males are severely limited, one male can be used to fertilize multiple females..
- If necessary to help meet spring-run Chinook production targets, dry spawning and on-site CWT reading (see Appendix D) may be used to identify additional spring-run Chinook for use as broodstock. Only fish with CWT indicating FRH spring-run Chinook origin will be used as supplemental FRH spring-run Chinook broodstock.

6.3 Numbers Collected

During the past ten years, FRH has collected an average of 3,320 spring-run Chinook salmon annually. Since 2002, FRH has annually spawned an average of 829 females and 1,097 males (Figure 6-1).

6.3.1 Program Goal

Approximately 750 males and 750 females are needed to meet the FRH spring-run Chinook salmon production target of releasing up to 2 million smolts.

6.3.2 Broodstock Collection Levels

Since 2002, FRH has annually spawned an average of 829 females and 1,097 males (Figure 6-1). Approximately 750 males and 750 females are needed to meet FRH spring-run Chinook salmon production goals.

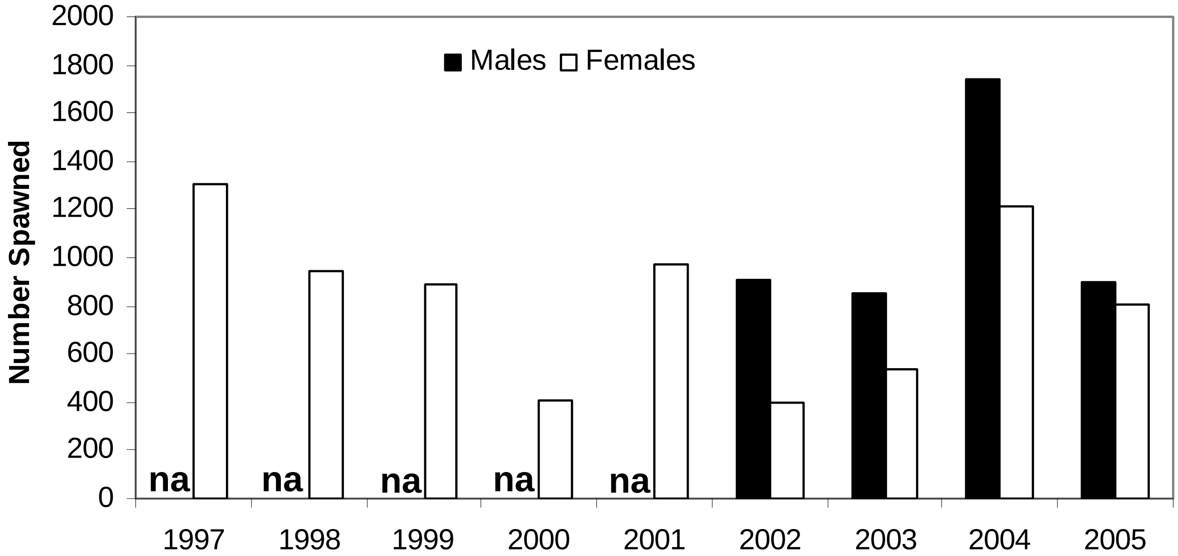

Figure 6-1. Numbers of males and females used as FRH spring-run Chinook salmon broodstock.

6.4 Disposition of Hatchery-origin Fish Collected in Surplus of Broodstock Needs

All Chinook salmon entering FRH after September 15 are euthanized, none will be returned to the Feather River (though essentially all spring-run Chinook salmon entering FRH are spawned). Fish that are not sexually mature are retained in the adult holding ponds. All adult Chinook salmon in excess to those needed for spawning are euthanized and processed as described in Section 6.8 (below).

6.5 Adult Fish Transportation and Holding Methods

No adult Chinook salmon are transported to or from FRH. All adult Chinook salmon trapped but not spawned are retained in one of the adult holding ponds or euthanized if the egg allotment needs have been met.

6.6 Fish Health Maintenance and Sanitation Procedures

No chemicals or therapeutics are used during the spawning process. All equipment used during spawning activities is routinely washed with clean, fresh water. Once the eggs have been fertilized, eggs are immersed for 1 hour in a 100 ppm PVP-Iodine (10% Povidone-Iodine Complex Solution) to help eliminate pathogens. PVP-Iodine is effective against a broad spectrum of disease-causing microorganisms, and is used to kill on contact a wide variety of bacteria, viruses, fungi, protozoa, and yeasts.

6.7 Disposition of Carcasses

All Chinook salmon carcasses collected by FRH personnel are processed in one of two manners. Carcasses suitable for human consumption are turned over in approximately equal proportions to the California Emergency Food Link who contracts with a fish processing company, or the Oroville-area Native American tribe. Carcasses and eggs not suitable for human consumption are disposed of through contract with a processing/rendering company.

6.8 Measures Applied to Minimize the Likelihood for Adverse Genetic or Ecological Effects to Listed Natural Fish Resulting from the Broodstock Collection Program

FRH broodstock collection program targets spring-run Chinook salmon that enter FRH broodstock collection system. There are 12 fish ESA species in California listed by the U.S. Secretary of the Interior or the U.S. Secretary of Commerce that occur within the distributional range of salmonids produced and released from FRH (Table 6-1). Of these, Chinook salmon, Winter-run; Chinook salmon, California coastal; Chinook salmon, Spring-run; Steelhead, Northern California; Steelhead, Central California Coast; Steelhead, South/Central California Coast; and Steelhead, Central Valley could be anticipated to enter into the FRH broodstock collection system. However, since none of the listed natural origin fish (other than steelhead) possess any distinguishable marks, tags, or morphological characteristics, it is not possible to identify when they occur.

Table 6-1. Common and scientific names and status of fish species listed by the U. S. Secretary of the Interior or the U. S. Secretary of Commerce and that occur within the distributional range of salmonids produced and released from FRH.

Common Name, ESU	Scientific Name	Status
Chinook salmon, Winter-run	*Oncorhynchus tshawytscha*	Endangered
Chinook salmon, California coastal	*Oncorhynchus tshawytscha*	Threatened
Chinook salmon, Spring-run	*Oncorhynchus tshawytscha*	Threatened
Coho salmon, Central California Coast	*Oncorhynchus kisutch*	Endangered
Coho salmon, So. Oregon/No. California	*Oncorhynchus kisutch*	Threatened
Steelhead, Northern California	*Oncorhynchus mykiss*	Threatened
Steelhead, Central California Coast	*Oncorhynchus mykiss*	Threatened
Steelhead, South/Central California Coast	*Oncorhynchus mykiss*	Threatened
Steelhead, Southern California	*Oncorhynchus mykiss*	Endangered
Steelhead, Central Valley	*Oncorhynchus mykiss*	Threatened

Natural origin Central Valley steelhead occur in the Feather River, but very few of these fish appear to enter FRH during spring-run Chinook broodstock collections (A. Kastner, Hatchery Manager II FRH, personal communication). Natural origin spring-run Chinook presumably occur in the Feather River, and likely enter FRH during broodstock collection. However, both hatchery and natural origin spring-run Chinook salmon are listed on the Feather River, and adverse ecological or genetic effects are not anticipated as a result of FRH broodstock collection.

7. MATING

7.1 Selection Method

In 1998, CDFG fish pathology personnel reviewed the mating protocols for Chinook salmon with Dr. Bernie May (Geneticist, University of California, Davis). Based on Dr. May's recommendations, no effort is made to select fish for spawning with regard to when fish entered the hatchery. Fish are selected for spawning based on characteristics diagnostic for sexually mature fish. Mating is accomplished using one female and one male, although one male may fertilize multiple females when necessary to help satisfy production goals. FRH spring-run Chinook broodstock will be spawned to mimic natural conditions wherein salmon pair with similar sized mates. Jacks will make up no more than 2 percent of males spawned unless necessary to meet mitigation goals.

7.2 Males

Males with free flow milt will be paired with similarly sized females.

7.3 Egg Collection and Fertilization

During the adult fish sorting process, Chinook salmon that expel free flowing eggs or milt (demonstrating they are sexually mature and ready to spawn) are euthanized (by pneumatic knife inserted into the spinal cord posterior to the head) and spawned. The incision method described by Leitritz and Lewis (1976) is used to collect Chinook salmon eggs. The ventral wall of the abdominal cavity of each female Chinook salmon is slit open with a Wyoming style knife and eggs allowed to freely flow into a metal spawning pan. The eggs from a single female Chinook salmon are fertilized as previously described. Sperm is expressed in to the pan with eggs by stroking the male fish's vent area. The flaccid eggs from the fertilization tub are measured (see below) and put into an incubator tray with 30ppm of iodine for an hour. The number of ounces are written on front of each tray. Two females are put in each incubation tray.

In order to sample egg size and to allow estimates of daily egg collections, immediately after fertilization one ounce of eggs are taken form each tub and but into a bucket to water hardened. At the end of the day, the sample eggs are sized and measure to get an expansion factor that is apply to the total number of flaccid ounces that were taken for the day.

Once placed in incubation trays eggs are left alone for 30 days, but receive daily iodine treatments of 23ml iodine per stack.

Green eggs develop into eyed eggs after an average of 513 Daily Temperatures Units (DTU). The range of DTU to eyed eggs are between 490-550. After about 30 days, FRH staff begin looking for eyed eggs. If two eyes are present and the DTUs are near 513, eggs are addled. After 24 hours, eggs are put through the bounces to remove dead eggs from good eggs. At this point eggs are re-sized and re-measured and put back into incubation trays; 100 ounce per tray. From this point on, eggs are checked daily and dead eggs are removed and iodine treatment is stopped.

All eggs taken and fertilized on a single day are identified as an egg lot and assigned a lot number, starting with the number 1. An attempt is made to retain representative egg lots to mimic the natural spawning period of Feather River spring-run Chinook salmon. Eggs in excess of FRH needs are disposed of through freezing and rendering.

7.4 Cryopreserved Gametes

No Chinook salmon eggs or sperm are preserved at FRH.

7.5 Measures Applied to Minimize the Likelihood for Adverse Genetic or Ecological Effects to Listed Natural Fish Resulting from the Mating Scheme

Both hatchery origin and natural origin spring-run Chinook salmon are listed as part of the Central Valley ESU. Thus, the spring-run Chinook salmon mating scheme at FRH should not have any inherent adverse effects.

8. INCUBATION AND REARING

8.1 Incubation

Green eggs develop into eyed eggs after an average of 513 Daily Temperatures Units (DTU). The range of DTU to eyed eggs are between 490-550. After about 30 days, FRH staff begin looking for eyed eggs. If two eyes are present and the DTUs are near 513, eggs are addled.

8.1.1 Number of Eggs Taken and Survival Rates to Eye-up and/or Ponding

Total number of fish spawned and number of eggs taken is summarized in FRH annual reports and in Figure 8.2.1. From available data, survival to hatching at FRH averages 72%, but survival rates have approximated 85% in recent years.

8.1.2 Cause For, and Disposition of, Surplus Egg Takes

Surplus eggs are not intentionally taken at FRH. However, egg lots subsequently determined not necessary to help meet production targets are disposed of through a rendering company.

8.1.3 Loading Densities Applied During Incubation

All eggs are held in vertical stacked incubator trays. The maximum loading density for each vertical tray is 150 ounces, but typically each tray is loaded with only 80 flaccid ounces (with 1.2 convention factor). All eggs incubated in the vertical trays remain until nearly all the alevins have buttoned-up. Alevins are released directly into rearing ponds.

8.1.4 Incubation Conditions

Fresh water is circulated through incubation trays at water temperatures averaging 55°F (±4) during the incubation period for Chinook salmon eggs. Iodine is flushed through incubators on a daily basis to reduce disease and egg mortality.

8.1.5 Ponding (Tanks)

Chinook salmon alevins are placed directly into raceways where they remain until ready for release.

8.1.6 Fish Health Maintenance and Monitoring

Health inspection data for infectious hematopoietic necrosis virus (IHNV) and the bacteria *Renibacterium salmoninarum* is collected from ovarian fluid of returning adult females annually during spawning.

Once placed in incubation trays eggs are left alone for 30 days, but receive daily iodine treatments of 23ml iodine per stack. After about 30 days, FRH staff begin looking for eyed eggs. If two eyes are present and the DTUs are near 513, eggs are addled. After 24 hours, eggs are put through bounces to remove dead eggs from good eggs. At this point eggs are re-sized and re-measured and put back into incubation trays; 100 ounce per tray. Thereafter, eggs are checked daily and dead eggs are removed and iodine treatment is stopped.

After alevins are moved from incubation trays to the raceways (or ponds), salt is added as needed until fish are released.

Fish health is monitored by the CDFG Fish Health Laboratory personnel during times of increased mortality. Diagnostic procedures for pathogen detection follow American Fisheries Society professional standards as described in Thoesen (1994). Appropriate treatments are recommended or prescribed by a CDFG Fish Pathologist/Veterinarian as appropriate, and follow-up examinations are performed as needed.

8.1.7 Indicate Measures Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish during Incubation

Both hatchery origin and natural origin spring-run Chinook salmon are listed as part of the Central Valley ESU. Thus, the spring-run Chinook salmon incubation at FRH should not have any inherent adverse effects.

8.2 Rearing

8.2.1 Survival Rate Data (Average Program Performance) by Hatchery Life Stage (Fry to Fingerling; Fingerling to Smolt) for the Most Recent 10 Years, or for Years Dependable Data are Available

Eyed egg to fingerling survival during the 10-year period 1997 to 2006 averaged 68%. During the same period fingerling to smolt survival averaged 78% (Figure 8-1).

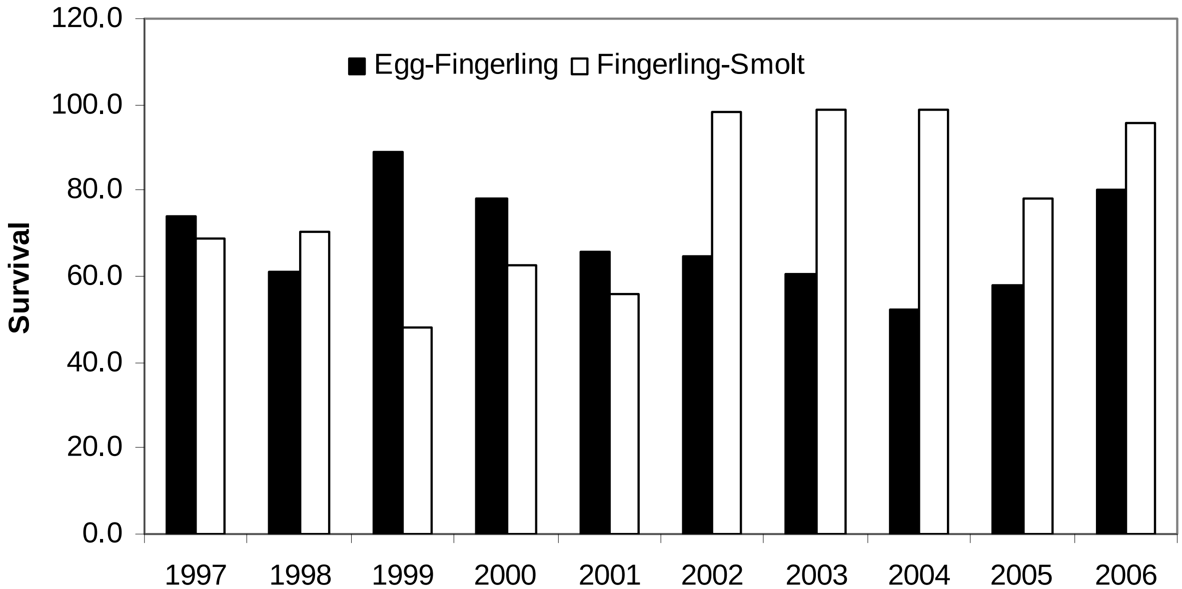

Figure 8-1. Percent survival from egg and fingerling life stages for FRH spring-run Chinook salmon.

8.2.2 Density and Loading Criteria (Goals and Actual Levels)

Raceways at FRH have a maximum capacity of 1 million fish per raceway.

8.2.3 Fish Rearing Conditions

The volume and flow rate of raceways can be varied by adjusting the flow rate and dam boards and the end of each raceway section.

8.2.4 Biweekly or Monthly Fish Growth Information (Average Program Performance), Including Length, Weight, and Condition Factor Data Collected During Rearing, if Available

Data on fish size are routinely collected by FRH personnel to help adjust feed size and amount during rearing. However, this information is not summarized annually, or included in the annual reports.

8.2.5 Monthly Fish Growth Rate and Energy Reserve Data (Average Program Performance), if Available

Growth rates for juvenile salmon are not available for FRH, but are anticipated to be similar to growth of fall-run Chinook salmon reared at Nimbus Fish Hatchery (NFH) (Figure 8-1).

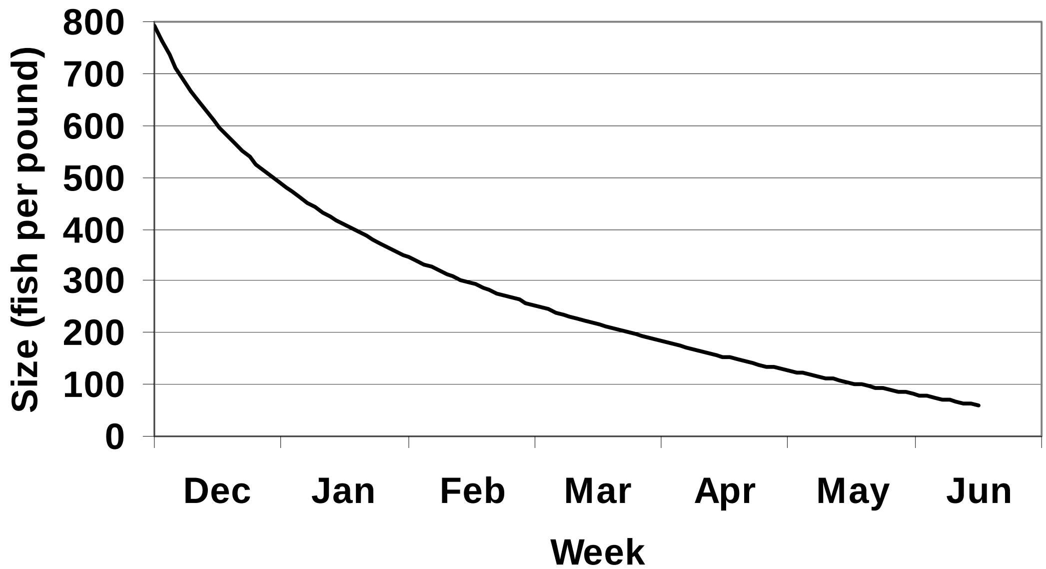

Figure 8-2. Projected growth rate of Chinook salmon at NFH but also representative for FRH.

8.2.6 Food Type Used, Daily Application Schedule, Feeding Rate Range (E.G. % B.W./day and lbs/gpm Inflow), and Estimates of Total Food Conversion Efficiency During Rearing (Average Program Performance)

Once the Chinook salmon alevins have absorbed their yolk sac, they are placed on dry food manufactured by Bio-Oregon Inc. Fry are fed up to 12 times per day. The ideal amount of food per fish is 3% of their total body weight. Fish in the raceways are fed using a blower mounted feeder driven past the raceways. The amount of food fed through the rearing period is dependent on their body weight and fish appetite, i.e., they are given as much as they will eat without wasting food.

8.2.7 Fish Health Monitoring, Disease Treatment, and Sanitation Procedures

As described in Section 8.1.6., fish health is routinely monitored by the CDFG Fish Health Laboratory personnel. Raceways are cleaned two to three times per week.

8.2.8 Smolt Development Indices (e.g., Gill ATPase Activity), if Applicable

No formal methods are used to indicate smolt development. However, visual indications such as "silvery" appearance and loosening of the scales are used as indicators of smolting.

8.2.9 Use of Natural Rearing Methods as Applied in the Program

No natural rearing methods are used at FRH.

8.2.10 Measures Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish under Propagation

Both hatchery origin and natural origin spring-run Chinook salmon are listed as part of the Central Valley ESU. Thus, the spring-run Chinook salmon propagation practices at FRH should not have any inherent adverse effects.

9. RELEASE

9.1 Proposed Fish Release Levels

As described earlier in Section 1.10, Feather River spring-run Chinook salmon annual spawning escapement defines FRH production targets. Abundance trends demonstrate that the annual release of 2 million spring-run Chinook salmon smolts (i.e., at 60 per pound or larger) satisfies mitigation requirements for Lake Oroville facilities.

9.1.2 Specific Location(s) of Proposed Release(s)

Releasing juvenile anadromous salmonids at the hatchery where they are reared is thought to encourage return of adult fish to the hatchery and reduce straying (Quinn 1993). Studies have shown that fish released in the lower portion of a river tend to return as adults to the lower portion of that river, whereas fish released in the upper portion of a river tend to returns as adults to all points downstream from the release site (Cramer 1981; Slaney et al. 1993). Results specific to the Feather River and FRH are described in Section 2.2.5.

Although Bay releases increase the likelihood of straying, local releases may increase the potential for density-dependent mortality or adverse ecological interactions with natural origin fish as both groups migrate downstream to the ocean. For example, releases of hatchery Coho in Oregon rivers apparently attract predators that incidentally consume more wild smolts than would have been the case without the releases (Nickelson 2003). Hatchery managers at CNFH try to reduce this type of risk by releasing fish toward the end of the smolt migration period, but there is still overlap (USFWS 2001). Additionally, juvenile salmon that do not migrate downstream immediately may compete with or prey on natural origin salmonids.

In the past, juvenile salmon reared at FRH have been released primarily into San Francisco Bay, but also at several locations in the Feather or Sacramento Rivers. Currently, two locations on the Feather River may be used as release sites for in-river releases of FRH spring-run Chinook salmon:

Live Oak Boat Ramp, Feather River (river mile 38); Longitude 39.2736, Latitude -121.6305; 1100 Pennington Road, Live Oak, CA 95953

Boyds Pump Launch Ramp, Feather River (river mile 22); Longitude 39.0698, Latitude -121.6060; South of Yuba City near the intersection of Oswald Road and the Garden Highway

Despite tradeoffs described previously, all future FRH spring-run juvenile Chinook salmon will be released directly into the Feather River between the Fish Barrier Dam and the Yuba River confluence. As described in Section 1.10, a program of experimental evaluation will be implemented to assess and improve the survival of in-river Chinook salmon releases on the Feather River.

9.2 Actual Numbers and Sizes of Fish Released by Age Class through the Program

Since operation of FRH began, over 51 million juvenile spring-run Chinook salmon have been released (Figure 9-1 and Appendix E).

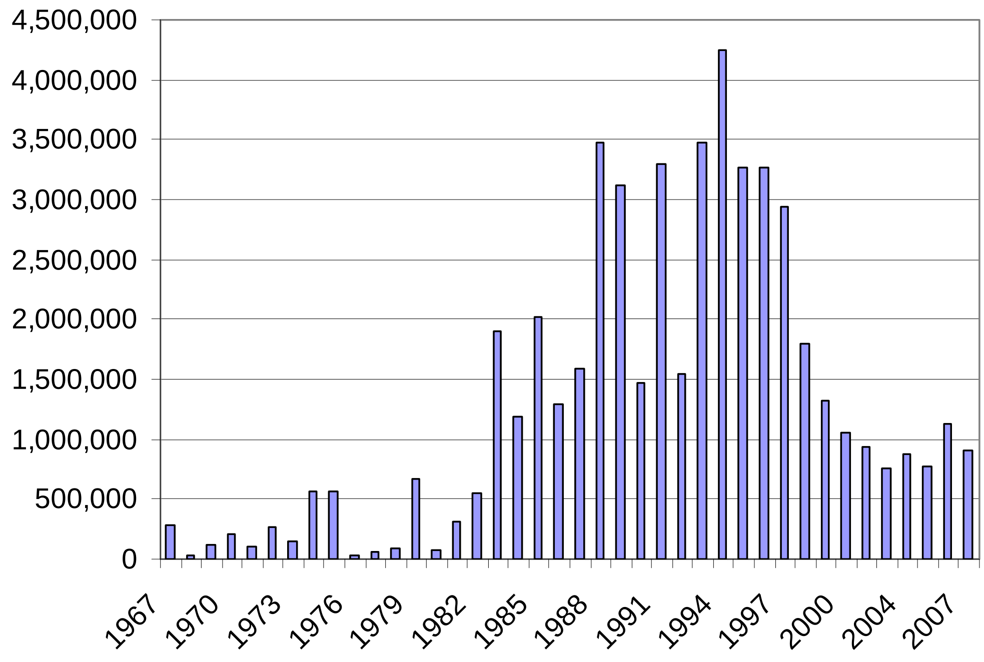

Figure 9-1. Number (Y-axis) of spring-run Chinook salmon released from FRH, 1967-2007.

9.3 Actual Dates of Release and Description of Release Protocols

Juvenile Chinook salmon are released as soon as they average 60 per pound. Depending on water temperatures and growth rates, the release period is generally April to May.

9.4 Fish Transportation Procedures

Juvenile Chinook salmon are transported to the release site using 2,800-gallon, 1,200-gallon, and/or 600-gallon tank trucks. In addition to fresh water, FRH uses a chiller to provide additional cold water when needed for transportation. Ice is not used. Tank trucks are typically loaded at no more than one pound of fish per gallon of water. No salt is added to the water in fish transport trucks. Fish are transferred into the tank using Nielson pumps and an Aqua-Life Harvester Dewatering Tower. Fish and water are released from the rear release gate at the release site.

9.5 Acclimation Procedures

Acclimation procedures are conducted prior to fish release. An effort is made to maintain tank water temperatures at the same temperature of the hatchery and river during transportation by adding chilled water to the transportation tank.

In river releases do not typically provide for acclimation. However, as mentioned earlier (in Section 9.1.2) improved survival is also desirable for in-river releases. In-river releases in future years will experiment with release strategies and locations which allow acclimation and minimize predation losses.

9.6 Marks Applied, and Proportions of the Total Hatchery Population Marked, to Identify Hatchery Adults

Beginning in 2002, FRH has attempted to adipose fin clip and tag 100% of spring-run Chinook salmon smolts produced. However, less than 100% have been marked in two years, and only a small fraction of FRH fall-run Chinook salmon have been marked. As a result, it is not possible to definitively identify individual fish as natural or hatchery origin. A constant fractional mark and tagging rate of 25% has been applied to fall-run Chinook salmon since 2006. Discussion is currently underway to potentially implement 100% marking and tagging among fall-run Chinook salmon.

All Chinook salmon produced by FRH have been subjected to race and brood year specific otolith thermal marks since 2005. Otolith thermal marks are created through manipulation of rearing water temperatures.

9.7 Disposition Plans for Fish Identified at the Time of Release as Surplus to Programmed or Approved Levels

If approved by the CDFG Fisheries Branch Chief, the Ecological Committee, and related fishery regulators, surplus fish may be stocked in non-anadromous waters. Under not circumstances will excess spring-run Chinook produced by FRH be released in anadromous waters.

9.8 Fish Health Certification Procedures Applied Pre-release

Hatchery management practices, including early detection and treatment of sick fish, minimize the release of fish infected with pathogens. A random sampling of fish is assessed for general health prior to release, and transfer of fish to saltwater is also a control measure for any freshwater parasites that may remain when the fish are released.

9.9 Emergency Release Procedures in Response to Flooding or Water System Failure

If emergency release of juvenile Chinook salmon is required and several days time is available, all fish held at FRH can be transferred to the Annex. If time is not available and it is necessary to release juvenile Chinook salmon for emergency reasons, the fish screen can be removed and the gate opened at the bottom of the rearing channel, and all dam boards removed beginning with the lowest boards first. This procedure will empty the rearing channel and all fish and water will be released directly to the Feather River.

9.10 Measures Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish Resulting from Fish Releases

Suggestions have been made for reducing adverse impacts on natural origin salmonids. The following measures are routinely implemented to reduce the ecological effects to listed fish resulting from the release of FRH spring-run Chinook salmon:

1. Use only indigenous Feather River brood stock expressing adult spring-run Chinook phenotype.
2. Release 100% of spring-run Chinook salmon production between the Fish Barrier Dam and the Yuba River confluence.
3. Release juvenile salmon at a size and time that encourages downstream migration and minimizes adverse ecological interactions
4. Tag and mark 100% of spring-run Chinook salmon produced at FRH so that hatchery origin fish can be readily identified for selective harvest, restricted access to spawning grounds, or restricted use in broodstock programs.

10. EFFECTS ON ESA-LISTED SALMONID POPULATIONS

10.1 ESA Permits or Authorizations in Hand for the Hatchery Program

Operation of the SWP, including the Oroville Dam and related structures is covered by the October 2004 NOAA Fisheries BO on the Operation of Long-Term CVP and SWP Operations Criteria and Plan.

DWR also has a 4-d permit from NOAA Fisheries that allows the ladder to the FRH to remain open from September 15 of one year through the end of July the following year. This allows DWR to mark (external Hallprint tag) all phenotypic spring-run in April, May, June and, if necessary, July.

10.2 Provide Descriptions, Status, and Projected Take Actions and Levels

There are two listed salmonids in the target area (i.e., spring-run Chinook salmon and steelhead rainbow trout) both listed as threatened under the federal ESA (NOAA 2005a). Both hatchery and naturally spawning populations for spring-run Chinook salmon are considered part of the ESU. In contrast, only natural origin *O. mykiss* are listed, hatchery produced *O. mykiss* are not included (NOAA 2006). The Sacramento Valley also includes the winter-run Chinook salmon, a state and federal endangered species. Green sturgeon are listed as threatened under the federal ESA (NOAA 2005b), and are known to occur in the Feather River.

Table 10.2.1 Projected maximum annual lethal take associated with FRH spring-run Chinook program

Species	Spring-run Tagging	Spring-run Spawning
Spring-run Chinook Salmon	500	1500
Wild Steelhead	2	2
Winter-run Chinook Salmon	0	0
Green Sturgeon	0	0

10.2.1 Description of NMFS ESA-listed Salmonid Population(s) Affected by the Program

Naturally spawning spring Chinook salmon and steelhead in the Feather River may be affected directly by the FRH spring-run Chinook salmon propagation program.

Central Valley Spring-run Chinook salmon

Central Valley spring-run Chinook salmon in the Sacramento-San Joaquin River system was once among the largest runs on the Pacific Coast (Yoshiyama et al. 1998). The Sacramento River drainage alone was estimated to support spring-run Chinook salmon exceeding 100,000 fish in many years between the late 1800s and 1940s (Moyle 2002). Historic runs were reported in the McCloud River, Pit River, Little Sacramento River, Feather River (including above Oroville Dam), Yuba River (including above Englebright Dam), and American River (including above Folsom Dam) (Moyle 2002).

In the Central Valley, spring-run Chinook salmon historically migrated upstream as far as they could in the larger tributaries to the Sacramento and San Joaquin Rivers, where they held for several months in deep cold pools (Moyle 2002). Today, Central Valley spring-run Chinook salmon persist in a few systems in the Sacramento River watershed. Currently, the principal habitats available to Central Valley spring-run Chinook salmon include Deer, Mill, and Butte creeks (Campbell and Moyle 1991; Yoshiyama et al. 2001; Moyle 2002). Considerably smaller spawning populations of spring-run Chinook salmon are also reported in several small tributaries of the Sacramento River (Moyle 2002). Spring-run spawners may also occur in the lower Yuba River (CDFG 1998).

Runs to Mill, Deer and Butte creeks are genetically distinguishable from other Central Valley salmonids (Banks et al. 2000). In the lower Feather River, a run of fish identified as spring-run Chinook salmon is produced by the FRH, and a portion of this run also spawns naturally in the Feather River. However, Feather River spring-run Chinook salmon more closely resemble fall-run Chinook salmon, and have not been separated by available genetic techniques. Coded wire tag returns also indicate that fish identified as spring-run Chinook salmon are intermixed at the hatchery with those identified as fall-run Chinook salmon (Hedgecock et al. 2001). Feather River hatchery and in-river spring Chinook salmon runs cannot be separated with the available information (Hedgecock et al. 2002).

Most spring-run Chinook salmon are thought to exhibit a classic “stream-type” life history pattern (Moyle 2002). Stream-type Chinook salmon spend one or more years in freshwater before migrating downstream toward the ocean. As a result, stream-type juveniles are more dependent on freshwater streams. At the time of saltwater entry, stream-type (yearling) smolts are much larger than their ocean-type (subyearling) counterparts and are therefore able to move offshore relatively quickly, making extensive offshore oceanic migrations. This life history pattern tends to separate spring-run Chinook salmon from other salmon runs. Spring-run Chinook salmon historically migrated further upstream than other Chinook salmon runs, taking advantage of higher elevation habitats that were inaccessible during summer and fall months as a result of high temperatures and low flows in lower reaches (Moyle 2002). This geographic separation also helped preserve their genetic integrity (Moyle 2002).

Spring-run Chinook salmon begin their upstream migration in late January to early February (CDFG 1998) and enter the Feather River as immature adults from March to September (Painter et al. 1977; CDFG 1993; CDFG 1998; Yoshiyama et al. 1998; Sommer et al. 2001). Spring-run Chinook salmon outside the Feather River have been observed to hold downstream to migrate later in the summer, possibly because of increasing water temperatures later in the spring. Because spring-run Chinook salmon enter freshwater as sexually immature adult fish, the holding period can last for several months before individuals are ready to spawn (Moyle 2002; CDFG 1998). Deep, cool, and oxygenated pools are important for salmon energy conservation (Berman and Quinn 1991; USBR and DWR 2000).

Sommer et al. (2001) reported that spring-run Chinook salmon in the Feather River spawn in the autumn (September and October), following their upstream migration. The inter-gravel egg and fry incubation life stage for spring-run Chinook salmon generally extends through March (Yoshiyama et al. 1998), but in the Feather River most spring-run Chinook salmon fry emerge from the gravel before February (Seesholtz et al 2004). The inter-gravel residence period of incubating eggs and alevins (yolk-sac fry), and egg incubation survival rates, are highly dependent on water temperature. Newly emerged fry remain in shallow, lower velocity edgewaters, particularly where debris aggregates, making fish less visible to predators (CDFG 1998). Fry then gradually move into deeper and faster water as they increase in size (Moyle 2002). Rearing juveniles require adequate space, cover, and food, and cool water temperatures. Suitable habitat includes areas with instream and overhead cover in the form of undercut banks, downed trees, and large, overhanging tree branches. The organic materials forming fish cover also help provide sources of food (i.e., aquatic and terrestrial insects). Juvenile spring-run Chinook salmon are opportunistic drift feeders and feed on terrestrial and aquatic insect larvae and crustaceans.

Juveniles may rear in streams for one to 15 months. Some authors (Yoshiyama et al. 1998; Moyle 2002) suggest that a shorter period of rearing may be a response to altered flow regimes (caused by dams and diversions) and required use of lower elevation sections of streams. Rearing occurs in natal streams, the mainstem of the Sacramento River, non-natal streams, and the Delta. Juveniles that remain in their natal streams to rear tend to emigrate as yearlings, while those that rear in non-natal streams leave as young-of-the-year (YOY). The overwhelming majority of spring-run Chinook salmon in the Feather River leave the system as YOY (Seesholtz et al. 2004).

Out-migrants may spend some time in the Sacramento River or in the estuary and gain additional size prior to smolting and migrating out to sea. Juveniles that migrate as yearlings move downstream with the onset of the stormy season, beginning in October of the year following spawning and continuing through March (CDFG 1998). Based on 1998 to 2000 rotary screw trap data, emigration of spring-run sized Chinook salmon from the Feather River peaks in December, and is followed by another pulse of juvenile YOY emigrants at Live Oak in April and May (Seesholtz et al. 2004).

The co-occurrence of spring- and fall-run Chinook salmon below Oroville Dam, along with incomplete run segregation practices at FRH, has led to considerable intermixing and confusion between Feather River fall- and spring-run. Beginning in 2004, DWR and CDFG began opening the FRH fish ladder from April to June. Salmon entering FRH during this time are externally tagged and released back into the Feather River. Much of information we have regarding FRH spring-run Chinook salmon results from spring FRH ladder operations and resulting recoveries of tagged salmon. However, these data represent only those fish which entered FRH, and may not be representative for in-river spawning hatchery origin fish or for natural origin salmon.

Central Valley Steelhead

Central Valley Steelhead are the anadromous form of rainbow trout. At one time, steelhead and resident rainbow trout were considered separate subspecies or different species altogether. However, most researchers have found little or no morphologic or genetic differentiation between the two forms inhabiting the same stream system

(McEwan and Jackson 1996), which could indicate interbreeding. DNA analysis indicates that steelhead stocks from the FRH, CNFH, Deer and Mill creeks, and the Stanislaus River are genetically similar but distinct from coastal steelhead stocks (Busby et al. 1996; NOAA 1998). Here, the term steelhead is used to refer both to the anadromous and resident life forms.

On 19 March 1998, naturally spawned Central Valley steelhead were federally listed as threatened by NOAA Fisheries (NOAA 1998). The Central Valley ESU includes all naturally spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin rivers and their tributaries, including the naturally spawned steelhead in the Feather River (NOAA 1998). The listing was further clarified in January 2006, redefining the protected fish as the Central Valley steelhead (NOAA 2006). The final designation for Central Valley steelhead critical habitat was published on 2 September 2005, and took effect on 2 January 2006 (NOAA 2005a)

The new critical habitat for Central Valley steelhead has redefined the boundaries of critical habitat to more specific areas in which the fish are found, or to include habitats that are specifically essential to their conservation. Proposed critical habitat for Central Valley steelhead includes: the lower Feather River; Battle, Cottonwood, Antelope, Mill, Deer, Big Chico, and Butte creeks; Sacramento, Yuba, American, Cosumnes, Mokelumne, Calaveras, San Joaquin, Merced, Tuolumne, and Stanislaus rivers; and, the Delta (NOAA 2005a).

Central Valley steelhead ranged throughout many of the tributaries and headwaters of the Sacramento and San Joaquin rivers, including tributaries above Shasta Dam such as the Little Sacramento, McCloud, Fall, and Pit rivers, and many tributaries on the west side of the Sacramento Valley (McEwan and Jackson 1996; Yoshiyama et al. 1996, 1998).

Steelhead distribution in Central Valley drainages has been greatly reduced because of construction of dams and other barriers, water development, and other human activities/ or manipulations (McEwan and Jackson 1996). NOAA (2003) estimated the Central Valley steelhead population at less than 3,000 adults. Steelhead are now primarily restricted to a few remaining free-flowing tributaries and to stream reaches below large dams. Naturally spawning steelhead populations have been found in: the upper Sacramento River and tributaries below Keswick Dam; Mill, Deer, and Butte creeks; and, the Feather, Yuba, American, and Mokelumne rivers. It is possible that naturally spawning populations exist in many other streams, but are undetected because of the lack of monitoring or research programs.

Steelhead may be distinguished from rainbow trout by their strong behavioral differences, which relate directly to their anadromous nature. Steelhead life history, however, can be quite variable with some populations reverting to residency when flow conditions block access to the ocean (McEwan and Jackson 1996).

Only winter steelhead are found in Central Valley rivers (Moyle 2002). This terminology refers to run timing, but in the Sacramento River watershed, winter steelhead might be better termed “fall” steelhead, as the adult steelhead migration begins in July to August, peaks at the end of September to October, and continues through February or March (Bailey 1954; Hallock et al. 1961; McEwan and Jackson 1996; Moyle 2002). Counts made on the Feather River generally follow a similar pattern, although some fish have been counted as late as April and May (Painter et al. 1997; USBR 2004).

Steelhead in the Feather River are reported to exhibit a relatively short holding time (Seesholtz et al. 2004). However, while in streams, adult steelhead are active, opportunistic carnivores, consuming aquatic invertebrates, terrestrial insects, and salmon eggs (Moyle 2002).

In the Feather River, steelhead spawn from December to March, with the peak in spawning occurring in late January (DWR 2004h). Steelhead differ from most other anadromous salmonids in that they are commonly iteroparous, potentially spawning more than once during their lives. Some may return to the ocean and repeat the spawning cycle for two or three years (McEwan and Jackson 1996). The percentage of adults surviving for multiple spawning is generally low for Central Valley steelhead, but varies annually and between stocks (McEwan and Jackson 1996). The intergravel egg and alevin incubation life stage for Feather River steelhead extends from December through May, with a peak from January through April. Newly hatched steelhead alevins remain in the gravel from two to six weeks (USBR and DWR 2000; Moyle 2002). Upon emergence from the gravel, steelhead fry move to shallow, protected areas along stream banks, live in small schools, and exhibit little aggressive behavior (McEwan and Jackson 1996; Cavallo and Kurth In prep). As the steelhead grow, the schools break up and the steelhead establish individual feeding territories. Steelhead juveniles are opportunistic feeders, consuming small aquatic invertebrates and terrestrial insects (Moyle 2002).

Most steelhead rear along the margins of riffles and glides, and with increasing age and size, juvenile steelhead are found in increasingly swifter waters (McEwan and Jackson 1996, Cavallo and Kurth In prep). Juvenile steelhead will rear in freshwater for one to three years, with most naturally produced Central Valley steelhead rearing for two years prior to emigrating (McEwan 2001). It is unknown when most steelhead smolts emigrate from the Feather River, however YOY and juveniles have been caught in screw traps between December and August, with a peak occurring in the spring (Seezholtz et al. 2004). Once in the ocean, steelhead remain there for one to four growing seasons before returning to spawn in their natal streams (McEwan and Jackson 1996).

10.2.2 Status of NMFS ESA-listed Salmonid Population(s) Affected by the Program

The following ESA-listed salmonid populations could be potentially affected the operation of FRH:

Chinook salmon, Winter-run, *Oncorhynchus tshawytscha* (Endangered)

Chinook salmon, Spring-run, *Oncorhynchus tshawytscha* (Threatened)

Steelhead, Central Valley, *Oncorhynchus mykiss* (Threatened)

Status of these species is described in Section 10.2.1.

10.2.3 Hatchery Activities Associated Monitoring, and Evaluation and Research Programs, that may Lead to the Take of NMFS-listed Fish in the Target Area, and Estimated Annual Levels of Take

Several FRH related monitoring, evaluation, or research programs may lead to take of spring-run Chinook salmon or steelhead trout. Release of spring-run Chinook salmon may result in an unknown level of take through various ecological interactions described in previous sections. Additionally, annual operation of the FRH fish ladder between April and July and September through February, will result in take of Central Valley spring-run Chinook salmon (hatchery and natural origin) and may also result in take of Central Valley steelhead (natural origin only). Up to 20,000 adult spring-run Chinook salmon may enter the FRH ladder from April through July. As described previously, these fish are all externally tagged and released back into the Feather River. When the FRH ladder reopens in September, up to 5,000 spring-run Chinook may be processed annually (though not more than 1,500 will be spawned). Take of natural origin steelhead associated with FRH ladder operations will be less than 50 fish annually.

11. RECOMMENDATIONS

The information assembled in this HGMP provides many useful insights to the current status and future management of the FRH spring-run Chinook program. However, a number of important issues remain to be addressed but are beyond the scope of this HGMP. The following recommendations address FRH and Central Valley salmon management issues which require additional research or further detailed evaluation.

11.1 Implement Effective Integrated Hatchery Broodstock Management Practices throughout the Central Valley

All hatchery fish produced at Central Valley Chinook hatcheries should be marked. 100% marking for FRH spring-run Chinook salmon is specified in Performance Standard 3. The ability to reliably distinguish hatchery and wild origin fish is essential for improved fishery management (Hatchery Scientific Review Group (HSRG) 2008).

Sampling and data analysis considerations strongly support that 100% of hatchery fish should also be coded wire tagged (CWT), though actual CWT rate is somewhat constrained by requirements for ocean harvest monitoring. *Responsible Agency: CDFG (primary), DWR, USBR and EBMUD.*

Throughout the Central Valley, it is extremely important to begin including and documenting the proportion of natural origin Chinook salmon used in hatchery broodstock, and to begin reducing numbers of hatchery origin fish spawning in-river. Related actions for the FRH spring-run Chinook salmon are specified in Performance Standard 7. These actions require mass marking, and some combination of selective fisheries, a segregation weir to control access to spawning grounds, and ability to collect natural origin fish for use as hatchery broodstock. *Responsible Agency: CDFG (primary), DWR, USBR and EBMUD.*

11.2 Provide for Improved Evaluation of Hatchery Strays, and Act to Reduce Risk of Hatchery Strays to Genetic Integrity, Long Term Fitness and Viability of Central Valley Natural Origin Chinook Salmon Populations

Mark and CWT all Central Valley hatchery origin Chinook salmon, so strays can be readily identified, and release information determined (hatchery of origin, release location, year, race). Seek to reduce FRH spring-run Chinook out-of-basin straying as described in Performance Standard 9. *Responsible Agency: CDFG (primary), DWR, USBR and EBMUD.*

Explore additional in-river relases of hatchery fish, particularly fall-run Chinook. Experiment with improved release practices (e.g., net pens, acclimation period, volitional release, etc.) and coordinated flow releases to improve survival (as described in Performance Standards 3 and 4). If survival can be improved while minimizing adverse effects to wild salmonids, then expanded in-river releases should be strongly considered. *Responsible Agency: CDFG (primary), DWR, USBR and EBMUD.*

Improve sampling for hatchery strays to sensitive streams including Deer Creek, Mill Creek, Butte Creek, Clear Creek, Battle Creek, and the Yuba River. Sampling for hatchery origin Chinook salmon on these streams is currently inadequate to detect low level, but potentially significant, straying from FRH. *Responsible Agency: CDFG (primary).*

11.3 Evaluate Potential Benefits of NATURES-type Program with the Goal of Determining if the FRH Spring-run Chinook Salmon Program Should Be Modified to Incorporate Some Features Designed to Improve Survival and Reduce Domestication Effects

Responsible Agency: CDFG (primary).

11.4 Conduct Regular Genetic Studies of Central Valley Spring- and Fall-run Chinook Salmon to Evaluate Changes in the Population and to Test the Effectiveness of Hatchery and In-river Management

Evaluate fitness of wild and hatchery origin Chinook salmon spawning pairs by applying Full Parental Genotyping to returning progeny (sensu Araki et al. 2007). This study will make it possible to evaluate effectiveness of improved broodstock management and hatchery fish management practices practices in Central Valley rivers. *Responsible Agency: CDFG (primary), DWR, USBR and EBMUD.*

11.5 Evaluate Carrying Capacity of the Feather River to Support Self-Sustaining In-river Spawning Spring-run Chinook Salmon and Fall-run Chinook Salmon Populations

This information will support placement of the segregation weir, egg taking stations, and inform future changes to FRH production goals which may be necessary to meet improved broodstock management practices. *Responsible Agency: DWR (primary).*

11.6 Continue Otolith Thermal Marking (OTM) Program to 100% Mark All Spring- and Fall-run Chinook Salmon Produced at FRH. Expand OTM Capacity to Provide for 100% Marking under All Temperature Conditions.

Explore techniques for rapidly assessing OTM in FRH spring- and fall-run broodstock. *Responsible Agency: DWR (primary).*

11.7 After Implementing Recommendations of this HGMP, Plan to Reevaluate FRH Spring-run Chinook Salmon Production Goals

In light of new hatchery, habitat, and harvest management practices it may be desirable to modify production goals to better align with capacity and conservation needs. Consider modifying FRH spring-run Chinook program to a conservation or segregated hatchery.

11.8 Evaluate Possible Need for Changes to River Fishing Regulations to Further Protect Feather River Spring-run Chinook Salmon and Perhaps allow Selective Harvest of Hatchery Fall-run

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Appendix A
California Fish and Game Commission Policies

Appendix B
California Department of Fish & Game Operations Manual sections relating to fish hatcheries

Appendix C
National Marine Fisheries Service Biological Opinion on the CVP-Operation Criteria and Plan

Appendix D
Spring-Run Chinook Broodstock Collection and Spawning Protocol

Trapping and tagging for spring-run Chinook salmon at FRH will begin on or about April 1st until June 30th. Fish tagged during this period will form the basis of FRH's spring-run broodstock.

Each salmon entering FRH during this period will be double tagged with numbered and color coded Hallprint Dart tags placed next to the dorsal fin. All references to "tagged" fish in this section refer to fish with these Hallprint Dart Tags. Tags will be sequential and the same color for each fish. Additionally, adipose fin clip status will be checked and recorded for each fish. Any tag recoveries and mortalities will also be recorded. Otoliths will be removed from any mortalities along with the head of any adipose clipped fish. After tagging and recording all necessary data all fish will be returned to the Feather River (through the FRH spawning room discharge tube) until fish are needed for spawning purposes. To minimize handling and stress on the fish, genetic tissue samples will not be collected during this tagging period.

- The FRH ladder will be closed on July 1st to prevent new fish from entering and to allow any spring-run left in the FRH ladder an opportunity to ascend the ladder and be tagged. Approximately one week later the ladder will be shut down and dewatered. Any fish remaining in the ladder during shut down will be crowded back out to the river.

- The FRH ladder will be reopened on or about September 15th. Tagged fish will be collected and isolated for spring-run production.

- Tagged fish will be spawned on a 1:1 ratio; the eggs from one female will be placed in a container and then combined with the milt from a single male. The FRH adult spring-run Chinook salmon broodstock will be spawned to mimic natural conditions where salmon pair with similar-sized mates. Jacks will make up no more than 2% of males spawned unless necessary to meet mitigation goals. The Hallprint Dart tag number from each fish will be recorded along with the length of each fish. During spawning operations, genetic samples can be collected after the fish are spawned. The head will be removed from any adipose clipped fish for CWT processing.

- If necessary to help meet spring-run Chinook production targets, dry spawning and on-site CWT reading (see Fall-run Chinook Broodstock Colleciton and Spawning Protocol) may be used to identify spring-run Chinook for use as broodstock. Only fish with CWT indicating FRH spring-run Chinook origin will be used as supplemental broodstock.

- The production goal for spring-run Chinook is a maximum of 2 million fish at release time with a maximum egg take goal of 4 million eggs. The actual number of eggs collected and spring-run Chinook produced at FRH in a given year will depend on the number of tagged fish available for spawning, but will never exceed the release of 2 million smolts.

- Spring-run spawning will continue until all tagged fish collected between April 1st and June 30th are exhausted regardless of date.

Fall-run Chinook Broodstock Collection and Spawning Protocol

The goal of the FRH fall-run Chinook program is to meet the current mitigation maximum target of producing 6 million smolts while minimizing adverse impacts to spring-run Chinook and natural origin fall-run Chinook . In addition, in years when enough broodstock are available FRH will produce up to an additional 2 million fall-run Chinook for fishery enhancement. Meeting or closely approaching these goals will also support in-river and ocean fisheries for Chinook salmon.

Any salmon entering FRH upon the reopening of the ladder on or about the 15th of September without a Hallprint Dart Tag and without an adipose fin clip will be considered Fall-Run. Adipose fin clipped fish may be spawned as fall-run Chinook only if on-site Coded Wire Tag (CWT) reading indicates they are not spring-run Chinook stock.

- Fall-run fish will be collected and held in round tanks until they are needed for spawning purposes.
- Fall-run spawning will begin after September 30th to maximize the separation between non-tagged spring-run and fall-run Chinook.
- Untagged and unmarked fish will be spawned as fall-run Chinook by combining the eggs from two females with the milt from two males.
- Untagged, but adipose clipped fish will have their coded wire tags read onsite prior to spawning. Individuals with spring-run Chinook CWTs will either be used to supplement spring-run Chinook broodstock or will be discarded. CWTed fish from outside the Feather River basin will not be used as broodstock. Techniques for on-site tag reading and protecting viability of eggs/milt will follow procedures developed and used in extensively in Washington and Oregon hatcheries (e.g. Lyons Ferry Hatchery)
- In order to produce up to 6 million mitigation fish and up to 2 million enhancement fish, the FRH egg take may collect as many as 12 million eggs. The actual number of eggs collected and spring-run Chinook produced at FRH in a given year will depend on the number of fish available for spawning. However, FRH fall-run Chinook egg take will never exceed 12 million. The number of smolts released into anadromous waters will never exceed 6 million mitigation smolts, and 2 million enhancement smolts.

Appendix E
Number of juvenile spring-run Chinook salmon released from FRH 1967 through 2007

Appendix F
Feather River Hatchery annual report outline

1. INTRODUCTION (Centered)
   A. Describe the hatchery location
   B. Describe the hatchery goals and objectives
   C. List the operator, owner, and contractor as appropriate
   D. Include period covered by this report mm/dd/year through mm/dd/year

2. PRODUCTION SUMMARY (Centered)
   A. Report number of eggs by broodyear taken or received
   B. Report number of adult fish spawned
   C. List number of fish released.
   D. Summarize in table (see example Table 1)

3. HATCHERY OPERATIONS (Centered)
   A. Fish Weir and Ladder
      a. Date of installation
      b. Any additional pertinent
   B. Water Supply
      a. Describe the hatchery water source
      b. Describe any temperature controls
      c. Report daily minimum and maximum water temperatures
      d. River Flows
      e. Include additional pertinent information - For example: Water flows were measured by the US Geological Survey at a gauging station located at latitude 38°38'08", longitude 121°13'36" referenced to North American Datum of 1927, in SE ¼ NE ¼ sec.17, T.9 N., R.7 E., Sacramento County, CA, Hydrologic Unit 18020111, on the right bank, 2,100 ft downstream from Nimbus Dam, 2.4 mi east of the town of Fair Oaks at river mile 22.2
      f. Include any graphs or tables (see example Figure 1 and Appendix Table 4 from: http://waterdata.usgs.gov/ca/nwis/rt
   C. Disposal of Salmon Carcasses
      a. List pounds, number, and disposal methods(s) for Chinook salmon carcasses

4. PUBLIC RELATIONS (Centered)
   A. List number of visitors and method of counts
   B. Describe any other related pertinent information
   C. Include Table 2. (See example and double click on the table to bring up imbedded MS Excel spreadsheet)

5. CHINOOK SALMON PROGRAM (Centered)
   A. Broodstock Collection

a. Report date of opening fish ladder and operations
   (1) Spring/Summer ladder operations
      (a) Report dates of spring/summer ladder operations
      (b) Report weekly trapping and tagging data
         (i) Number of fish trapped
         (ii) Number of fish Hallprint tagged as spring-run (list tag numbers in Appendix)
         (iii) Number of fish Hallprint tagged as fall-run (list tag numbers in Appendix)
         (iv) Number of mortalities
         (v) From 50 fish selected at random
            1. Record and report fork length, sex, tag number, adipose clip status (yes or no), and fishing hooks/scar status (yes or no)
   (2) Fall ladder operations
      (a) Report dates of fall ladder operations
      (b) Report **weekly** Chinook salmon trapping data
         (i) Number of Hallprint tagged spring-run passed to roundtanks
         (ii) Number of Hallprint tagged fall-run passed to roundtanks
         (iii) Number of Hallprint tagged spring-run returned to river
         (iv) Number of Hallprint tagged fall-run returned to river
         (v) Number of mortalities

b. Summarize Chinook salmon trapping data (see Table 3 example)

c. Include weekly numbers in Appendix Table 1.

B. Sorting and Spawning
   a. Report spawning data
      (1) Start and end dates
      (2) **Weekly** spring-run Chinook salmon spawning data
         (a) Number of males, females, jacks, and jills spawned
         (b) Eggs taken, number of eggs per female, size of eggs per ounce, and fertility rate
         (c) From 50 fish used for spawning (sampled at random)
            (i) Record and report fork length, sex, Hallprint tag number, adipose clip status (yes or no), head tag code, fishing hooks/scar status (yes or no), and number of eggs collected (for females)
            (ii) Collect scales, otoliths and tissues from each fish, record sample ID. Indicate how samples how and where samples were stored. If moved off site, indicate person responsible and new location.
      (3) **Weekly** fall-run Chinook salmon spawning data
         (a) Number of males, females, jacks, and jills spawned
         (b) Eggs taken, number of eggs per female, size of eggs per ounce, and fertility rate
         (c) From 50 fish used for spawning (sampled at random)
            (i) Record and report fork length, sex, Hallprint tag number, adipose clip status (yes or no), head tag code, fishing hooks/scar status (yes or no), and number of eggs collected (for females)

(ii) Collect scales, otoliths and tissues from each fish, record sample ID. Indicate how samples how and where samples were stored. If moved off site, indicate person responsible and new location.

(4) Report total number of spring-run Chinook salmon eggs collected
(5) Report total number of fall-run Chinook salmon eggs collected
(6) Prepare graph of length frequency of male and female spring-run Chinook spawned
(7) Prepare graph of length frequency of male and female fall-run Chinook spawned

b. Describe methods of artificially spawning (e.g. only Chinook salmon that expel free flowing eggs were euthanized and spawned, euthanization method, etc.).
c. Describe spring-run Chinook mating protocols (e.g. all mating and paring of spring-run Chinook salmon used only fish Hallprint tagged as spring-run, pairing at random, etc.)
d. Describe fall-run Chinook mating protocols (e.g. all mating and paring of fall-run Chinook salmon used only untagged fish or fish Hallprint tagged as fall-run, pairing at random, etc.)

C. Marks and tags observed
a. Report **weekly** mark and tag data
(1) List total number of fish examined for marks (adipose fin clip status)
(2) Number of marked fish observed
(3) Number of marked fish collected (i.e. heads collected for CWT recovery)
(4) For tags recovered (other than CWT) report:
(a) Tag description, tag number, fish fork length, fish sex
b. For each CWT recovered report (as Appendix Table 2)
(1) Brood year, release location, release size, release race, recovery race, recovery fork length, recovery sex, recovery Hallprint tag code

D. Chinook salmon rearing and smolt release
a. Report **weekly** rearing and release data by *fall-run* and *spring-run* Chinook
(1) Report number and size of fish on hand
(2) Report unmarked fish released: number, size and release location
(3) Report marked (and untagged) fish released: number, size and release location
(4) Report marked and tagged fish released: number, size and release location
(5) Report tagged (and unmarked) fish released: number, size and release location
(6) Report survival rates for eggs, fry, parr and/or smolt
(7) See Table 4 example
(8) Repeat as needed for more than one brood year

E. Chinook salmon disease Information
a. Describe any outbreaks of pathogens or disease

(1) Include control information
(2) Describe any medicated feed
(3) Describe any routine treatments

6. STEELHEAD MAINTENANCE PROGRAM (Centered)
   A. Steelhead Broodstock Collection
      a. Report date of opening fish ladder and operations
      b. Report first spawning date
      c. Report **weekly** steelhead trapping data
         (1) Number of adult males spawned, held or released to river
         (2) Number of adult females spawned, held or released to river
         (3) Number of grilse (specify size criteria, e.g. grilse are <40.6cm (16 inches) fork length or smaller)
         (4) Number of mortalities
      d. Summarize steelhead trapping data (see Table 3 example)

   B. Sorting and Spawning
      a. Report spawning data
         (1) Start and end dates for spawning
         (2) **Weekly** steelhead spawning data
            (a) Number of males and females spawned (See Table 5 example)
            (b) Eggs taken, number of eggs per female, size of eggs per ounce, and fertility rate
            (c) From 50 fish used for spawning (sampled at random)
               (i) Record and report fork length, sex, adipose clip status, and number of eggs collected (for females)
               (ii) Collect scales, otoliths and tissues from each fish, record sample ID. Indicate how samples how and where samples were stored. If moved off site, indicate person responsible and new location.
         (3) Report total number of eggs collected
         (4) Prepare graph of length frequency of male and female fish spawned
      b. Describe methods of artificially spawning (e.g. only steelhead that expel free flowing eggs were euthanized and spawned, euthanization technique, etc.)
      c. Describe mating protocols (e.g. all mating and paring of fish was done randomly, or fish paired with mates of similar size, etc.)

   C. Marked and tagged steelhead
      a. Report **weekly** mark and tag data
         (1) List total number of steelhead examined for marks (adipose fin clip status)
         (2) Number of marked fish observed
         (3) Number of marked and tagged fish collected (i.e. heads collected for CWT recovery)
         (4) Number of tagged (but unmarked) fish collected (i.e. heads collected for CWT)
         (5) For tags recovered (other than CWT) report:
            (a) Tag description, tag number, fish fork length, fish sex

(6) For each CWT recovered report (as Appendix Table 2)
(a) Brood year, release location, release size, release race, recovery race, recovery fork length, and recovery sex

D. Steelhead Incubation and Ponding
a. Incubation methods
b. Egg density
c. Size and dates of ponding

E. Steelhead Rearing Conditions
a. Rearing facilities
b. Describe any natural rearing methods
c. Diet and feeding regiment
d. Method of feeding.

F. Steelhead Marking and Tagging
a. Report **weekly** rearing and release data
(1) Report number and size of fish on hand
(2) Report marked (and untagged) fish released: number, size and release location
(3) Report marked and tagged fish released: number, size and release location
(4) Report tagged (and unmarked) fish released: number, size and release location
(5) Report survival rates for eggs, fry, parr and/or smolt
(6) See Table 6 example
(7) Repeat as needed for more than one brood year

G. Steelhead Disease Information
a. Describe any outbreaks of pathogens or disease
(1) Include control information
(2) Describe any medicated feed.
(3) Describe any routine treatments

7. Historical Summary of Fish Trapped (Center)
A. Summarize all fish trapped for all years of operation (see example Appendix Table 3)

8. Literature Cited
A. Add any Literature Cited references here using the CBE (Council of Biology Editors) Style Manual.

Note - Hatchery annual reports are published by the Department of Fish and Game as Fisheries Branch Administrative Reports. See Inland Fisheries - Informational Leaflet No. 44 INSTRUCTIONS TO AUTHORS OF INLAND FISHERIES ADMINISTRATIVE REPORTS.