



2022 – 2023 Annual Report

Feather River Fish Hatchery

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North Central Region Fisheries
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List of Abbreviations

BKD	Bacterial Kidney Disease
BY	Brood Year
CAEP	Classroom Aquarium Education Program
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
cfs	Cubic Feet per Second
CV	Central Valley
CVFC	Central Valley fall-run Chinook Salmon
CVSC	Central Valley spring-run Chinook Salmon
CVSH	Central Valley steelhead trout
CVTA	Central Valley Tissue Archive
CWT	Coded-Wire Tag
DWR	Department of Water Resources
FERC	Federal Energy Regulatory Commission
FHL	CDFW Fish Health Laboratory
FRFH	Feather River Fish Hatchery
FRHOT	Feather River Hatchery Operations Team
HCl	Hydrochloride
NMFS	National Marine Fisheries Service
PSMFC	Pacific States Marine Fisheries Commission
RM	River Mile
TDC	Thiamine Deficiency Complex

Executive Summary

This report summarizes the Feather River Fish Hatchery's (FRFH) operations from July 1, 2022, to June 30, 2023. It details the processes of trapping, spawning, rearing, and releasing of Central Valley spring-run Chinook Salmon (*Oncorhynchus tshawytscha*), Central Valley fall-run Chinook Salmon (*Oncorhynchus tshawytscha*), and Central Valley steelhead trout (*Oncorhynchus mykiss*). This report compares the planned operations detailed in annually developed spawning and release protocols with the actual operations, assessing whether goals and objectives were achieved.

Central Valley Spring-Run Chinook Salmon Brood Year 2022 Production:

Production goals outlined in the 2022 Spring-Run Spawning and Release Protocol

- 2,000,000 smolts

Summary

A total of 1,608 Hallprint tagged Central Valley spring-run Chinook Salmon (CVSC) (1,463 green Hallprint tags and 145 yellow Hallprint tags) entered the hatchery from September 19 through September 30, 2022, however 300 of these fish were released into the Feather River and were not counted toward spring-run broodstock totals. CVSC with Hallprint tags continued to enter the hatchery after CVSC broodstock spawning was completed, and the last recorded Hallprint tag was collected on November 8, 2022. In total, 1,720 CVSC with Hallprint tags (1,569 green Hallprint tags and 151 yellow Hallprint tags) were collected at the hatchery in the fall of 2022. Broodstock collection began on September 19 and spawning of CVSC occurred September 20 through September 30, 2022. A total of 588 females were spawned producing 3,564,586 green eggs, exceeding the collection goal by 0.4%. On average, each female produced 6,070 green eggs. A total of 2,824,500 eyed eggs developed (88.6% of the eyed egg collection goal) and the green-to-eyed egg survival rate was 79.2%. A total of 2,342,329 CVSC fry were produced resulting in an 88.5% eyed egg to fry survival rate. The release strategy for Brood Year (BY) 2022 CVSC followed the plan that was outlined in the 2022 FRFH Spring-Run Chinook Salmon Spawning and Release Protocol (Appendix C) to release all FRFH CVSC into the lower Feather River using three paired releases during the months of March and April. A total of 2,338,945 CVSC (117% of the production goal) were 100% Coded-Wire Tagged (CWT) and marked with an adipose fin-clip and released into the lower Feather River at Boyd's Pump Boat Launch (River Mile (RM) 22.3) and Gridley Boat Launch (RM 50) during March and April.

Central Valley Inland Chinook Salmon Brood Year 2022 Production:

Production goals outlined in the 2022 Fall-Run Spawning and Release Protocol

- 125,000 smolts (Lake Oroville)
- 1,400,000 triploid green eggs (Statewide Inland Salmon Program)

Summary

Spawning for the California Department of Fish and Wildlife (CDFW) Inland Salmon Program occurred October 3 through October 6, 2022. A total of 1,022 Chinook Salmon were collected to be used as inland broodstock. Of these, 421 fish (306 females and 115 males) were spawned, 307 fish (185 females and 122 males) were found dead in the holding tanks, and 294 fish (37 females and 257 males) were culled. On average, each female produced 5,000 green eggs, and a total of 1,541,625 green eggs were collected. After fertilization, all eggs were triploidized following standardized methods with assistance from CDFW trout hatchery staff. Approximately 1,288,416 eggs were transferred as triploid green eggs (92.0% of the green egg goal) on the same day of spawning to the Silverado Fish Planting Base to support the statewide Inland Salmon Program. To support the California Department of Water Resources (DWR) Federal Energy Regulation Commission (FERC) license requirement to provide a cold-water fishery in Lake Oroville, approximately 253,209 triploid green eggs (84.4% of the green egg goal) were retained and incubated at FRFH. A total of 143,942 eyed eggs were produced (84.7% of eyed egg production goal), resulting in a 56.8% green-to-eyed egg survival rate. Due to an unforeseen fungal infection, a portion of these eggs held at FRFH for Lake Oroville were lost and only 100,710 fry were ponded resulting in 70.0% eyed egg to fry survival rate. An additional 22,000 juveniles were transferred from Silverado to meet the FRFH production goals for Lake Oroville. In May, a total of 122,410 (97.9% of the production goal) inland Chinook Salmon were planted in Lake Oroville at the Loafer Creek boat ramp. Approximately 15,973 of the fish were planted by boat via live wells and nets.

Central Valley Fall-Run Chinook Salmon Brood Year 2022 Production:

Production goals outlined in the 2022 Fall-Run Spawning and Release Protocol

- 6,000,000 smolts for Mitigation Production
- 2,000,000 smolts for Drought Enhancement
- 1,500,000 pre-smolts for Drought Enhancement

Summary

Broodstock collection and spawning of Central Valley fall-run Chinook Salmon (CVFC) occurred October 10 through November 9, 2022. A total of 2,937 females were spawned producing 17,231,836 green eggs (109.7% of the green egg collection goal), which yielded 12,469,663 eyed eggs (97.5% of the eyed egg goal), for a green-to-eyed egg survival rate of 72.4%. A total of 10,310,590 CVFC fry were produced resulting in an 82.7% eyed egg to fry survival rate. Approximately 10,295,925 BY 2022 CVFC (108.4% of production goal) were released from FRFH in April, May, and June of 2023, into the San Francisco and San Pablo bays and the Feather River. The Feather River

releases were day-time direct releases into the river at either Gridley Boat Launch or Boyd's Pump Boat Launch. The releases into the San Francisco Bay were direct night-time releases at the Estuary and Ocean Science Center in Tiburon, and the releases into the San Pablo Bay were either a direct night-time release at Conoco or a net pen release at Mare Island. These CVFC releases followed the plan that was outlined 2022 in the Feather River Hatchery Fall-Run Chinook Salmon Spawning and Release Protocol (Appendix F), with 1,000,000 mitigation production smolts released into the Feather River, and the remainder of the mitigation production (5,000,000 smolts) and the drought enhancement production (2,000,000 smolts) released into the San Francisco and San Pablo bays. Additionally, 1,500,000 pre-smolt CVFC were released into the Feather River at the Gridley Boat Launch shortly after tagging. The production and releases of these fish was coordinated with the Feather River Hatchery Operations Team (FRHOT), a multi-agency team with representatives from CDFW, DWR, and NOAA Fisheries, after the final spawning and release protocol was developed; this release was therefore not described in the protocol.

Central Valley Steelhead Trout Brood Year 2023 Production:

Production goals outlined in the 2022 Steelhead Spawning and Release Protocol

- 400,000 yearlings for Mitigation Production
- 50,000 yearlings for 1986 Delta Fish Agreement between DWR and California Department of Fish and Game

Summary

Broodstock collection of Central Valley steelhead trout (CVSH) began on November 21, 2022, and spawning of BY 2023 occurred December 28, 2022 through February 22, 2023. During this time, 789 adult CVSH, 430 males and 359 females, were trapped for broodstock. In total, 311 pairs were spawned (42 individuals were unclipped) resulting in the collection of 854,344 green eggs collected, yielding 57.0% of the production goal being met. On average, each female produced 2,638 green eggs. Approximately 79,765 eyed eggs were lost due to an error that occurred during pathogen treatments with iodine, resulting in a total of 694,890 eyed eggs produced, and the green-to-eyed egg survival rate was 81.3%. A total of 665,432 CVSH were ponded, resulting in a 95.8% eyed egg to fry survival rate. These fish will be released as yearlings in 2024. After being spawned or stripped, 289 adipose fin-clipped adult male CVSH were released into the Thermalito Afterbay to enhance the recreational fishery.

A total of 408,985 BY 2022 yearling SH (90.9% of the production goal) were released into the Feather River and the Thermalito Afterbay. A total of 404,249 yearlings were released into the Feather River at Boyd's pump starting on February 6 and ending on February 23, 2023. Additionally, approximately 4,736 yearlings were released into the Thermalito Afterbay to contribute to the local fishery after discussions between CDFW

and DWR.. The actual release of CVSH yearlings differed slightly from the plan outlined in the 2022 Feather River Steelhead Spawning and Release Protocol, as 4,736 yearlings were released into the Thermalito Afterbay, instead of into the Feather River as originally planned.

Introduction

This report describes activities at the Feather River Fish Hatchery (FRFH) during the 55th year of operation, beginning July 1, 2022, and ending June 30, 2023. The hatchery is located on the north embankment of the Feather River, about four river miles downstream from the Oroville Dam, in the town of Oroville, in Butte County. The hatchery was constructed by the California Department of Water Resources (DWR) as part of the California State Water Project to mitigate for the loss of spawning habitat for Central Valley spring-run Chinook Salmon (CVSC), Central Valley fall-run Chinook Salmon (CVFC), and Central Valley steelhead trout (CVSH) above the Oroville Dam. CVSC are listed as threatened under the California Endangered Species Act, and CVSH and CVSC are both listed as threatened under the Federal Endangered Species Act.

Hatchery operations began in 1967 and the California Department of Fish and Wildlife (CDFW) operates the facility under contract with DWR. The facility consists of eight outdoor raceways which are 600 feet long, two outdoor raceways which are 300 feet long, and one rearing channel which is 0.5 miles long. Hatchery inflow is supplied by an intake within the Thermalito Diversion pool, and discharge water is delivered through two settling ponds that percolate the water back to the Feather River. Influent and effluent are permitted through the State Water Resources Control Board order number R5-2014-0161, following mandatory monitoring and reporting requirements.

During this reporting period, the hatchery was staffed with fifteen permanent employees and six seasonal employees. Permanent staff included one Manager II, one Manager I, one Staff Service Analyst, two Habitat Assistants, eight full-time Fish and Wildlife Technicians, and two permanent-intermittent Fish and Wildlife Technicians. Seasonal employees included five Scientific Aids and one Fish and Wildlife Aid. Funding for these positions were provided through an operations contract between CDFW and DWR. This contract also provided funding for a quarter of a Senior Environmental Scientist Supervisor position. Additional drought funding was provided by CDFW for two limited term positions, one Manager I and one Habitat Assistant, to support increased workload and workload complexity associated with the drought actions implemented during the reporting period. Lastly, grant funding provided to CDFW by NOAA Fisheries supported an Environmental Scientist, specific to FRFH, to aid in the development and implementation of Hatchery and Genetic Management Plans and provide scientific support to hatchery programs.

Annually, Spawning and Release Protocols are developed in coordination with the Feather River Hatchery Operations Team (FRHOT), a multi-agency team with representatives from CDFW, DWR, and NOAA Fisheries, detailing Brood Year (BY) goals for fish production and releases. BY 2022 CVSC, BY 2022 CVFC, and BY 2023 CVSH production goals supporting DWR's mitigation requirement for the loss of habitat resulting from the construction of the Lake Oroville Dam are as follows:

- Spring-run Chinook Salmon: 2,000,000 smolts
- Fall-run Chinook Salmon: 6,000,000 smolts
- Steelhead trout: 400,000 yearlings

Additionally, 2022 production goals included up to 125,000 Chinook Salmon to support DWR's Federal Energy Regulatory Commission (FERC) requirement to provide a cold-water fishery in Lake Oroville and 50,000 yearling CVSH for part of the 1986 Delta Fish Agreement between DWR and California Department of Fish and Game (CDFG). This agreement was established to aid in offsetting adverse fishery impacts from the diversion of water at the Harvey O. Banks Delta Pumping Plant.

Drought conditions pose significant challenges to Chinook Salmon populations, with lower river flows, increased water temperatures, and decreased dissolved oxygen levels negatively impacting adult and juvenile survival, and increasing predation, disease transmission, and redd superimposition. To help offset the impacts associated with multiple years of drought, actions were coordinated with the FRHOT and implemented during the 2022-2023 broodstock collection and spawning operations. The drought actions summarized below were intended to address impacts to both adult and juvenile life stages of CVSC and CVFC.

1. Release thiamine treated adult female CVSC broodstock in excess to those required to support mitigation production goals back to the river.
2. Increase CVFC production goals to include an additional 1,500,000 pre-smolts, to be released into the Feather River shortly after coded-wire-tagging, and 2,000,000 smolts to be released at sites along the San Pablo or San Francisco bays.

Hatchery Operations

Fish Ladder

Water flow of 16 cubic feet per second (cfs) was initiated on September 15, 2022, to attract the 2022 CVSC broodstock into the hatchery. The ladder remained open until after the broodstock tagging of returning 2023 CVSC was finished. Flows in the fish

ladder were reduced on July 13, 2023, to discourage fish from ascending the ladder, and the ladder was fully closed on July 14, 2023. This is two weeks later than in previous years to facilitate the extension of the broodstock tagging window due to low returns of adult CVSC in the spring of 2023.

Water Supply

Freshwater is supplied to the facility from the Feather River downstream of the Lake Oroville Dam, through an intake at the Thermalito Diversion Dam. The maximum flow rate to the hatchery is 110 cfs, however normal hatchery operations require approximately 74 cfs. Water is gravity fed to an aeration tower and subsequently delivered throughout the facility.

The 1983 interagency agreement between CDFG and DWR provides water temperature criteria for the hatchery following the schedule below (Table 1).

Table 1: Temperature requirements from the 1983 CDFG and DWR Agreement. Temperature requirements are in degrees Fahrenheit and criteria include a buffer, plus 4°F.

Date	Temperature
April 1 – May 15	51°F
May 16 – May 31	55°F
June 1 – June 15	56° F
June 16 – August 15	60°F
August 16 – August 31	58°F
September 1 – September 30	52°F
October 1 – November 30	51°F
December 1- March 31	No greater than 55°F

During the reporting period, the highest temperature was observed in August at 61.7°F, and the lowest temperature was observed in March at 44.2°F (Table 2).

Table 2. Monthly average, minimum, and maximum FRFH water temperature in degrees Fahrenheit, 7/1/2022 – 6/30/2023.

Month	Mean	Minimum	Maximum
July, 2022	58.8	55.7	61.5
August, 2022	58.5	54.3	61.7
September, 2022	54.4	50.9	60.8
October, 2022	52.3	50.0	55.8
November, 2022	52.0	50.0	55.5
December, 2022	49.5	47.1	52.0
January, 2023	47.7	45.5	49.9
February, 2023	46.0	44.7	47.6
March, 2023	46.1	44.2	48.5
April, 2023	50.2	45.8	55.9
May, 2023	53.2	49.4	58.0
June, 2023	55.6	52.3	58.4

Feeding

Once fry are transferred to the outdoor raceways (ponded), they are hand fed BioOregon BioPro Starter #0 until growth allows for the transition to BioOregon BioPro Starter #2, which can be distributed by a cart mounted feed blower.

Feed type and size is dependent on fish size and growth. Chinook Salmon and CVSH were fed following the manufacturer's recommendations (Appendix A). A total of 214,481 pounds of feed of various sizes and types was purchased to support the Chinook Salmon smolt and CVSH production at FRFH (Table 3).

Table 3. Summary of feed type and amount purchased, 7/1/2022 – 6/30/2023.

Month	BioPro Starter #0	BioPro Starter #1	BioPro Starter #2	BioPro Starter #3	BioVita #1 (Medicated)	BioVita #1.2 (Medicated)	Classic Fry 1.5 mm	Classic Fry 2.5 mm	Classic Trout 3.5 mm	Total Pounds
July, 2022				2,112			1,296			3,408
August, 2022				2,156			2,028			4,184
September, 2022				1,300			5,400			6,700
October, 2022							5,840	2,240		8,080
November, 2022							2,440	14,920		17,360
December, 2022	929	80						24,070		25,079
January, 2023	2,496	2,807	662					18,943	7,600	32,508
February, 2023	5,940	3,256							5,600	14,796
March, 2023		5,383	7,971	16,468						29,822
April, 2023		600	4,424	35,084						40,108
May, 2023	376		2,594	24,020						26,990
June, 2023	65	510	2,946	1,925						5,446
Total Pounds	9,806	12,636	18,597	83,065	0	0	17,004	60,173	13,200	214,481

Fish Health

Pathology

The CDFW Fish Health Laboratory (FHL) provides the FRFH with pathology diagnostic calls and consultations. Diagnostic calls and consultations include collection of specimens (eggs, fish, ovarian fluid, and other fish tissues), necropsy and diagnostic workup for virology, bacteriology, and other pathogens that may affect fish health. The FHL provides reports of diagnosis with recommendations for treatments and prescriptions for restricted antibiotics or other therapeutics, as necessary. Fish Health Certifications are also provided by the FHL each year on a subset of juvenile CVSC, juvenile inland Chinook, juvenile CVFC, and juvenile CVSH. The FRFH conducts their own pre-release health assessments on a subset of all fish release groups prior to release.

During spawning operations in 2022, ovarian samples were collected from a subset of CVSC, CVFC, and CVSH and screened for pathogens. A total of 550 samples were collected from adult CVSC, 530 samples were collected from adult CVFC, and 120 samples were collected from adult CVSH. Two samples of ovarian fluid collected from CVSC adults tested positive for Bacterial Kidney Disease (BKD) and eggs collected

from these fish were subsequently culled. One sample from CVSH tested positive for presumptive infectious hematopoietic necrosis virus (IHNV). All other samples were negative for pathogens. CVSC and CVFC Fish Health Certifications were performed on January 12, 2023, and one was performed for inland Chinook and CVSH on March 3, 2023. The certificates stated that the fish appeared healthy, were appropriate shape and size, had no gross external lesions, and were free of any infectious agents (e.g., IHNV, Infectious Pancreatic Necrosis, or BKD).

During this reporting period, the FHL was requested to the hatchery three times to examine the rearing CVFC and CVSH for infectious diseases (Table 4). Low to moderate bacterial colonization of *Flavobacterium branchiophilum*, causative agent of bacterial gill disease, was detected in a few juvenile CVFC on April 10, 2023. FHL recommended reducing stress by decreasing the fish density and salting regularly. Cold-water disease (CWD), causative agent *Flavobacterium psychrophilum* bacteria, was detected in the juvenile CVSH on April 25, 2023, and June 6, 2023. Veterinary Feed Directives and prescriptions for antibiotic treatments were provided, in addition to recommendations for chemical treatments.

Table 4: Diagnostic report for juvenile CVFC and CVSH, 7/1/2022-6/30/2023.

Date	Species	Disease/Pathogen	Treatment
4/10/2023	CVFC	Low to moderate bacterial colonization of <i>Flavobacterium branchiophilum</i> , causative agent of bacterial gill disease	Reduce density and continue to salt
4/10/2023	CVSH	No significant findings	Reduce density and continue to salt
4/25/2023	CVSH	<i>Flavobacterium psychrophilum</i> , causative agent of CWD	Florfenicol medicated feed
6/6/2023	CVSH	<i>Flavobacterium psychrophilum</i> , causative agent of CWD	Florfenicol medicated feed

Thiamine Treatment

Thiamine Deficiency Complex (TDC) is an ongoing threat to both returning adult Chinook Salmon and progeny of thiamine deficient parents within the Central Valley. Juveniles with TDC experience loss of equilibrium, abnormal swimming patterns,

lethargy, and early life-stage mortality (Mantua et al. 2021). To help alleviate the impacts from TDC, thiamine treatments are given to Chinook Salmon at FRFH. The FRFH has three different methods of treatment depending on the life-stage. Thiamine hydrochloride (HCl) is administered to the returning CVSC during the broodstock identification process to help boost egg thiamine concentration. Treating returning adults prior to spawning has the added benefit of likely improving survival during the adult over summer holding period as thiamine deficiency decreases a fish's ability to tolerate stress.

Dr. Kevin Kwak (FHL) developed a thiamine HCl injection protocol specific to treating CVSC at FRFH during broodstock identification (Appendix B). A total of 1,966 CVSC 2022 broodstock were treated with thiamine HCl injections between May 4, 2022 and July 5, 2022. An additional 200 CVSC were injected with saline to act as a control group to compare to the thiamine treated fish to measure treatment impacts and provide baseline egg thiamine concentration levels in FRFH CVSC. The thiamine treated CVSC ($n = 28$) had an average egg thiamine concentration of 32.7 ± 10.0 nmol/g and the saline treated CVSC ($n = 30$) had an average egg thiamine concentration of 8.8 ± 5.6 nmol/g egg thiamine concentration. CVSC fry produced from fish that received saline solutions were treated with a thiamine immersion bath when they were moved to the outdoor raceways.

CVFC eggs were treated with thiamine mononitrate at fertilization to treat for TDC following established protocols developed by the FHL (Appendix B). To determine baseline egg thiamine concentration levels in CVFC, a total of 30 untreated CVFC were sampled. The average egg thiamine concentration was 7.8 ± 4.0 nmol/g.

Salmon Carcass Disposal

Chinook Salmon carcasses that are fit for human consumption, typically from culled or spawned fish, are provided to the Enterprise Rancheria, a local Tribal nonprofit organization, or to California Emergency Foodlink operating under a contract and a California Endangered Species Act Memorandum of Understanding with CDFW. California Emergency Foodlink coordinates with American Canadian Fisheries for carcass collection and processing prior to distribution to local food banks. In 2022, a total of 12,268 Chinook Salmon carcasses were deemed suitable for human consumption. A total of 385 whole fish were given to local native tribes and 11,883 carcasses were transferred to American Canadian Fisheries for processing and distributed by California Emergency Foodlink. A total of 1,275 carcasses not suitable for human consumption were disposed of through a contractual agreement with a local rendering company.

Aquatic Invasive Species Monitoring

Monitoring for aquatic invasive species is conducted regularly throughout the year. Regular sampling was initiated after CDFW received notice from the CSU Chico Aquatic Bioassessment Lab on February 5, 2016 that samples taken from the Feather River (immediately upstream and downstream of FRFH) on June 2, 2016 tested positive for the presence of New Zealand Mud Snails. To date, New Zealand Mud snails have not been found inside the hatchery or on its surrounding premises.

Public Relations and Outreach

Estimates of hatchery visitors are made using auto counting sensors located at the visitor parking lots and visitor counts made during formal tours conducted by DWR personnel. Visitors arriving by foot or bus are unable to be captured in current methods of estimating visitor numbers and, therefore, these estimations are likely lower than the actual number of visitors. It is estimated that there was 84,820 visits to the hatchery during the reporting period (Table 5).

Table 5. Estimated number of FRFH visitors, 7/1/2022-6/30/2023.

Month	Estimated Number of Visits
July, 2022	7,527
August, 2022	7,935
September, 2022	12,152
October, 2022	9,470
November, 2022	5,681
December, 2022	4,026
January, 2023	5,396
February, 2023	5,320
March, 2023	6,712
April, 2023	6,910
May, 2023	7,109
June, 2023	6,582
Total	84,820

In coordination with the CDFW Classroom Aquarium Education Program (CAEP), Chinook Salmon eggs were provided to 23 public schools in Butte County, Yolo County, and Colusa County. An additional 4,200 eggs were transferred to Nimbus Fish Hatchery for distribution to CAEP's in the Sacramento County area.

Spring-Run Chinook Salmon Production

2022 Broodstock Identification

Between May 4 and July 5, 2022, a total of 2,166 Chinook Salmon were tagged with Hallprint tags. There were 673 recaptures during this time, with the majority of the fish only being recaptured one time (Table 6). CVSC broodstock tagging was extended until July 5, 2022, as a result of a drought action that was coordinated with FRHOT. This drought action was implemented as an effort to offset the impacts of multiple years of drought by increasing the number of thiamine treated CVSC released into the river and increasing the potential CVSC broodstock in the fall. The ladder boards were removed on July 15, 2022, and the water to the ladder was reduced to prevent further entry of Chinook Salmon into the hatchery.

Table 6: Number of recaptured Hallprint tagged CVSC, 05/04/2022- 7/5/2022.

Recapture Events	Number of Recaptures
1	385
2	101
3	17
4	6
5	1
6	1

2022 Broodstock Collection and Spawning

Annually, a FRFH Spawning and Release Protocol for CVSC is developed in coordination with the FRHOT. This protocol describes the goals and approach for egg collections, fish production, and fish release. Important aspects of the egg collection model are to support genetic contribution from throughout the CVSC spawn timing and the continuation of actions that recreate the temporal separation between hatchery origin spring- and fall-run Chinook Salmon in the Feather River (Appendix C). BY 2022 CVSC egg collections goals targeted in this protocol included 3,550,500 freshly fertilized, or green eggs, and 2,987,746 eyed eggs to produce 2,000,000 ($\pm 10\%$) CVSC smolts.

On September 15, 2022, flow to the ladder was initiated allowing adult Chinook Salmon to ascend the ladder. CVSC broodstock, identified by the presence of a green or yellow Hallprint tag, began entering the hatchery building on September 19 and were retained for spawning. Spawning of CVSC began on September 20 and continued until September 30, 2022. A total of 1,608 Hallprint tagged CVSC (1,463 green Hallprint tags and 145 yellow Hallprint tags) entered the hatchery from September 19 through

September 30, 2022. In implementation of the drought actions referenced earlier in this document, 300 of these fish were released into the Feather River. CVSC broodstock released back to the river from FRFH were not counted in the FRFH spring-run broodstock totals. A total of 588 females (548 green and 40 yellow) were spawned, producing 3,564,586 green eggs, exceeding the collection goal by 0.4%. On average, each female produced 6,070 green eggs. A total of 2,824,500 eyed eggs developed (88.6% of the eyed egg collection goal) and the green-to-eyed egg survival rate was 79.2%. There were two trays of CVSC that were culled due to two females testing positive for BKD. A total of 2,342,329 CVSC fry were produced resulting in an 88.5% eyed egg to fry survival rate. CVSC with yellow Hallprint tags were only spawned with other yellow Hallprint tagged fish, because these fish did not receive thiamine treatments during broodstock tagging in the spring. These fish also did not receive thiamine treatments at fertilization as described in the spawning and release protocol. Instead, Dr. Kevin Kwak (CDFW FHL) and Rachel Johnson (NOAA Southwest Fisheries Science Center) requested to collect untreated eyed eggs to study TDC. A total of 1,456 eyed eggs were collected to fulfill this request and the remaining untreated eggs were hatched, and the resulting fry were treated with thiamine when ponded.

CVSC with Hallprint tags continued to enter the hatchery after CVSC broodstock spawning was completed, and the last recorded Hallprint tag was collected on November 8, 2022. In total, 1,720 Chinook Salmon with Hallprint tags (1,569 green Hallprint tags and 151 yellow Hallprint tags) were collected at the hatchery in the fall of 2022. This represented 79.3% of the total number of Chinook Salmon that were tagged with Hallprint tags during the spring of 2022. As part of a drought action that was coordinated with the FRHOT, thiamine treated CVSC that were in excess to those needed to meet production goals were returned live to the Feather River. A total of 329 adults (113 males, 214 females, and 2 unknown sex) with green Hallprint tags were released back into the Feather River to augment in-river spawning. The Hallprint tag on these fish were cut in half before release for ease of identification of any fish observed in the Feather River escapement survey or subsequent broodstock collection activities at FRFH. There was a total of 54 fish (21 males and 33 females) that were recaptured at the hatchery after release. The excess non-thiamine treated CVSC with yellow Hallprint tags were not released back into the river and were instead culled.

Coded-Wire Tag Data

Adults

In addition to inspection for Hallprint tags, all Chinook Salmon trapped were examined for the presence of an adipose fin. Adipose fins of juvenile hatchery-origin Chinook Salmon are removed, indicating they have been implanted with a Coded-Wire Tag (CWT). CVSC from FRFH are marked with adipose fin clips and tagged with CWTs at a rate of 100%. During CVSC spawning, September 19 and September 30, 2022, a total

of 1,347 CWT-confirmed FRFH CVSC entered the hatchery. Chinook Salmon with a spring-run CWT continued to enter the hatchery until October 20, 2022. In total, 1,889 CWT confirmed FRFH CVSC (840 adult males, 985 adult females, and 64 grilse) entered the FRFH between September 19 and October 20, 2022. The heads of these Chinook Salmon were collected by CDFW Central Valley Tissue Archive (CVTA) and CWT Lab staff for CWT extraction and analysis. CWT analysis allows for the detection of adult CVFC contribution in the CVSC egg lots and the culling of eggs resulting from CVSC and CVFC crosses to help maintain the temporal separation between these two runs. In 2022, there were no spawned pairs that included CWT-confirmed CVFC. The CWT data is also used in the identification of Chinook Salmon originating from other Central Valley hatcheries (Appendix D). During the CVSC broodstock collection and spawning season, September 19 through September 30, 2022, a total of 109 FRFH CVFC CWTs were recovered, as well as 3 Coleman National Fish Hatchery CVFC CWTs, and 9 CVSC CWTs from the San Joaquin River Conservation Hatchery (Figure 1).

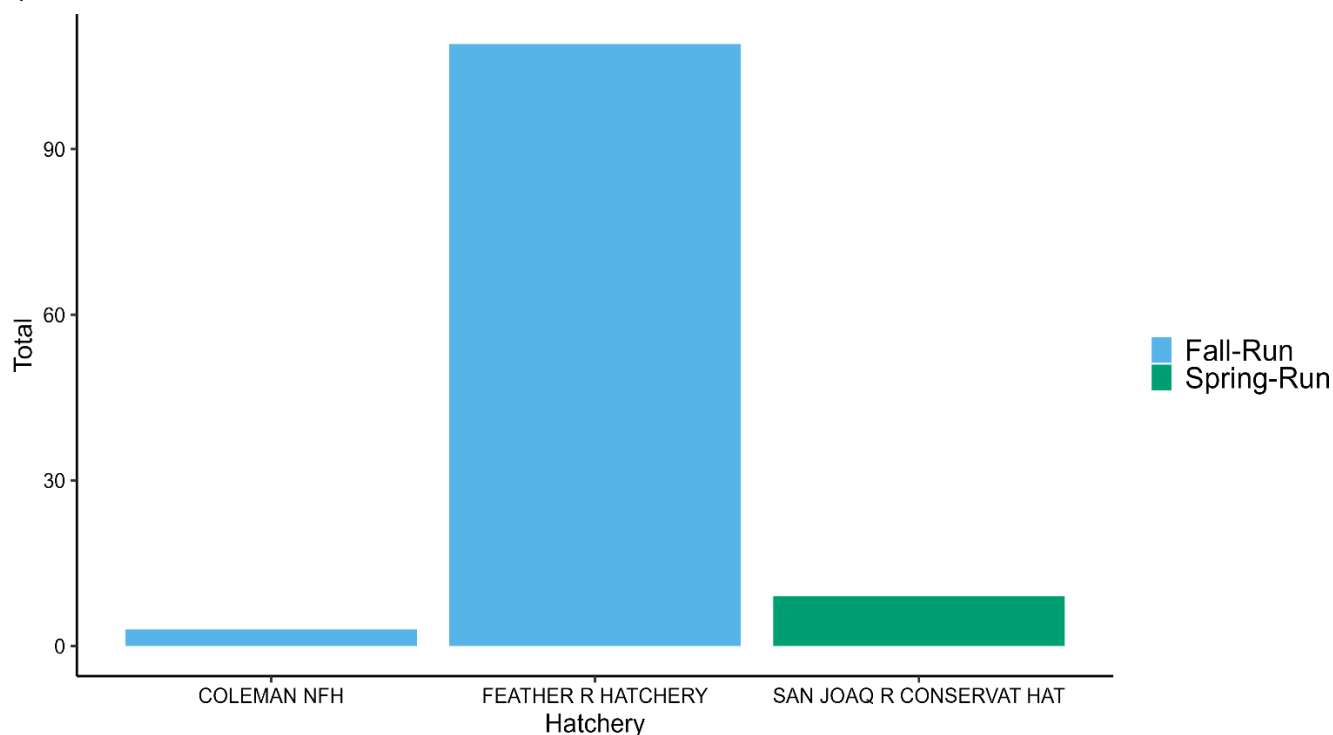


Figure 1: CWT recovery of FRFH CVFC and other hatchery strays at FRFH during CVSC spawning, 9/19/2022-9/30/2022.

The CVTA and CWT Lab staff also recorded fork lengths, sex, and adipose fin status on every Hallprint tagged and CWT CVSC. The CWT data revealed that 1,131 four-year olds, 711 three-year olds and 47 two-year old fish containing a FRFH CVSC CWT

returned to the hatchery from September 19, 2022, through October 20, 2022. (Figure 2). The CVSC CWT fish fork lengths ranged from 469 mm to 1100 mm, and the average grilse fork length was 578 mm, and the average adult fork length was 840 mm. The grilse fork length cutoff used at FRFH is 650 mm, and in 2022 there were 21 CWT fish out of 1,889 fish that were mis-characterized as an adult or a grilse based on their fork length. There were 2 two-year old males that measured over 650 mm. Additionally, 14 three-year olds (10 females and 4 males) and 5 four-year olds (3 females and 3 males) that measured under 650 mm were observed.

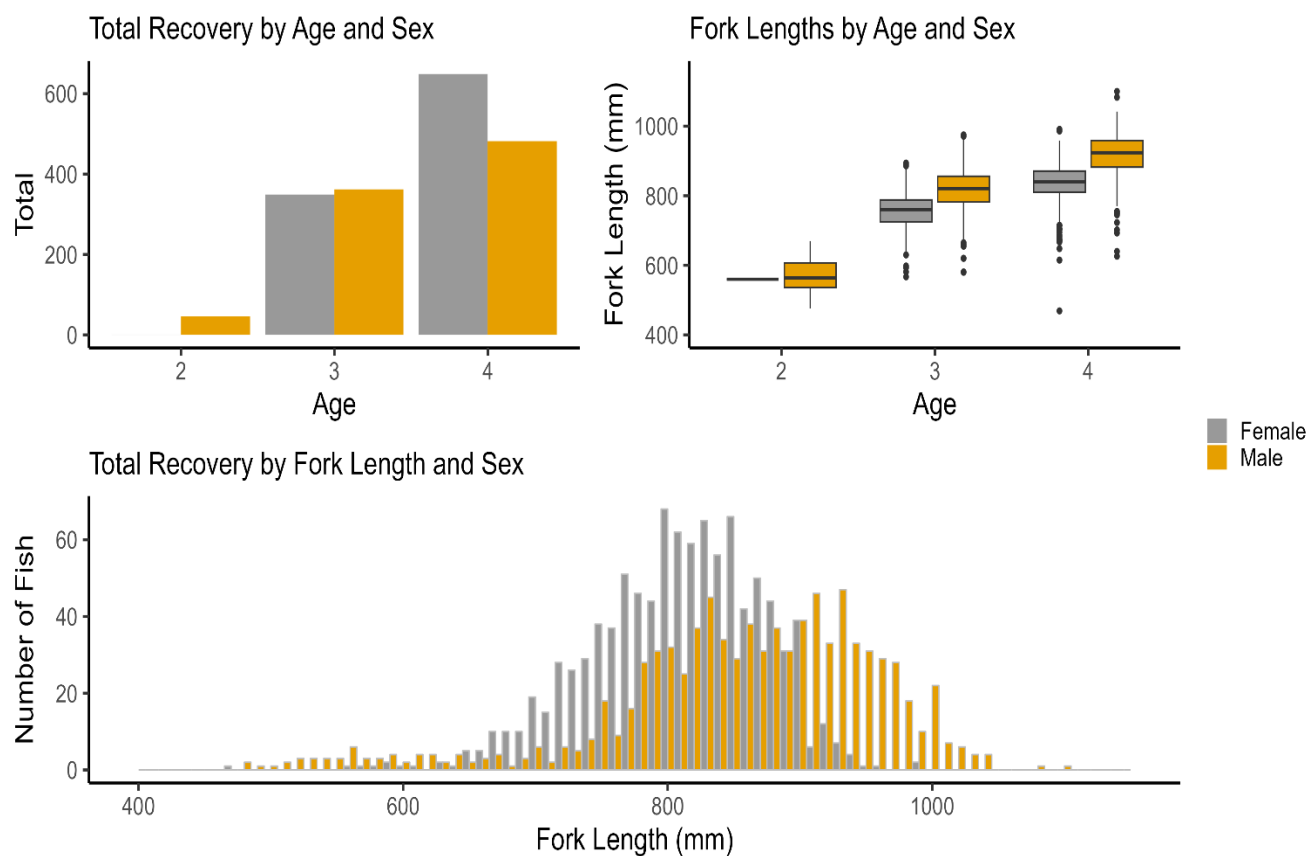


Figure 2: 2022 FRFH CVSC CWT recovery data summarized by age, fork length, and sex, 9/19/2022 – 10/20/2022.

Juveniles

When juvenile CVSC reach roughly 66 mm, or 185 fish per pound, they are implanted with a CWT and their adipose fin is removed using a Westmark CWT tagging trailer. A total of 2,342,229 BY 2022 juvenile CVSC were split into six total groups. Four groups each contained approximately 366,000 fish, one group contained approximately

430,000 fish, and one other group contained approximately 450,000 fish. Each group was 100% tagged with a unique CWT and was 100% marked with adipose fin clips. This work was completed by Pacific States Marine Fisheries Commission (PSMFC) personnel under contract with DWR.

Releases

Historically, releases of CVSC have occurred at locations along the Feather River, including sites such as Boyd's Pump Boat Launch (River Mile (RM) 22.3) and at the Gridley Boat Launch (RM 50). The release strategy for BY 2022 CVSC followed the plan that was outlined in the 2022 FRFH Spring-Run Chinook Salmon Spawning and Release Protocol (Appendix C) to release all FRFH CVSC into the lower Feather River using three paired releases during the months of March and April. A total of 2,338,945 (117% of the production goal) CVSC that were 100% CWT and marked with adipose fin clips were released into the Feather River (Appendix E). The three paired releases, each consisting of uniquely coded groups of fish, were released at Gridley Boat Launch and Boyd's Pump Boat Ramp on the same day. The first release occurred on March 16, 2023, and fish were approximately 95 to 97 fish per pound. A total of 366,267 fish were released at Boyd's Pump Boat Launch, and a total of 365,190 fish were released at Gridley Boat Launch. The second release occurred on March 24, 2023, and fish were approximately 91 to 94 fish per pound. A total of 362,142 fish were released at Boyd's Pump Boat Launch, and a total of 366,147 fish were released at Gridley Boat Launch. The third release occurred on April 11, 2023, and fish were approximately 61 to 75 fish per pound. A total of 448,533 fish were released at Boyd's Pump Boat Launch, and a total of 430,666 fish were released at Gridley Boat Launch.

2023 Broodstock Identification

Chinook Salmon that ascend the fish ladder in the spring are trapped, tagged with two identically numbered Hallprint tags, and returned to the Feather River. These external tags identify phenotypic CVSC for broodstock collection when they return to the hatchery in the fall.

The 2023 CVSC broodstock identification process began on May 4 and continued until July 13, 2023. Typically, the broodstock tagging process ends by June 30, but due to the low number of returning CVSC to FRFH by the end of June in 2023, a drought action was coordinated with FRHOT to extend the tagging period until July 13, 2023. This drought action was an effort to offset impacts of multiple years of drought by increasing the number of thiamine treated CVSC and increasing the potential CVSC broodstock available to the hatchery for spawning in the fall. Fish tagged prior to June 30 received a green or yellow Hallprint tag, consistent with prior years. Fish tagged after June 30 received a blue Hallprint tag for easy identification during broodstock collection in the fall. A total of 2,164 adult Chinook Salmon were tagged as CVSC and returned to

the Feather River (Table 7).

Table 7: 2023 CVSC broodstock identification.

Date	5/4/2023	5/15/2023	5/22/2023	5/30/2023	6/15/2023	6/20/2023	6/21/2023	6/26/2023	6/30/2023	7/13/2023	Season Total	Percent of Season Total
Fish Tagged	27	357	35	255	342	400	191	107	213	237	2164	100.00%
Green/Thiamine	22	337	30	235	293	352	166	80	213	237	1965	90.80%
Yellow/Control	5	20	5	20	49	48	25	27	0	0	199	9.20%
Grilse	1	27	0	15	20	35	31	24	63	52	268	12.38%
Wild	1	6	0	3	13	37	10	24	35	82	211	9.75%
Mortalities	0	0	0	0	1	1	0	1	1	1	5	0.23%
Single Tag	1	4	0	0	4	10	6	2	0	3	30	1.39%
Recaps	0	2	3	12	65	143	109	98	146	294	872	40.30%
Fish Tagged	27	357	35	255	342	400	191	107	213	237	2164	
Wild	1	6	0	3	13	37	10	24	35	82	211	
Clipped	26	351	35	252	329	363	181	83	178	155	1953	
Clip Rate	96.30%	98.32%	100.00%	98.82%	96.20%	90.75%	94.76%	77.57%	83.57%	65.40%	90.25%	

Thiamine and saline injections were administered during broodstock tagging for the third year in a row to evaluate the prevalence and alleviate impacts of TDC. The fish injected with thiamine solution were tagged with green or blue Hallprint tags, and the fish injected with saline solution were tagged with yellow Hallprint tags for ease of identification when returning in the fall during CVSC spawning. The fish injected with the saline solution are a control group for this evaluation and will provide baseline egg thiamine level data to compare to the treatment group. The thiamine injection methods that were followed were developed by Dr. Kevin Kwak at the FHL (Appendix B).

Inland Salmon Program

DWR, as part of their requirements for the Oroville Facilities FERC Project No. 2100, supports a cold-water fishery for Chinook Salmon in Lake Oroville. Eggs collected from FRFH broodstock are used to produce the triploid juveniles released into Lake Oroville to support this fishery. FRFH also supplies the triploid eggs to support CDFW's Statewide Inland Salmon Program, which provides fish for cold-water fisheries of Chinook Salmon at several waters throughout the state.

2022 Broodstock Collection and Spawning

Annually, a FRFH Spawning and Release Protocol for CVFC is developed in coordination with the FRHOT; included in this protocol are goals for the Inland Salmon Program (Appendix F). Inland Salmon BY 2022 egg collection goals captured in this protocol included 300,000 freshly fertilized, or green eggs, and 170,00 eyed eggs to

produce 125,000 smolts to support the DWR's FERC license requirement to provide a cold-water fishery in Lake Oroville. Additionally, there is a 1,400,000 green egg collection goal to support the CDFW's Statewide Inland Salmon Program. The eggs for the Statewide Inland Salmon Program are transferred the same day of spawning to the Silverado Fish Planting Base for incubation and grow out for stocking into approved waters throughout the state.

Eggs to support production for the Inland Salmon programs are collected from adult Chinook Salmon that enter the hatchery during the CVSC spawning period but do not have a Hallprint tag. Spawning of BY 2022 inland Chinook Salmon began on October 3, 2022 and ended on October 6, 2022. A total of 1,022 Chinook Salmon were collected to be used as inland broodstock. Of these, 421 fish (306 females and 115 males) were spawned, 307 fish (185 females and 122 males) were found dead in the holding tanks, and 294 fish (37 females and 257 males) were culled. On average, each female produced 5,000 green eggs, and a total of 1,541,625 green eggs were collected. After fertilization, all eggs were triploidized, rendering progeny reproductively sterile, following standardized methods with assistance from CDFW trout hatchery staff. Approximately 1,288,416 eggs were transferred as triploid green eggs (92.0% of the green egg goal) the same day of spawning to the Silverado Fish Planting Base to support the statewide Inland Salmon Program. To support the cold-water fishery in Lake Oroville, approximately 253,209 triploid green eggs (84.4% of the green egg goal) were retained and incubated at FRFH. A total of 143,942 eyed eggs were produced (84.7% of eyed egg production goal), resulting in a 56.8% green-to-eyed egg survival rate. Due to an unforeseen fungal infection, a portion of the eggs held at FRFH for Lake Oroville were lost and only 100,710 fry were ponded, resulting in 70.0% eyed egg to fry survival rate. An additional 22,000 juveniles were transferred from Silverado to meet the FRFH production goals for Lake Oroville.

Coded-Wire Tag Data

During the inland spawning period (October 3 through October 6, 2022), a total of 567 CWTs were recovered. The CVTA and CWT Lab staff collected the heads of these Chinook Salmon. Of the 567 CWT fish that were recovered during this time, 408 were FRFH CVSC, 144 were FRFH CVFC, 12 were Coleman Nation Fish Hatchery CVFC, and 3 were San Joaquin River Conservation Hatchery CVSC (Figure 3).

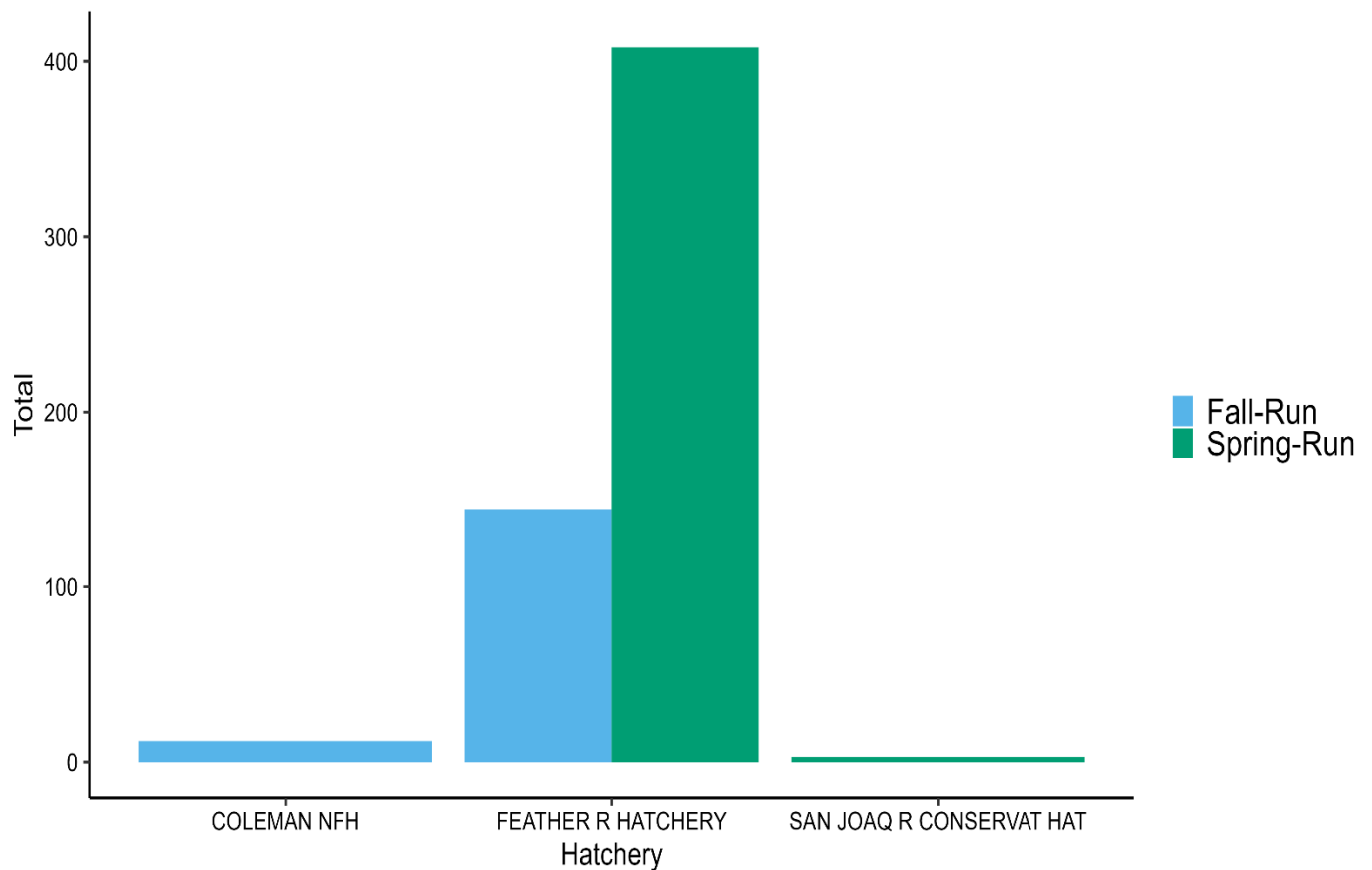


Figure 3: CWT recovery at FRFH during inland Chinook Salmon spawning, 10/3/2022-10/6/2022.

Releases

A total of 122,410 (97.9% of the production goal) BY 2022 inland Chinook Salmon were planted into Lake Oroville on May 15, 2023, at the Loafer Creek boat ramp. These fish were not released with any type of tag or mark, and they were approximately 31 to 32 fish per pound. Upon request by local fishing groups and DWR, the CDFW Inland Salmon program and North Central Region fisheries staff coordinated an offshore release using vessels equipped with live wells. Approximately 14,973 of the fish were planted by boat at several locations in open waters near the Loafer Creek launch ramp.

Fall-Run Chinook Salmon Production

2022 Broodstock Collection and Spawning

Annually, a FRFH Spawning and Release Protocol for CVFC is developed in coordination with the FRHOT. These protocols describe the goals and approach for egg

collections, fish production, and fish release (Appendix F). BY 2022 CVFC egg collections goals captured in this protocol included 15,702,643 freshly fertilized, or green eggs, and 12,793,024 eyed eggs to produce 6,000,000 ($\pm 10\%$) smolts for mitigation, and 2,000,000 ($\pm 10\%$) smolts for drought enhancement. Additionally, 1,500,000 ($\pm 10\%$) pre-smolts were produced for drought enhancement that were not described in the spawning and release protocol because these were coordinated after the final spawning and release protocol was produced.

Adult CVFC began arriving to the hatchery concurrently with the CVSC broodstock; however, only adults returning to the hatchery beginning on October 10 were used as CVFC broodstock. Adult Chinook Salmon without a Hallprint tag collected prior to this date were either retained for use in the Inland Salmon Program or culled. Spawning of BY 2022 CVFC began October 10 and ended on November 9, 2022. CVFC continued to enter the hatchery until December 21, 2022. A total of 2,937 females were spawned producing 17,231,836 green eggs and exceeded the collection goal by 9.7%. On average, each female produced 6,141 green eggs. A total of 12,469,663 eyed eggs developed, 97.5% of the eyed egg collection goal, and the green-to-eyed egg survival rate was 72.4%. A total of 10,310,590 CVFC fry were produced resulting in an 82.7% eyed egg to fry survival rate.

Coded-Wire Tag Data

Adults

CVFC trapped at FRFH throughout the spawning period were examined for the presence of an adipose fin. Adipose fins of juvenile hatchery-origin Chinook Salmon are removed indicating the presence of a CWT. CVFC from FRFH are marked with adipose fin clips and tagged with CWTs at a rate of 25%. Between September 19 and October 6, 2022, prior to broodstock collection and spawning, a total of 253 CWT-confirmed FRFH CVFC entered the hatchery. During the CVFC broodstock collection and spawning period from October 10 to November 9, 2022, a total of 2,510 CWT-confirmed FRFH CVFC entered the hatchery. Chinook salmon continued entering that hatchery until December 8, 2022, when 113 CWT-confirmed FRFH CVFC entered the hatchery. In total, 2,876 CWT FRFH CVFC (1,242 adult males, 1,203 adult females, and 431 grilse) entered the hatchery in the fall of 2022. The heads of these Chinook Salmon were collected by CDFW CVTA and CWT Lab staff for CWT extraction and analysis. CWT analysis allows for the detection of adult CVSC contribution in the CVFC egg lots. This allows staff to identify and cull the eggs containing CVSC and CVFC crosses to help maintain the temporal separation between these two runs. In 2022, there were nine CVSC spawned as CVFC, and their eggs were subsequently culled after receiving the CWT results. The CWT data is also used in the identification of Chinook Salmon originating from other Central Valley hatcheries (Appendix G). Eggs spawned from fish originating from other Central Valley hatcheries are not culled and are incorporated into

FRFH CVFC production. From October 10 to December 8, 2022, a total of 147 FRFH CVSC CWTs were recovered, as well as 83 Coleman National Fish Hatchery CVFC CWTs, 48 Mokelumne River Fish Hatchery CVFC CWTs, 11 Nimbus Fish Hatchery CVFC CWTs, 6 Merced River Fish Facility CVFC CWTs, and 5 CVSC CWTs from the San Joaquin River Conservation Hatchery (Figure 4).

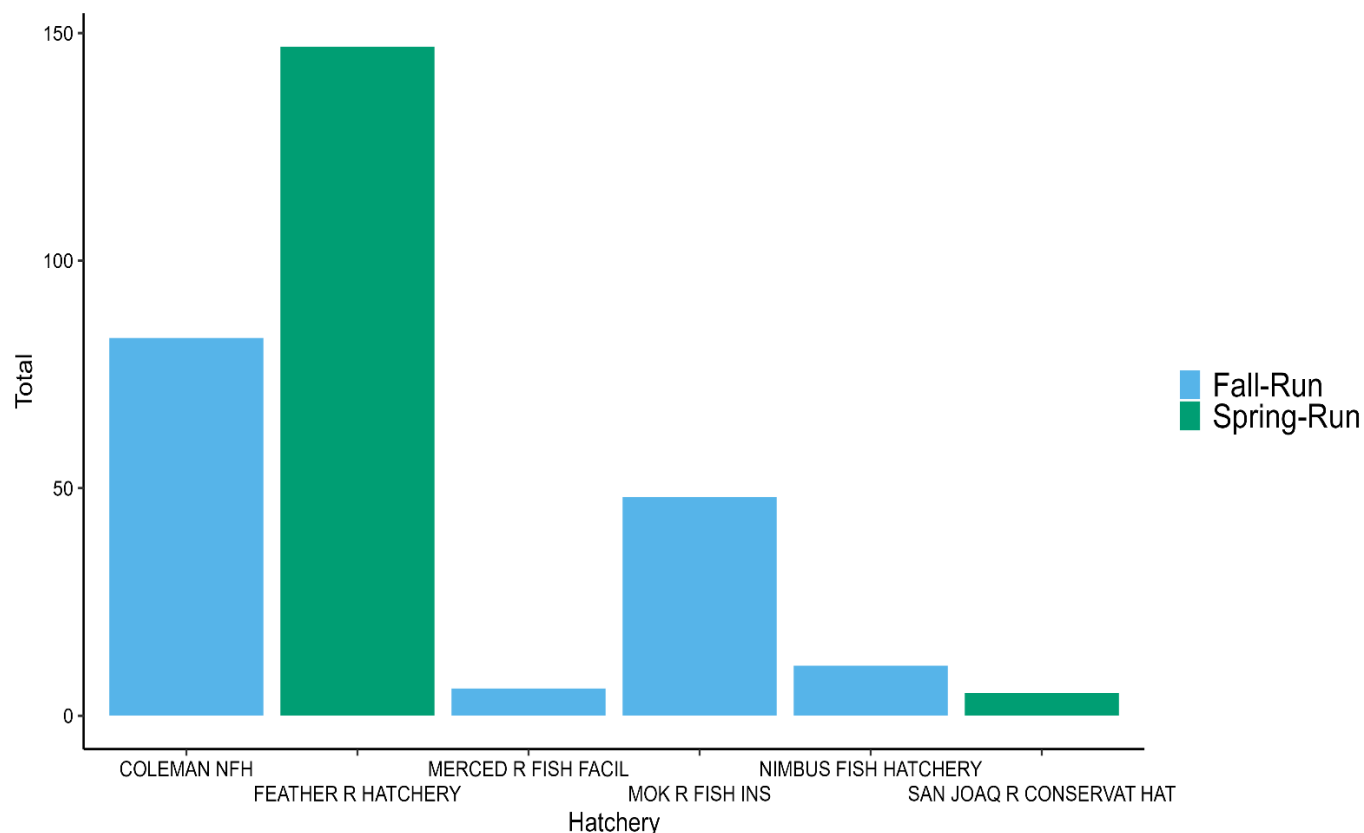


Figure 4: CWT recovery of FRFH CVSC and other hatchery strays at FRFH, 10/10/2022-12/08/2022.

The CVTA and CWT Lab staff also recorded fork lengths, sex, and adipose fin-clip status on all adipose fin-clipped fish. The CWT data revealed that 6 five-year olds, 430 four-year olds, 1,792 three-year olds, and 648 two-year-olds FRFH CVFC returned to the hatchery in the fall of 2022 (Figure 5). The FRFH CVFC CWT fish fork lengths ranged from 455 mm to 1100 mm, and the average grilse fork length was 598 mm, and the average adult fork length was 824 mm. The grilse fork length cutoff at FRFH is 650 mm and in 2022 there were 265 out of 2,876 fish that were mis-characterized as an adult or grilse based on their fork length. There were 241 two-year olds (224 males and 17 females) that measured over 650 mm, and 21 three-year olds that measured under 650 mm (7 males and 17 females).

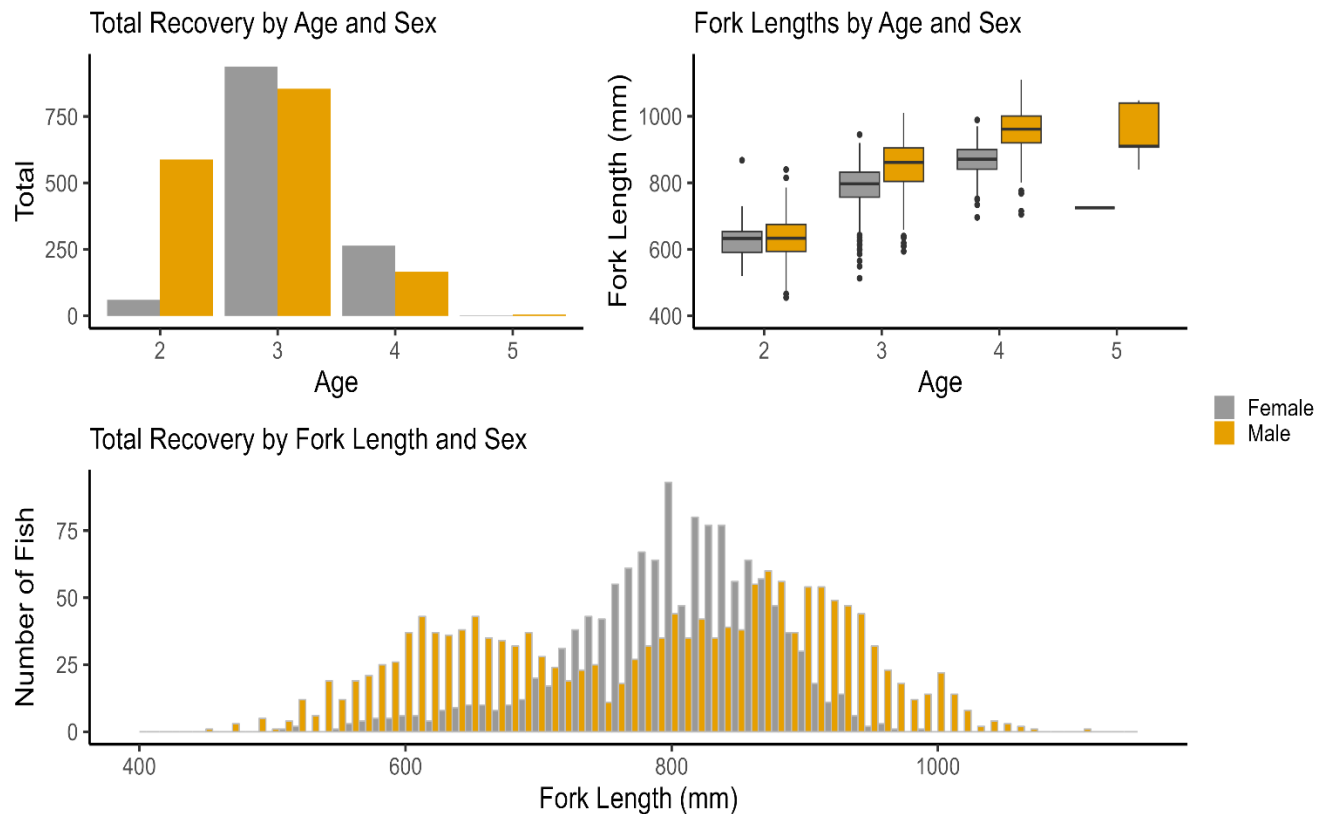


Figure 5: 2022 FRFH CVFC CWT recovery data summarized by age, fork length, and sex, 9/19/2022-12/08/2022.

Juveniles

When juvenile CVFC reach roughly 69 mm, or 170 fish per pound, they are implanted with a CWT and their adipose fin is removed using Westmark CWT tagging trailer. BY 2022 juvenile CVFC were split approximately into nine groups of 366,000 fish, two groups of 1,000,000 fish, and four groups of 4,000,0000 fish. Each group was 25% tagged with unique CWTs and 25% marked with adipose fin clips. Additionally, there was one group of 200,000 fish that was 100% tagged with a unique CWT and 100% marked with adipose fin clips to support a community engagement collaboration between Gold State Salmon Association, the City of Richmond, and CDFW. This work was performed by PSMFC personnel under contract with DWR. A total of 2,660,601 BY 2022 juvenile CVFC were marked and tagged.

Releases

Releases of FRFH CVFC typically occur at locations along the Feather River and

locations in the San Francisco and San Pablo bays. During the spring of 2023, the releases of CVFC followed the plan that was outlined in the 2022 Feather River Hatchery Fall-Run Chinook Salmon Spawning and Release Protocol (Appendix F), with 1,000,000 mitigation production smolts released into the Feather River, and the remainder of the mitigation production (5,000,000 smolts ($\pm 10\%$)) and the drought enhancement production (2,000,000 smolts ($\pm 10\%$)) released at locations in the San Francisco and San Pablo bays. After finalization of the spawning and release plan, an additional 1,500,000 pre-smolt ($\pm 10\%$) CVFC were requested to be released into the Feather River at approximately 120 fish per pound to help evaluate release strategies of fish in various stages of development and offset impacts of multiple years of drought on natural production. This effort was coordinated after the final spawning and release protocol was developed and therefore was not detailed in the protocol.

A total of 10,295,925 CVFC (108.4 % of the production goal) were released from FRFH in April, May, and June, into the Feather River and San Francisco and San Pablo bays (Appendix H). Releases into the Feather River used a day-time direct release strategy at either the Gridley Boat Launch or at the Boyd's Pump Boat Launch. The releases into the San Francisco Bay used a direct night-time release strategy at the Estuary and Ocean Science Center in Tiburon, and the releases into the San Pablo Bay used either a direct night-time release strategy at Conoco or an acclimation net pen release strategy at Mare Island.

The pre-smolt drought enhancement fish were released into the river in three different groups. The first group totaled 266,540 and was released into the Sutter Bypass at Sacramento Avenue on March 15, 2023, at approximately 533 fish per pound to take advantage of increased flows associated with strong winter storms, which inundated flood relief bypasses. This group did not have CWTs or adipose fin clips, but 8,601 (3.2%) were marked with a yellow VIE tag in the snout. The remaining two groups, totaling 1,012,449 pre-smolts, were 25% marked with adipose fin clips and CWTs were released with planned releases of CVSC and CVFC smolts into the Feather River at the Gridley Boat Launch on April 11 and April 21, 2023 at approximately 135 and 134 fish per pound, respectively. The drought enhancement smolts, approximately 2,198,298, were released into the San Francisco Bay as night-time direct releases. Approximately 1,996,866 of the drought enhancement smolts were released at the Estuary and Ocean Science Center in Tiburon on May 11 and June 12, 2023 at approximately 61 and 60 fish per pound, respectively, and were 25% marked with adipose fin clips and CWTs. The remainder of the drought enhancement smolts, approximately 201,432 fish, were released into the San Francisco Bay at Brickyard Cove on June 24, 2023, at approximately 47 fish per pound and were 100% marked with adipose fin clips and CWTs. These fish were part of a community engagement collaboration between Gold State Salmon Association, the City of Richmond, and CDFW.

The mitigation production smolts, approximately 6,818,638 fish, were 25% marked with adipose fin clips and CWTs and were released into the Feather River, the San Francisco Bay in Tiburon, or the San Pablo Bay in Conoco or Mare Island. A total of 1,004,181 smolts were released into the Feather River at Boyd's Pump on April 21, 2023, at approximately 81 fish per pound, while the remainder, approximately 5,814,457 million smolts, were released into the San Pablo and San Francisco bays. A total of 2,790,865 CVFC smolts were released into the San Pablo Bay at Conoco on May 8, May 24, and June 7, 2023, at approximately 63 to 66 fish per pound using a nighttime direct release strategy. A total of 2,350,736 smolts were released into the San Pablo Bay at Mare Island using the acclimation net pen release strategy on May 1, May 2, May 31, and June 3, 2023, at approximately 63 to 65 fish per pound. The remainder of the mitigation smolts, 672,856, were released at the Estuary and Ocean Science Center in Tiburon into the San Francisco Bay on May 26, 2023, at 63 to 64 fish per pound using the same nighttime release strategy employed at the Conoco release site.

Central Valley Steelhead Production

Brood Year 2023

2023 Broodstock Collection and Spawning

Annually, a FRFH Spawning and Release Protocol for CVSH is developed in coordination with the FRHOT. These protocols describe the goals and approach for egg collections, fish production, and fish release (Appendix I). BY 2023 CVSH egg collection goals captured in this protocol included 1,500,000 green eggs to produce 400,000 yearlings to support mitigation production and 50,000 yearlings to support the 1986 Delta Fish Agreement between DWR and CDFG.

Broodstock collection of BY 2023 CVSH began on November 21, and spawning began on December 28, and continued until February 22, 2023. During this time, 789 adult CVSH (430 males and 359 females) were trapped for broodstock (Table 8). An additional 80 CVSH measuring less than 16 inches total length, or "half pounder" CVSH, were trapped and released back into the river in accordance with the protocols described in the 2022 Steelhead Spawning and Release Protocol (Appendix I). Half pounder CVSH are not used as broodstock to promote anadromy within the hatchery population. CVSH often enter the hatchery during CVSC and CVFC broodstock collection, prior to the period when CVSH are spawned at FRFH. CVSH collected at the hatchery prior to the beginning of CVSH spawning on December 28 were released back to the river. In total, 266 CVSH (147 males and 119 females) were collected and released during this time and are not captured in Table 8, below.

Table 8: Number of CVSH trapped at the FRFH during the spawning season, 12/28/2022 – 02/22/2023.

	Spawned				Fish Released (Not spawned)				Mortalities		
Date	Male	Wild Male	Female	Wild Female	Male	Wild Male	Female	Wild Female	Male	Female	Total
12/28/2022	30		28	2				4	3	2	69
1/4/2023	34	4	37	1	1						77
1/11/2023	67	7	69	5	3			5	4		160
1/18/2023	53	7	58	2	6					4	130
1/25/2023	30	2	30	2	13			6	4	3	90
2/1/2023	24	4	28						2		58
2/8/2023	18		17	1	1			1	5		43
2/15/2023	17	2	17	2					3	1	42
2/22/2023	11	1	12	0	71	3	20	2			120
Total	284	27	296	15	95	3	20	18	21	10	789

Beginning in 2018, the hatchery adopted a 2:2 factorial spawning method for CVSH, which was continued during the 2022 spawning season. Both adipose fin-clipped, and adipose fin-intact adult CVSH were used for broodstock during this spawning season. In total, 311 pairs were spawned (42 individuals were unclipped) resulting in the collection of 854,344 green eggs collected, yielding 57.0% of the production goal being met. On average, each female produced 2,638 green eggs. Approximately 79,765 eyed eggs were lost due to an error that occurred during pathogen treatments with iodine, resulting in a total of 694,890 eyed eggs produced, and the green-to-eyed egg survival rate was 81.3%. A total of 665,432 CVSH were ponded, resulting in a 95.8% eyed egg to fry survival rate. After being spawned or stripped, 289 adipose fin-clipped adult male CVSH were released into the Thermalito Afterbay to enhance the recreational fishery.

The CVTA and CWT Lab collected fork lengths, sex, adipose fin status, and tissues samples from every spawned CVSH, as well as a scale sample from every fifth fish and/or every adipose fin-intact fish. The fork lengths of the spawned males ranged from 363 mm to 669 mm, with an average fork length of 478 mm. The fork lengths of the spawned females ranged from 361 mm to 681 mm, with an average fork length of 497 mm.

Hatchery origin Steelhead recoveries

All CVSH trapped during the spawning period of December 28 to February 22, 2023, were examined for the presence of adipose fins. In total 92.0%, or 789, of the CVSH retained as broodstock were adipose fin-clipped, indicating hatchery origin.

Brood Year 2022

Marking of Juvenile Steelhead

Since 1999, 100% of juvenile CVSH released by FRFH have been adipose fin-clipped (marked). Once juvenile CVSH reach roughly 80mm, or 90 fish per pound, they are marked using Westmark CWT tagging trailer. This work was performed by PSMFC personnel under contract with DWR. For BY 2022, a total of 408,900 CVSH were marked prior to being released in February 2023.

Releases

In 2023, a total of 404,249 yearling BY 2022 CVSH were released into the Feather River at Boyd's pump starting on February 6 and ending on February 23, 2023. Approximately 4,736 yearlings were released into the Thermalito Afterbay to contribute to the local fishery in coordination with DWR. The actual release of CVSH yearlings differed slightly from the plan outlined in the 2022 Feather River Steelhead Spawning and Release Protocol, as 4,736 yearlings were released into the Thermalito Afterbay instead of into the Feather River as originally planned.

References

Mantua, N., R. Johnson, J. Field, S. Lindley, T. Williams, A. Todgham, N. Fangue, C. Jeffres, H. Bell, D. Cocherell, J. Rinchard, D. Tillitt, B. Finney, D. Honeyfield, T. Lipscomb, S. Foott, K. Kawk, M. Adkison, B. Kormos, S. Litvin, and I. Ruiz-Cooley (2021). Mechanisms, Impacts, and Mitigation for Thiamine Deficiency and Early Life Stage Mortality in California's Central Valley Chinook Salmon. North Pacific Anadromous Fish Commission. Technical Report 17: 92-93.

Appendices

Appendix A: Bio-Oregon and Skretting Manufacturers Recommended Size and Rate Guidelines.



FEED SIZE & FEED RATE GUIDELINES*

for Salmon and Trout

Lifestage Diets for Fish®

FEED SIZE (MM)		Mash	#0	#1 0.6	#2 0.9	1.2	1.5	2.0	2.5	3.0	4.0	Temperature °F °C	
FISH SIZE	Grams	< 0.15	0.15 - 0.8	0.8 - 1.5	1.5 - 3.0	3.0 - 5.0	5.0 - 8.0	8.0 - 18	18 - 40	40 - 75	75 - 454		
	# Fish / LB	> 3000	3000 - 570	570 - 300	300 - 150	150 - 90	90 - 60	60 - 25	25 - 11	11 - 6	6 - 1		
	Inches	hatch	hatch - 1.7	1.7 - 2.1	2.1 - 2.6	2.6 - 3.1	3.1 - 3.5	3.5 - 4.6	4.6 - 6.0	6.0 - 7.4	7.4 - 12.5		
Feed Rate: % fish biomass per day		0.7	0.7	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.1	36	2
		1.3	1.2	1.1	1.1	1.0	0.9	0.7	0.6	0.4	0.3	39	4
		2.1	2.0	1.8	1.7	1.6	1.4	1.2	0.9	0.7	0.5	43	6
		2.7	2.6	2.4	2.3	2.2	2.0	1.7	1.4	0.9	0.6	46	8
		3.1	3.0	2.7	2.6	2.5	2.4	2.1	1.7	1.1	0.8	50	10
		3.5	3.3	3.1	3.0	2.9	2.7	2.4	1.9	1.4	1.0	54	12
		4.1	3.8	3.7	3.6	3.5	3.2	2.8	2.3	1.7	1.2	57	14
		4.7	4.5	4.3	4.1	4.0	3.7	3.3	2.6	1.9	1.3	61	16

Feed Size (mm)	Sinking			Sinking Pellets							Floating Pellets								
	#0	#1	#2	1.0	2.0	3.0	4.0	6.0	8.0	10.0	1.5	2.5	3.5	4.5	5.5	7.5	9.5		
Feed Type	crumble	crumble	crumble	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet		
Grams	0.15 - 0.8	0.8 - 1.5	1.5 - 3.0	3-8	8-40	40-80	80-300	300-500	600-2000	> 2000	3-8	8-40	40-80	80-300	300-500	600-2000	> 2000		
# Fish per lb.	3000 - 570	570 - 300	300 - 150	150 - 60	60 - 11	11 - 6	6 - 1.5	1.5 - 0.8	0.8 - 0.2	> 0.2	150 - 60	60 - 11	11 - 6	6 - 1.5	1.5 - 0.8	0.8 - 0.2	> 0.2	Temperature	
Fish Length-inch	hatch - 1.7	1.7 - 2.1	2.1 - 2.6	2.6 - 3.1	3.1 - 4.6	4.6 - 7.4	7.4 - 12.5	12.5 - 16	16 - 22	> 22	2.6 - 3.1	3.1 - 4.6	4.6 - 7.4	7.4 - 12.5	12.5 - 16	16 - 22	> 22	°F	°C
Feed Rate : % of Fish Biomass / day	0.7	0.7	0.6	0.5	0.3	0.1	0.1	0.09	0.08	0.07	0.5	0.3	0.1	0.1	0.09	0.08	0.07	36	2
	1.2	1.1	1.1	1.0	0.7	0.4	0.3	0.20	0.15	0.10	1.0	0.7	0.4	0.3	0.20	0.15	0.10	39	4
	2.0	1.8	1.7	1.6	1.2	0.7	0.5	0.35	0.30	0.25	1.6	1.2	0.7	0.5	0.35	0.30	0.25	42	6
	2.6	2.4	2.3	2.2	1.7	0.9	0.6	0.50	0.45	0.35	2.2	1.7	0.9	0.6	0.50	0.45	0.35	46	8
	3.0	2.7	2.6	2.5	2.1	1.1	0.8	0.60	0.55	0.45	2.5	2.1	1.1	0.8	0.60	0.55	0.45	50	10
	3.3	3.1	3.0	2.9	2.4	1.4	1.0	0.80	0.70	0.60	2.9	2.4	1.4	1.0	0.80	0.70	0.60	54	12
	3.8	3.7	3.6	3.5	2.8	1.7	1.2	0.90	0.80	0.70	3.5	2.8	1.7	1.2	0.90	0.80	0.70	57	14
	4.5	4.3	4.1	4.0	3.3	1.9	1.3	1.00	0.90	0.75	4.0	3.3	1.9	1.3	1.00	0.90	0.75	61	16
	5.2	5.0	4.7	4.2	3.0	1.7	1.2	0.90	0.80	0.70	4.2	3.0	1.7	1.2	0.90	0.80	0.70	64	18

Appendix B: Thiamine Treatment Protocols Developed by CDFW Fish Health Lab (Dr. Kevin Kwak).

Spring-run Chinook Salmon Thiamine HCl injection protocol at Feather River Fish Hatchery Prepared by Kevin Kwak

April 22, 2021

Spring-run Chinook Salmon Thiamine HCl injection protocol at Feather River Fish Hatchery

Prepared by Kevin Kwak

Objective: To determine if intraperitoneal thiamine injections during tagging will prevent thiamine deficiency for Spring-run Chinook Salmon eggs at spawning.

Materials

Items needed to conduct the study

- Tags (Different colors)
- Spring-run Chinook salmon
- CO₂ for sedation
- Thiamine HCl (100ml of 500mg/ml)
- NaCL 0.9% injectable (1L)
- 21g needles 1.5 inches
- Sharps container
- 50 ml Pistol Grip Mega-Shot by Neogen
- Personnel to conduct study
- Recording sheet

Prior to injecting fish, if only one person is tagging/injecting, two repeating syringes should be filled with Thaimine HCl and one repeating syringe filled with saline. A new needle should be used every time the syringe is refilled (unless otherwise indicated). Discarded needles are to be placed into a sharp's container. These syringes will be enough to inject 100 salmon for Thiamine HCl and 50 salmon as control. The number of syringes will likely be adjusted based on the number of expected fish or injection teams operating.

To fill the syringes, always with a new needle with a cap on, attach the needle to the syringe and twist to lock it in place. With the needle attached to the syringe, draw some air (approximately 20 ml) into the syringe before inserting into the bottle. Push the

needle into the rubber stop on the top of the thiamine bottle or on the side of the saline bag. While the needle is inserted into the bottle, invert the bottle/syringe and slowly pull back at approximately 10 sec per ml. If the pull is too fast, fluid will likely escape past the plunger and will be wasted. After the syringe is filled by 1/3, air will need to be exchanged for fluid in the bottle. Push the plunger forward and air will be introduced into the bottle. This should relieve some of the vacuum and then continue to draw more thiamine into the syringe. If no air is pushed into the bottle, it may be difficult to draw back.

Once the syringe is filled (it may not be the full 50 ml), replace the needle cap to prevent any accidental pokes or contamination.

Spaghetti tags should be ready to tag fish. These tags will be color coordinated to identify Thiamine vs saline injected fish.

Methods

Tagging/injection: Spring-run Chinook arriving at the hatchery will be sedated, tagged, and injected with 1 ml of either thiamine HCl or 0.9% saline and then release back to the Feather River.

1. Fish will be sedated using CO₂ gas bubbled into the holding tank. Once fish are handleable, the tank will be lifted to where staff can sort fish.
2. Tags to indicated Spring-run and color coded for Thiamine or saline will be inserted in the dorsal fin area.
3. To prepared fish for injection, staff will invert fish so the dorsal fin is towards the ground. Fish will then be injected intraperitoneally (IP) with 1ml of either thiamine HCl or saline. The syringe will be inserted near the pelvic fin region with the needle penetrating approximately 1 inch into the body wall.
4. Fish will then be released back to the Feather River

Spawning: Upon returning, 10gms of eggs will be collected from 30 Spring-run Chinook immediately prior to fertilization from tagged fish injected with Thiamine and saline.

1. Tagged fish will be identified upon returning to the hatchery for spawning.
2. Fish will be sedated using CO₂ gas bubbled into the holding tank. Once fish are handleable, the tank will be lifted to where staff can sort fish.
3. 10gms of eggs (approximately 30) will be placed into a labeled Ziploc bag, spread into a single monolayer and immediately sandwich between two sheets of dry ice. Once frozen, the bag of eggs can be transfer to a storage cooler containing dry ice.

4. Eggs from 30 females injected with Thiamine as well as 30 females injected with saline will be sampled for a total of 60 females.

Thiamine analysis: Egg thiamine levels will be analyzed using reverse phase HPLC

1. Frozen labeled Ziploc bags containing eggs will be ship in a cooler box with dry ice to a lab for reverse phase HPLC.

Thiamine Mononitrate supplementation during Fertilization for Chinook Salmon at CDFW Anadromous Hatcheries



State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Fish Health Laboratory
2111 Nimbus Road
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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director



August 19, 2021

Thiamine Mononitrate supplementation during Fertilization for Chinook Salmon at CDFW Anadromous Hatcheries

Prepared by Kevin Kwak

Aim: To increase Thiamine levels in green eggs by supplementing the water used for fertilization during Chinook Salmon spawning.

Materials

- 5-gallon buckets
- Fall-run Chinook salmon
- Spawning water (0.09%-1.3% salt w/w in UV water)
- Thiamine mononitrate powder (TM)
- colander
- Individual spawning tubs

Method

Returning Chinook Salmon from rivers will be used to spawn. Fish will be anesthetized using electric current/Carbon Dioxide, then euthanized with blunt force trauma. For each female, the gills will be cut for exsanguination. A lateral incision starting at the vent and proceeding cranially will be performed to remove eggs. Eggs will be collected into a colander that will drain any excess fluids then place eggs into a spawning tub. It is important to try and avoid any water egg contact.

Spawning water will be made by approximately adding 10 oz of salt to 4.5 gallons.

For TM high dose at 4500ppm, add 76.5 gm of TM to the spawning water bucket and stir until dissolved.

Collect eggs into a colander, drain ovarian fluid off, place eggs into a spawning tub.

Add milt to the eggs and immediately add the spawning water containing TM. Depending on size of eggs and tub, use enough spawning water with TM to bathe every egg (anywhere from 1-3 cups) and gently mix the eggs, milt, and spawning water by hand (3-5 sec).

Transport the spawning tub to the rinse area, use UV treated water to rinse the eggs (at least 2-3 rinses). This period is about 30-60 sec.

Place fertilized eggs in iodophor (100ppm) for about 20 min. After 20 min., rinse fertilized eggs by either rinsing or moving to Heath stacks for incubation.

Appendix C: 2022 Feather River Hatchery Spring-Run Chinook Salmon
Spawning and Release Protocol

2022 FEATHER RIVER HATCHERY SPRING-RUN CHINOOK SALMON SPAWNING AND RELEASE PROTOCOL

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Background

The Feather River Fish Hatchery (FRFH) conducts two artificial propagation programs for Central Valley (CV) Chinook Salmon (CV spring-run and CV fall-run) and one artificial propagation program for CV steelhead. CV spring-run Chinook (SRCS) Salmon are listed as threatened under both the California Endangered Species Act and the Federal Endangered Species Act.

The primary purpose of the FRFH SRCS program is to conserve and promote phenotypic spring-run Chinook Salmon in the Feather River. A coequal purpose of the program is to mitigate for the loss of spawning and rearing habitat due to construction of Oroville Dam. Additionally, due to the threatened status of CV SRCS it is crucial that hatchery operations are conducted in a way that minimizes impacts to natural spawning populations of CV spring-run populations, including those in Mill, Deer, Clear, and Butte Creeks.

Due to past hatchery spawning practices and overlap in spawning habitat in-river, spring and fall runs have experienced introgression that blurs the distinctions of spring- and fall- runs in the Feather River. In 2012, the California Hatchery Scientific Review Group (CA HSRG 2012) released the California Hatchery Review Report that establishes specific recommendations for California's Central Valley and Klamath-Trinity anadromous fish hatcheries, including the FRFH. (See Attachment A for specific program recommendations) The report states, "Most hatcheries were producing fish for harvest primarily to mitigate for past habitat loss (rather than for conservation of at-risk populations) and were not considering the effects of their programs on naturally spawning populations (CA HSRG 2012). With numerous species listed as threatened or endangered under the Endangered Species Act, Congress identified salmon conservation as a high priority." The document further states, "The goal of this hatchery program review initiative is to ensure that hatchery programs are managed and operated to meet one or both primary purposes for hatcheries:

Helping recover and conserve naturally spawning salmon and steelhead populations and supporting sustainable fisheries with little or no deleterious consequence to natural populations."

Since 2012, spawning practices at FRFH have been refined and reviewed annually to further meet CA HSRG recommendations and to specifically minimize introgression between runs on the Feather River (California Hatchery Policy Team 2016).

In March 2020, the State of California initiated and implemented measures to reduce the spread of COVID-19 among State Employees working at state facilities and conducting State

business at offsite locations. These measures have also been incorporated into hatchery operations. Standard operating procedures for spawning and release of Chinook Salmon and steelhead by FRFH staff continue to align with the most current Department and local guidance on COVID protocols. Current guidance on measures necessary to reduce the spread of COVID-19 will be constantly monitored and incorporated into hatchery operations. While it is generally accepted that these measures will not eliminate all risk of contracting and spreading COVID-19, it is believed these measures will reduce the risk of doing so.

Spring-run Chinook Salmon Broodstock Collection

Broodstock Identification

Only early arriving Chinook Salmon are used as broodstock for the spring-run Chinook Salmon hatchery program at FRFH. Typically, fish ascending the fish ladder in the spring are trapped, tagged with two uniquely numbered, sequential Hallprint Dart tags, and recorded as either hatchery- or natural-origin, determined by the presence or absence of an adipose fin. The trapping and tagging of early arriving adult Chinook Salmon began on May 3, 2022, continuing through July 5, 2022. Water flow into the FRFH fish ladder was reduced on June 30, 2022, to prevent newly arriving fish from entering the ladder. Any mortality observed during the broodstock tagging was documented. Heads were removed for coded- wire tag (CWT) extraction from fish with an adipose fin-clip.

During spring of 2022, 2,166 adult Chinook Salmon were tagged as spring-run Chinook and returned to the Feather River (Table 1). For comparison to the number of fish tagged in previous years see Table 2.

Table 1. 2022 FRFH Spring-run Broodstock Tagging

Date	5/4/2022	5/12/2022	5/16/2022	5/18/2022	5/23/2022	5/27/2022	6/3/2022	6/8/2022	6/13/2022	6/17/2022	6/24/2022	6/27/2022	7/5/2022	Season Total	Percent of Season Total
Fish Tagged	166	154	457	73	319	174	106	102	373	22	88	118	14	2166	100.00%
Green Thiamine	156	144	437	68	299	164	101	72	343	22	28	118	14	1966	90.77%
Yellow Control	10	10	20	5	20	10	5	30	30	0	60	0	0	200	9.23%
Grilse	1	2	20	3	9	8	4	6	9	4	10	6	1	83	3.83%
Wild	8	4	9	2	3	4	2	5	20	1	10	11	5	84	3.88%
Mortalities	0	0	0	1	0	0	0	2	0	0	0	1	0	4	0.18%
Single Tag	0	0	2	1	2	3	4	5	9	1	1	0	0	28	1.29%

Recaps	0	1	30	8	23	29	28	41	224	30	65	150	44	673	31.07%
Fish Tagged	166	154	457	73	319	174	106	102	373	22	88	118	14	2162	
Wild	8	4	9	2	3	4	2	5	20	1	10	11	5	84	
Clipped	158	150	448	71	316	170	104	97	353	21	78	107	9	2082	
Clip Rate	95.18%	97.40%	98.03%	97.26%	99.06%	97.70%	98.11%	95.10%	94.64%	95.45%	88.64%	90.68%	64.29%	96.30%	

Table 2. Spring-returning adult Chinook Salmon tagged and released to the Feather River as potential spring-run Chinook broodstock, 2004-2022.

Year	Total Spring Run Hallprint Tagged
2004	3,650
2005	6,021
2006	17,438
2007	9,755
2008	1,915
2009	1,462
2010	3,502
2011	6,023
2012	7,494
2013	20,057
2014	7,289
2015	5,355
2016	2,917
2017	7,62
2018	3,206
2019	5,945
2020	2,746
2021	4,797
2022	2,166
Average	5,921

* 2004 was the first year that juvenile spring-run were coded-wire-tagged at a 100% rate. This likely increased the adipose fin-clip rate observed in returning adults for the subsequent four years.

Broodstock Thiamine Treatment

CDFW and DWR mutually agreed to treat a large majority of adult and grilse SRCS that enter FRFH during SRCS broodstock identification process with Thiamine HCL to help alleviate

impacts from Thiamine Deficiency Complex (TDC). In recent years, impacts from TDC have been observed in eggs collected from adult Chinook returning to the Central Valley including Sacramento River winter-run Chinook Salmon, and Central Valley spring- and fall-run Chinook Salmon (Taylor Lipscomb, USFWS, personal communication). The treatment methods employed at FRFH result from piloted methods at Livingston-stone National Fish Hatchery during 2000, where adult winter-run Chinook Salmon broodstock were injected with a thiamine solution to help boost egg thiamine concentration. At FRFH a portion of returning adults will be injected with a saline solution to act as controls.

Comparison of performance of control to treatment fish will measure treatment impacts and provide a baseline of egg thiamine levels. Males and females both receive treatment since sexual morphological differences will not be identifiable at the time of treatment. This action is a conservation effort aimed at mitigating the effects of thiamine deficiency in FRFH broodstock but will also benefit treated SRCS that do not return to the hatchery and spawn in-river.

To conduct this work, CDFW FRFH & Fish Health Lab staff will procure thiamine HCl 500mg/ml solution, buffer solution, saline, sharps containers, and continuously adjustable vaccine syringe with 20-gauge 1.5-inch needles to inject approximately 6,000 SRCS broodstock. Thiamine HCl has a shelf life of 1.5 years and excess doses can be used during the 2023 broodstock identification. Dr. Kevin Kwak (CDFW) will write an extra label prescription for the thiamine injections and provide onsite training for DWR and Pacific States Marine Fisheries Commission (PSMFC) personnel who will be performing injections.

FRFH staff will follow methods piloted by USFWS staff at Livingston Stone National Fish Hatchery where a buffered thiamine HCl solution of 500 mg/ml was injected at a rate of approximately 50 mg/kg of body weight. The average weight of 309 Feather River Chinook Salmon weighed by CDFW's Central Valley Angler Survey in 2020 was 6.94 kg. Based on an email from Taylor Lipscomb (USFWS, see below) the proper injection dose for a 6.94 kg fish would be 0.882 ml of thiamine HCl. Following recommendations from CDFW Fish Health Laboratory staff, a 1.0 ml injection was given to all fish (regardless of size) to account for larger than average fish. All injections will be posterior to the pelvic fin in the coelomic cavity (Figure 1). Two green Hallprint tags will be implanted in the group of SRCS treated with thiamine HCL according to DWR's normal protocol for broodstock tagging. A second group of approximately 200 individuals, the control group, will receive a sterile saline injection and be tagged with two yellow Hallprint tags. Different color Hallprint tags will be used for treatment and control groups will provide easy identification during spawning. This will also allow us to sample eggs during spawning that will analyze for thiamine concentration.

During the last five seasons (2016-2020) an average of 3,153 SRCS have been Hallprint-tagged. During this period there was a low number of 752 fish tagged in 2017 and a high number of 6,052 in 2019. A control group of approximately 200 fish was the target for the saline tagging program. Typically, upwards of 50% of Hallprint-tagged fish return to FRFH. This means that approximately 50 control group females should return to FRFH during the spawning season, more than the minimum of 30 females needed to establish baseline thiamine concentrations for the population. One individual in each incoming group of

untagged fish (approximately 1 in 10) was targeted for the saline (control) injection to spread the control group fish as evenly as possible across the run.



Figure 1. Thiamine injection site posterior to pelvic fin into the coelomic cavity.

Broodstock collection and spawning

FRFH staff will open the ladder on Thursday, September 15, 2022, and begin spawning salmon on Monday, September 19, 2022, continuing through Friday, September 30, 2022. Fish entering the hatchery are sorted and Hallprint-tagged SRCS broodstock are separated from unmarked Chinook. Additionally, thiamine treated, and control groups will be separated. SRCS in the treatment and control groups will be held in the alleyways between the tanks on day of spawn until enough pairs are obtained for spawning. Fish that cannot be spawned on a given day will be placed into round tanks for spawning on subsequent days. Treatment and control groups will be sorted and held separately to facilitate spawning operations unique to each group. Spawning will occur whenever enough mature, or ripe, SRCS broodstock of roughly equal sex ratio, have accumulated in the round tanks.

Spawning and egg collection will follow the run-timing egg collection model described in Table 3. However, deviations from this model may be necessary. If any modifications will be made in consultation with the tech team and/or genetic staff.

Some adult SRCS which enter FRFH in excess to those needed to meet production goals will be returned live to the Feather River. This is an action coordinated between CDFW and DWR, with guidance from NMFS, to help offset anticipated natural spawning impacts resulting from the current drought conditions. Once it is projected that egg collection goals will be met and are sufficient to meet SRCS smolt production goals, adult spring-run will be returned to the Feather River under the following conditions:

Thiamine treated spring-run entering the hatchery will be returned to the river as soon as logistically possible and up to the last scheduled day of spawning for the Inland Salmon Program on 10/7/2022. All Hallprint tagged fish that enter the hatchery after this date will be excised following normal practice. Thiamine treated adult Hallprint tagged SRCS that are overripe, spawned out, showing obvious signs of disease including external fungus, or are in otherwise poor physical condition will be excised following normal practice. Adult SRCS with Hallprint tags that haven't received a thiamine treatment and all Hallprint tagged grilse not incorporated into broodstock for the hatchery will not be returned to the river and will be spawned for experimental purposes or excised following normal practice. All Hallprint tagged SRCS broodstock released to the river will receive an identifying mark, and the Hallprint tag ID will be recorded for easy identification and counting if observed during the Feather River carcass survey and genetic samples will be collected prior to release.

CDFW and DWR will coordinate to determine a logistically appropriate schedule for returning qualifying adult SRCS while not interrupting necessary hatchery operations.

Following spawning, the head will be removed from any adipose-clipped fish for coded-wire tag (CWT) extraction and analysis. CWT analysis is used to examine contribution rates of hatchery-origin strays from other CV hatcheries in individual incubation egg trays. To evaluate origin in each tray/stack CWT analysis will be used to identify stacks and trays with fall-run contribution and/or strays. Trays that include both offspring of spring and fall-run parents and/or strays as identified by CWT will be removed from production and culled.

One round tank will be reserved to hold non-Hallprint-tagged Chinook Salmon that have entered the hatchery prior to the start of fall-run spawning for the Inland Chinook program. All non-Hallprint-tagged Chinook Salmon in excess to those needed for the Inland Program production goals are counted and excised

[Broodstock spawning](#)

Spawning Procedures

Fish will be anesthetized using CO₂ and lifted into the hatchery. Two staff, with appropriate PPE, if applicable, will sort anesthetized fish by sex.

As fish are pulled off the table to spawn, the front of house (FOH) data recorder, will record sex, grilse or adult based on total length, adipose fin-clip status, and the unique Hallprint tag number on a data card. The data card is then attached to the egg tub to track the parentage of the eggs in each tub.

Grilse, less than 640mm are incorporated into FRFH SRCS production at a rate of 2%. Spring-run Chinook are spawned using a true 1 male: 1 female spawning protocol. FRFH staff will limit the reuse of males as much as possible. However, if males are used multiple times, they are treated as new fish each time they are spawned. This is recorded and highlighted on the associated data card for each tub and number is recorded for hatchery files.

Each tub of eggs (2) has a data card attached and brought to the back of house (BOH). Each tub of eggs will be measured in ounces (oz.) before fertilized eggs are combined and put in a tray.

If 3- and 4-year-old returns are low, discussion and consensus by the Feather River Hatchery Operations Team (FRHOT) will determine whether adjustment of the grilse incorporation rate for the current broodstock collection season is appropriate.

While in the egg room egg weight in oz. will be recorded on the data cards and data sheets. The data cards will be removed from the tub and given to the BOH data recorder who will be wearing appropriate PPEs, if applicable. At the time the eggs are emptied into an incubation tray. Each tub will be measured into the incubation tray and egg data will be recorded on sheet (Attachment C). Egg tubs will be rinsed thoroughly with UV treated water prior to being reused.

If an unacceptable number of overripe eggs are observed in a tub, the whole tub will be discarded, and the BOH data recorder will check the 'Discarded' box on the data card. The stack and tray fields will be left blank on the datacard

To ensure maximum survival, eggs will be counted at the collection stage.

A 2-ounce (oz) sample of eggs will be taken from each egg tub that are taken to BOH. The eggs will be water hardened and counted at end of day to estimate eggs per ounce. The average eggs per ounce will be applied to the total volume collected each day to estimate total eggs taken.

The fertilized eggs will be drained of ovarian fluid and milt in a colander and then hardened in incubation trays and disinfected with 4 oz of iodophor.

When the tub of fertilized eggs is emptied into an incubator tray, the stack, tray number, and section within the tray will be recorded on the data card by the BOH data recorder.

When a data card is filled and complete, it will be grouped with the other cards from the day, scanned and distributed to the CDFW Tissue Archive for storage. All data sheets will be analyzed for quality assurance and quality control.

All fish carcasses (spawned, culled, not spawned, and culled, or dead in tank) will be immediately brought to the CWT sampling station. The staff will be preparing fish for genetic tissue sampling, scale sampling, and CWT collection. Fish condition, adipose fin-clip status, sex, and fork length will be recorded. Hallprint tag numbers will be recorded, and tags removed. The Hallprint tags will be included in the head bag for all ad-clipped fish. For non-ad-clipped fish the Hallprint tags will be included in the tissue sample envelope. All Hallprint tag numbers will be verified in the Coded-wire tag lab. A caudal fin-clip (or other fin if caudal is covered in fungus or otherwise unusable, fin type will be recorded in comments field on data sheet) will be collected from each Hallprint-tagged fish and given a unique sample ID. A scale sample (skin patch) will be collected from each Hallprint-tagged fish and given a unique sample ID. The head will be collected from each adipose fin-clipped Hallprint-tagged fish, given a unique head tag ID, and sealed in a bag with the head tag and Hallprint Tag. An example of the data sheets used during spawning can be found in Attachment C.

Thiamine Treatment of Eggs

Portions on of the broodstock contributing to the SRCS production at FRFH may consist of adults injected with a saline solution as a control to provide a baseline measure of egg thiamine concentration to compare against the adults treated with thiamine during broodstock collection. As such, eggs from a control male X a control female, or a control male X a treated female, or a treated male X a treated female, could lack sufficient thiamine to offset the effects of TDC.

To help safeguard the fish produced from eggs collected from these pairings, eggs will be collected into a colander that will drain any excess fluids then place eggs into a spawning tub. It is important to try and avoid any water egg contact. Spawning water will be made by approximately adding (0.09%-1.3% salt w/w in UV water) or approximately 10 oz of salt to 4.5 gallons. For Thiamine mononitrate powder (TM) high dose at 4500ppm, add 76.5 gm of TM to the spawning water bucket and stir until dissolved. Collect eggs into a colander, drain ovarian fluid off, place eggs into a spawning tub. Add milt to the eggs and immediately add the spawning water containing TM. Depending on size of eggs and tub, use enough spawning water with TM to bathe every egg (anywhere from 1-3 cups) and gently mix the eggs, milt, and spawning water by hand (3-5 sec). Transport the spawning tub to the rinse area, use UV treated water to rinse the eggs (at least 2-3 rinses). This period is about 30- 60 sec. Place fertilized eggs in iodophor (100ppm) for about 20 min. After 20 min., rinse fertilized eggs by either rinsing or moving to Heath stacks for incubation. The methods for treating eggs at fertilization were piloted by CDFW Fish Health Lab staff during the fall of 2020 (unpublished). This study demonstrated that sufficient thiamine could be absorbed by the

eggs in the moments prior to fertilization to increase egg thiamine levels above the level of concern. These methods will be used at all CDFW anadromous fish hatcheries for eggs collected from all untreated adult Chinook to help prevent the effects of TDC in the hatchery production population.

San Joaquin Collection

Eggs will be collected for transfer to the San Joaquin River Restoration Program (SJRRP) when enough Hallprint-tagged SRCS return to the hatchery to meet broodstock collection goals. The goals for the SJRRP program are secondary to collection of SRCS broodstock for the FRFH program. One representative from the SJRRP will be outfitted with appropriate PPE (as necessary) to collect eggs for that program at FRFH.

To achieve enough genetic variability for the SJRRP, eggs will be collected from the spring run trays ensuring that at least 350 paired crosses are represented for a total take of 5,470 eggs. Data from each pair will be collected for the SJRRP and virology samples will be taken for Infectious hematopoietic necrosis (IHN). This will allow rejection of a significant number of crosses and yet provide substantial genetic variability in the future SJRRP broodstock. Egg collection for the SJRRP will be subject to Covid-19 guidelines, allotted time, and availability of broodstock (see AttachmentA).

Spring-run Chinook Salmon Production Goals

During the 2022/2023 spawning and rearing season priority will be given to improving temporal separation between spring- and fall-runs. If spring-run production goals cannot be met during the defined spawning period, the spawning days will not be extended to meet the goal. If Covid-19 statewide restrictions are implemented causing inconsistent staffing, meeting goals for 2022/2023 may be difficult.

The 2021/2022 production goal for CV SRCS at the FRFH is as follows: Mitigation production goal of 2,000,000 smolts

Scientific Study Requests totaling 114,000 smolts*

*Draft study request subject to change

Egg models and collection goals were developed using survival estimates for specific developmental periods. Estimated survival from green to eyed egg is 85 % and estimated survival from eyed egg to fry is 92 percent. While actual egg survival may be significantly different from these estimates, these estimates allow the hatchery to account for potential mortality in egg trays and culling of trays, if necessary. After adding, eggs above the daily

eyed egg goals listed in Table 3 and Figure 2 will be culled. When culling, an equal proportion of eggs will be removed from each tray to maintain groups similar size and development, which helps feeding, growth, and timing of releases.

Table 3. 2022 Spring-run Chinook Salmon egg collection model and survival projections

Date	Status	Lot #	# of females (assume one spawning pair per incubation tray)	Actual Green Eggs Collection 4,500 eggs/female	Predicted Percent culling rate	Predicted Egg Collection after culling	Assumed 80% Survival to eyed after culling	Assumed 85% Survival to eyed after culling	90% Survival to eyed after culling	Assumed 90% Survival from eyed egg to ponded fish	Assumed 90% Survival from eyed egg to ponded fish	Assumed 95% Survival from eyed to ponded
9/19	Expected	1	67	301,500	1%	298,485	238,788	253,712	253,712	228,341	228,341	241,027
*	Expected	2	133	598,500	1%	592,515	474,012	503,638	503,638	453,274	453,274	478,456
*	Expected	3	222	999,000	1%	989,010	791,208	840,659	840,659	756,593	756,593	798,626
*	Expected	4	178	801,000	1%	792,990	634,392	674,042	674,042	606,637	606,637	640,339
9/30	Expected	5	133	598,500	1%	592,515	474,012	503,638	503,638	453,274	453,274	478,456
	Totals		733	3,298,500		3,265,515	2,612,412	2,775,688	2,775,688	2,498,119	2,498,119	2,636,903

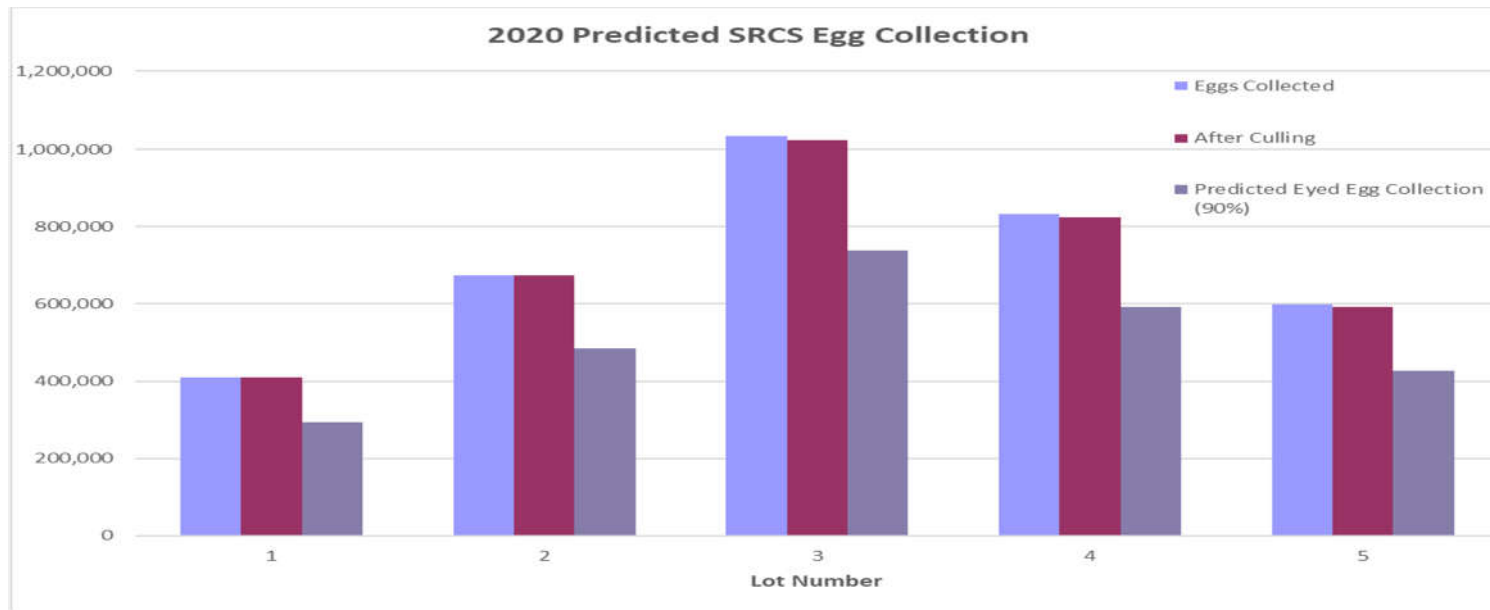


Figure 2. 2022 Spring-run Chinook Salmon Egg Collection Model

Chinook Feeding Strategy

When 90-100% of the fish in incubation stacks have buttoned-up, they will be transferred to outdoor concrete raceways. Fry will be hand-fed Bio-Oregon Bio- Pro 2 to satiation at each feeding, 4-8 times a day depending on age and size (Table 4). All spring-run will be fed Bio-Pro 2 until release. Medicated and antibiotic feeds will be used, if necessary, as prescribed by -CDFW pathologists.

Table 4. Feed manufacturer recommended feeding scheduled for Chinook Salmon

Fish size (fish/lb.)	Feed Size	Fish Food Type	Fed Times a day
3000 to 570	#0	Bio-Pro2	7-8
570 to 300	#1	Bio-Pro2	7-8
300 to 150	#2	Bio-Pro2	4-6
350 to 150	#2	Bio-Pro2	4-6
150 to 60	#3	Bio-Pro2	4-6
140 to 60	1.2	Bio-Pro2	4-6
140 to 60	1.2	Bio-Pro2	4-6

Spring-run Chinook Releases

Releases in 2022 will be like the release strategy that was implemented in 2020. The SRCS will be split into 6 groups of 336,000 fish with each group 100% uniquely tagged with same CWT number and marked by the removal of the adipose fin.

The first release of SRCS will be coordinated through the FRHOT and will be timed to coincide with an increase in river flow, ideally generated by a storm event, in early March. The release will occur on the climbing limb of the flow event and will consist of two groups of 336,000 fish each; one group will be released at the Boyd's pump release location and the other will be released at the Gridley release location. The release size will be a minimum of 120 fpp, to enable fish to be processed by the auto fish tagging trailer. However, fish size at the time of release will depend on when and if an increased flow event occurs.

The second release will be like the previous release, occurring on the climbing limb of the flow event and consisting of two groups of 336,000 fish each; one group will be released at the Boyd's pump release location and the other will be released at the Gridley release location. This release will occur during late March or early April. The target release weight is a minimum of 90 fpp.

The third release will be planned for mid to late-April. Like the previous two releases, fish will be released on the climbing limb of the flow event and consist of two groups of 336,000 fish each; one group will be released at the Boyd's pump release location and the other will be released at the Gridley release location. The target release weight is a minimum of 60 fpp.

Data from the early march releases will be used to evaluate survival of spring-run Chinook Salmon released in-river at a smaller size than past releases and under conditions of high flow and turbidity. Each set of releases will use two in-river release sites (Gridley and Boyd's Pump Boat Launch) to enable evaluation of differences in survival and stray rate by release location.

Sentinel hatchery fish, used as an indicator of exposure to pathogens, will be used during the releases, and water quality samples will be collected to continue monitoring for the prevalence and severity of *Ceratonova shasta* and its effect on Feather River Chinook Salmon.

Table 5. Spring-run Release Strategy for BY2022

Date	Location	# of Fish	Fish/lb.	With CWT and Mark
Early March	Gridley	336,000	>120	100% Ad Clip
Early March	Boyd's pump	336,000	>120	100% Ad Clip
Late March	Gridley	336,000	90	100% Ad Clip
Late March	Boyd's	336,000	90	100% Ad Clip
Mid-April	Gridley	336,000	60	100% Ad Clip
Mid-April	Boyd's	336,000	60	100% Ad Clip

Release Contingencies

Criteria and Contingencies In coordination with National Marine Fisheries Service (NMFS), -CDFW has developed the following criteria and triggers that will be used to inform decisions on the release strategy to be implemented in 2022/2023. These criteria and triggers were developed based on review of water temperature, river flow, Delta Cross Channel Gate operations. Each of the criteria indicated below are intended to be independent of the others, meaning that if any one or more of the criteria are anticipated to be met then an alternative release location will be coordinated with the FRHOT. If none of the triggers are forecast to be met, then juveniles will be released into Feather River, as describe above in section 5.2.

Delta Cross-channel Gates operations – Survival of juvenile salmon is significantly reduced when the DCC gates are open, and more fish are diverted into the interior Delta.

Cross-channel gates are forecast to be open within 21 days of the date when the hatchery salmon are to be released.

Water Temperature – Prolonged exposure to increased water temperatures above 70°F are thought to result in juvenile salmon survival approaching zero.

Sustained Daily Average Water temperatures are expected to be greater than 68 F at Verona within 21 days of the date when the hatchery salmon are to be released.

Sustained Daily Average Water temperatures are expected to be greater than 68 F at Freeport within 21 days of the date when the hatchery salmon are to be released.

Flow – Decreased flows in the Sacramento River led to significantly reduced survival of juvenile salmon because of reduced travel times exposing the fish to increased predation and increased risk of diversion into the interior Delta where survival is significantly reduced.

A Sacramento River flow at Verona of less than 4,000 cfs is forecast to occur within 21 days of the date when the hatchery salmon are to be released.

A Sacramento River Flow of less than 6,000 cfs at Freeport is forecast to occur within 21** days of the date when the hatchery salmon are to be released.

Delta Outflow is forecast* to be less than 3,000 cfs within 21** days of the date when the hatchery salmon are to be released.

If existing/predicted conditions are expected to meet the criteria triggering consideration of the alternative release strategy.

Alternative release strategies include:

Early release of all SRCS into the Feather River at Boyd's pump

Early of all SRCS into the Feather River release during high flow event

Releasing SRCS at the Live Oak Boat Launch facility instead of Gridley release location

Ceratonova shasta – An evaluation of this release contingency criteria has not yet been completed. Data from monitoring prevalence of *C. shasta* within the Feather River would need to be analyzed and discussed before alternate release sites for FRFH SRCS could be considered.

Literature Cited

California Hatchery Policy Team. 2016. California Anadromous Hatcheries Strategic Management Implementation 2016 Annual Report. Update on California Hatchery Scientific Review Group Progress and Recommended Actions for the Next 12 Months. California Department of Fish and Wildlife, Fisheries Branch, 1010 Riverside Parkway, West Sacramento, CA. 31 pp. with Appendices.

Appendix D: Spring-Run Coded-Wired Tagged Returns to Feather River Hatchery between July 1, 2022, and June 30, 2023.

CWT Number	Total Recovered	Brood Year	Hatchery of Origin	Release Location
060502	39	2019	FEATHER R HATCHERY	FEATHER AT GRIDLEY
060503	166	2019	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
061534	75	2018	FEATHER R HATCHERY	FEATHER AT GRIDLEY
061607	14	2018	FEATHER R HATCHERY	FEATHER AT GRIDLEY
061972	70	2018	FEATHER R HATCHERY	FEATHER AT LIVE OAK
061973	131	2018	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
061974	261	2018	FEATHER R HATCHERY	FEATHER AT GRIDLEY
061975	283	2018	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
061976	269	2018	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
062004	13	2018	FEATHER R HATCHERY	FEATHER AT GRIDLEY
062043	70	2019	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP

062044	394	2019	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
062045	37	2019	FEATHER R HATCHERY	FEATHER AT GRIDLEY
062290	19	2020	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
062291	14	2020	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
062292	9	2020	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
062293	5	2020	FEATHER R HATCHERY	FEATHER BOYDS PUMP RAMP
068788	3	2018	FEATHER R HATCHERY	FEATHER AT GRIDLEY
060768	3	2019	SAN JOAQ R CONSERVAT HAT	SAN JOAQ R GRT VAL GR 140
060936	1	2019	SAN JOAQ R CONSERVAT HAT	SAN JOAQ R GRT VAL GR 140
061409	2	2018	SAN JOAQ R CONSERVAT HAT	SAN JOAQ R GRT VAL GR 140
061410	3	2018	SAN JOAQ R CONSERVAT HAT	SAN JOAQ R GRT VAL GR 140
061964	7	2018	SAN JOAQ R CONSERVAT HAT	SAN JOAQ R GRT VAL GR 140
068020	1	2019	SAN JOAQ R CONSERVAT HAT	SAN JOAQ R GRT VAL GR 140

Appendix E: Brood Year 2022 Spring-Run Chinook Salmon Releases

Date	Location	Mark and CWT Code	Fish Size (Fish per Pound)	Fork Length (mm)	Released with CWT and AdClip	Released with AdClip and no CWT	Released with CWT and adipose fin intact	Released with no CWT and adipose fin intact	Total Released
3/16/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-30-61	95	82	362,604	3,663	0	0	366,267
3/16/2023	Feather River, Gridley Boat Launch	Ad-Clip 06-20-62	97	82	361,940	3,250	0	0	365,190
3/24/2023	Feather River, Gridley Boat Launch	Ad-Clip 06-30-63	94	83	361,606	4,541	0	0	366,147
3/24/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-30-64	91	84	357,359	4,783	0	0	362,142
4/11/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-30-65	75	89	359,712	6,519	0	0	366,231

4/11/2023	Feather River, Gridley Boat Launch	Ad-Clip 06-30-66	69	92	362,216	2,186	0	0	364,402
4/11/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-23-80	65	93	53,659	645	0	0	54,304
4/11/2023	Feather River, Gridley Boat Launch	Ad-Clip 06-07-91	61	96	65,509	755	0	0	66,264
4/11/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-20-81	69	92	6,580	76	0	0	6,656
4/11/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-23-69	72	91	21,099	243	0	0	21,342
Total Released									2,338,945

2022 FEATHER RIVER HATCHERY FALL-RUN CHINOOK SALMON SPAWNING AND RELEASE PROTOCOL

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Background

The Feather River Hatchery (FRH) conducts two artificial propagation programs for Central Valley (CV) Chinook Salmon, CV spring-run (SRCS) and CV fall-run (FRCS), and one artificial propagation program for CV steelhead. FRCS are a species of special concern under the federal ESA. FRCS originating from the Feather River Hatchery contribute to economically important commercial fisheries as well as popular ocean and inland sport fisheries.

The primary purpose of the FRH FRCS program is to mitigate for the loss of spawning and rearing habitat due to construction of Oroville Dam, with a coequal purpose to support river and ocean fisheries. Additionally, FRH produces triploid Chinook Salmon for a small cold-water Chinook Salmon fishery in Lake Oroville. This inland fishery meets the needs of DWR's FERC program as well as the statewide Inland Chinook salmon program.

Due to past hatchery spawning and release practices and current overlap in spawning habitat, spring and fall runs on the Feather River show evidence of extensive introgression. In 2012, the California Hatchery Scientific Review Group (CA HSRG) released the California Hatchery Review Report that establishes specific recommendations for anadromous fish hatcheries in California's Central Valley and the Klamath-Trinity Rivers, including the FRH. (See Attachment A) The report states, "Most hatcheries were producing fish for harvest primarily to mitigate for past habitat loss (rather than for conservation of at-risk populations) and were not considering the effects of their programs on naturally spawning populations (CA HSRG 2012). With numerous species listed as threatened or endangered under the Endangered Species Act, Congress identified salmon conservation as a high priority." The document further states, "The goal of this hatchery program review initiative is to ensure that hatchery programs are managed and operated to meet one or both of the primary purposes for hatcheries:

Helping recover and conserve naturally spawning salmon and steelhead populations, and
Supporting sustainable fisheries with little or no deleterious consequence to natural populations."

Since 2012, spawning practices for all artificial propagation programs at FRH have been refined and reviewed annually to further meet CA HSRG (2012) recommendations and to specifically minimize mixing of fall- and spring-runs at FRH.

In March 2020, the State of California initiated and implemented measures to reduce the spread of COVID-19 among State Employees working at state facilities and conducting State

business at offsite locations. These measures have also been incorporated into hatchery operations. Standard operating procedures for spawning and release of Chinook salmon and steelhead by FRH staff have been modified from prior years to align with the most current COVID guidance. Current guidance on measures necessary to reduce the spread of COVID-19 will be constantly monitored and incorporated into hatchery operations. While it is generally accepted that these measures will not eliminate all risk of contracting and spreading COVID-19, it is believed these measures will reduce the risk of doing so.

Lake Oroville Coldwater Fishery and Inland Collection

Adult Chinook without a Hallprint tag, that enter the hatchery during the spring-run spawning period from September 13, 2021, through September 30, 2021, will be held in two of the four round tanks to be used as broodstock for the Lake Oroville cold-water fishery and the statewide Inland Chinook program. Additionally, any excess SRCS adipose fin-clipped and Hallprint tagged salmon may be used for the Inland Chinook Program collection. Following current State and local COVID-19 guidelines, crews will begin egg collection for the Inland Chinook Program on October 3 through October 7, 2022.

All eggs intended for the Lake Oroville cold-water fishery program and eggs intended for the statewide inland Chinook program will be triploid following standard protocols.

Approximately 300,000 green triploid eggs will be collected for the Lake Oroville cold-water fishery. Eggs will be disinfected then isolated in the FRH Inland Hatchery building following procedures outlined in FRH SOP 015 (see Hatchery Manager if more information is requested). Once eyed, eggs will be added and approximately 170,000 eyed eggs will be kept at the FRH inland building for the Lake Oroville Inland Chinook program. Viable eggs more than the 170,00 needed for the Lake Oroville Inland Chinook program will be culled. Additionally, approximately 1.4 million green eggs will be collected for the statewide inland Chinook program. The statewide inland Chinook will be transferred to the Silverado Fish Base (SFB) on the day of spawning for incubation, rearing, and release at approved waters throughout the State.

Because triploidizing Chinook salmon is still a relatively new process at FRH and for CDFW, we do not have historical data from which to estimate expected mortality. We have conservatively set the assumed green to hatch survival rate at 50%. Currently the production target for the statewide inland program is limited by incubation space.

Therefore, the number of green eggs collected will maximize the available space. Losses will be tracked for green eggs shipped to SFB to refine future production targets in relation to reservoir allotment goals. Annual data and analysis will be included in annual reports.

All adult Chinook salmon held as potential broodstock for the Inland Chinook program remaining at the hatchery after Friday, October 7, 2021, will be excised before the beginning of fall-run broodstock collection on October 8, 2022.

Fall-run Chinook Broodstock Collection and Spawning Protocol

Broodstock collection and spawning FRCS spawning will commence on Monday, October 10, 2022. The practice of using Hallprint tags to identify early arriving salmon and real time CWT analysis has confirmed improved separation in the arrival timing of spring- and fall-run adults to the hatchery. All salmon entering the hatchery on or after this date that do not carry a Hallprint tag will be considered a candidate for inclusion in the fall-run broodstock. Broodstock collection and spawning will be conducted in a manner that represents fish arriving throughout the fall- run spawning period.

FRCS broodstock can include any adipose fin intact and adipose fin-clipped salmon that enter the hatchery on or later than October 8, 2022, except for any Hallprint tagged salmon. Spawning and egg collection will follow the egg collection model described in Table 4 as closely as logistically possible. Deviations from this model may be necessary due to Covid-19 operational adjustments.

Beginning in 2019, juvenile Chinook salmon produced at FRH displayed abnormal swimming behavior and suffered higher than normal levels of egg and fry mortality. This increased mortality was shown to be due to Thiamine Deficiency Complex (TDC) resulting from a dietary shift in adult Chinook salmon in the Ocean. TDC has been observed in hatchery and natural spawning Chinook salmon runs throughout California's Central Valley. It is anticipated juvenile Chinook salmon produced from adults returning in the fall of 2022 will show similar levels of thiamine deficiency and associated mortality based on samples collected from ocean harvested adult Chinook. To treat TDC, juvenile Chinook salmon produced at FRH will be treated with thiamine.

Eggs collected during the fall-run spawning period will be treated with a solution of 4500 parts per million (ppm) of Thiamine Mononitrate at fertilization. The methods for treating eggs at fertilization were evaluated by CDFW Fish Health Lab staff during the fall of 2020 (unpublished). This study demonstrated that sufficient thiamine could be absorbed by the eggs in the moments following fertilization to increase egg thiamine levels above the level of concern. These methods will be used at all CDFW anadromous fish hatcheries for eggs collected for mitigation and enhancement production from all untreated adult Chinook to help treat the effects of TDC in the hatchery produced juveniles.

FRCS broodstock will include both adipose fin-intact and adipose fin-clipped fish. CWT analysis will be used to identify stacks and trays with one or more spring-run parents. Trays that contain juveniles with any spring-run parentage, as identified by CWT, will be culled.

FRCS broodstock will be collected and held in round tanks until needed for spawning. FRCS are spawned using a 1 male:1 female spawning protocol. The broodstock sex ratio will also be held to 1 male:1 female. Each male will be used only once. If the daily egg take goal is not met, that number of eggs will be added to the target for the next day. Grises will be incorporated at no more than 2% of all males spawned.

The head will be removed from any adipose fin-clipped fish for coded-wire tag (CWT) recovery and analysis. CWT analysis is used to examine contribution rates of hatchery-origin strays from other CV hatcheries into individual egg trays and allow for culling of crosses that include one or more spring-run parent. The FRCS mitigation production goal is 7.75 million smolts at release. Approximately, 15 million green eggs will be collected throughout the run to meet this target. This target allows for a buffer to meet production targets in case of disease or other loss and culling of trays containing eggs from spring-run parents. Excess eyed eggs above the eyed egg goal will be culled. The number of culled eggs per season is recorded and kept in hatchery files. Eggs will be collected and culled to represent the spectrum of the run to meet production goals according to the chart provided (Figure 2). Due to Covid 19 operating restrictions, egg collection may be adjusted throughout the spawning period to stay consistent with state guidelines for staffing.

Spawning Procedures

Fish will be anesthetized using CO₂, lifted into the hatchery, where two staff will sort fish on the table by sex. Each ad-clipped fish will be marked with a reusable tag (5 ¾ inch safety pin with uniquely numbered tag attached to the lower jaw or operculum). Males will get an odd numbered tag and females will get an even numbered tag.

As fish are pulled off the table to spawn, the front of house (FOH) data recorder will record sex, grise or adult based on total length, and ad-clip status of each spawned fish on the data card. For non-adipose fin-clipped fish, a line will be drawn through the 'ID Number' field. For ad-clipped fish, the staff member spawning will read the tag ID number to the data recorder. Completed data cards will be attached to the egg tub. Each tub will have at least one and no more than two data cards associated with it.

Thiamine Treatment -Eggs will be collected into a colander that will drain any excess fluids then place eggs into a spawning tub. It is important to try and avoid any water egg contact. Spawning water will be made by approximately adding (0.09%-1.3% salt w/w in UV water) or

approximately 10 oz of salt to 4.5 gallons. For Thiamine mononitrate powder (TM) high dose at 4500ppm, add 76.5 gm of TM to the spawning water bucket and stir until dissolved. Collect eggs into a colander, drain ovarian fluid off, place eggs into a spawning tub. Add milt to the eggs and immediately add the spawning water containing TM. Depending on size of eggs and tub, use enough spawning water with TM to bathe every egg (anywhere from 1-3 cups) and gently mix the eggs, milt, and spawning water by hand (3-5 sec). Transport the spawning tub to the rinse area, use UV treated water to rinse the eggs (at least 2-3 rinses). This period is about 30-60 sec. Place fertilized eggs in iodophor (100ppm) for about 20 min. After 20 min., rinse fertilized eggs by either rinsing or moving to Heath stacks for incubation.

Grilse are incorporated at 2% rate. If 3- and 4-year-old returns are low, discussion and consensus by the Feather River Hatchery Operations Team may revise the grilse incorporation rate for the current broodstock collection season.

FRCS are spawned using a true 1 male: 1 female ratio. Each male will be spawned only once.

If two tubs of eggs will be combined after fertilization for incubation in a single eggs tray, each tub of eggs will be measured before combining the two females. Both data cards will be attached to the egg tub of combined eggs. Fertilized eggs from a maximum of two females can be combined in a tub to avoid confusion and data recording errors, and to maximize separation of families.

Once a tub is filled with fertilized eggs, the FOH data recorder will attach the data card(s) to the tub. Then the filled tub will be taken to the egg room. The data cards will be removed from the tub and given to the back of house (BOH) data recorder. Egg weight (in ounces) will be recorded on the data cards and data sheets (Attachment C). The eggs are then emptied into an incubation tray. Egg tubs will be rinsed thoroughly with UV water prior to being reused.

When the tub is emptied into an egg tray, the back of house (BOH) data recorder will record the stack and tray number on the data card. If the tub is split between two trays, the data recorder will record the numbers of both stacks and trays containing that family on the data card. The emptied tub will be rinsed thoroughly with UV water and sent back to the spawning room to be used again.

If some overripe eggs are observed in the tub, the whole tub will be discarded and the BOH data recorder will check the 'Discarded' box on the data card. The stack and tray fields are left blank on the datacard.

Fertilized eggs will be drained of ovarian fluid and milt in a colander and placed into incubation trays with 4 oz. iodophor for disinfection. Further information on egg incubation

procedures can be found in FRH SOP 001 Egg Culture (see Hatchery Manager if more information is requested).

When a data card is filled and complete, it will be grouped with the other cards from the day, scanned and sent to CDFW Ocean Salmon Project (OSP) for entry into a database. All data sheets will be subjected to quality assurance and quality control review at the end of season. In the interest of time, documents will be shared with OSP on a weekly basis using One Note (Attachment C).

All fish carcasses (spawned, killed not spawned, and dead in tank) will be immediately brought to the sampling station. Fish will be prepared for scale sampling and CWT collection. Fish condition, adipose status, sex, and fork length will be recorded. Fish ID tag numbers will be recorded, and tags removed. A scale sample (skin patch) will be collected from a percentage of fish and given a unique sample ID. The head will be collected from each adipose fin clipped fish, given a unique head tag ID and sealed in a bag with the head tag. Data sheets can be found in Attachment B

Fall-run Chinook Salmon Production Goals

During the 2022/2023 spawning and rearing season priority will be given to improving temporal separation between spring and fall runs, with additional limitations on spring run mixing with fall run broodstock.

The Chinook salmon production goal for 2022-2023 is 7,765,400 fall-run Chinook salmon smolts at time of release. The current FRH mitigation goal for FRCS is 6 million smolts (+10 percent) at 60 to 90 fish per pound. An additional 1.75 million smolts will be produced to help offset the anticipated impacts of the current drought on natural production. The additional 1.75 million fish will be tagged as follows: 1.55 million @ 25% and 200,000 @ 100%. Additionally, CDFW received requests for FRH juvenile Chinook salmon totaling 55,828 fish for special studies.

Mitigation production goal of 6,000,000 smolts

Drought enhancement production of 1,750,000 smolts

Scientific Study Requests totaling 55,828 fish

Egg models and collection goals were developed using survival estimates for specific developmental periods. Estimated survival from green to eyed egg is 85 % and estimated survival from eyed egg to fry is 90 percent. While actual egg survival may be significantly

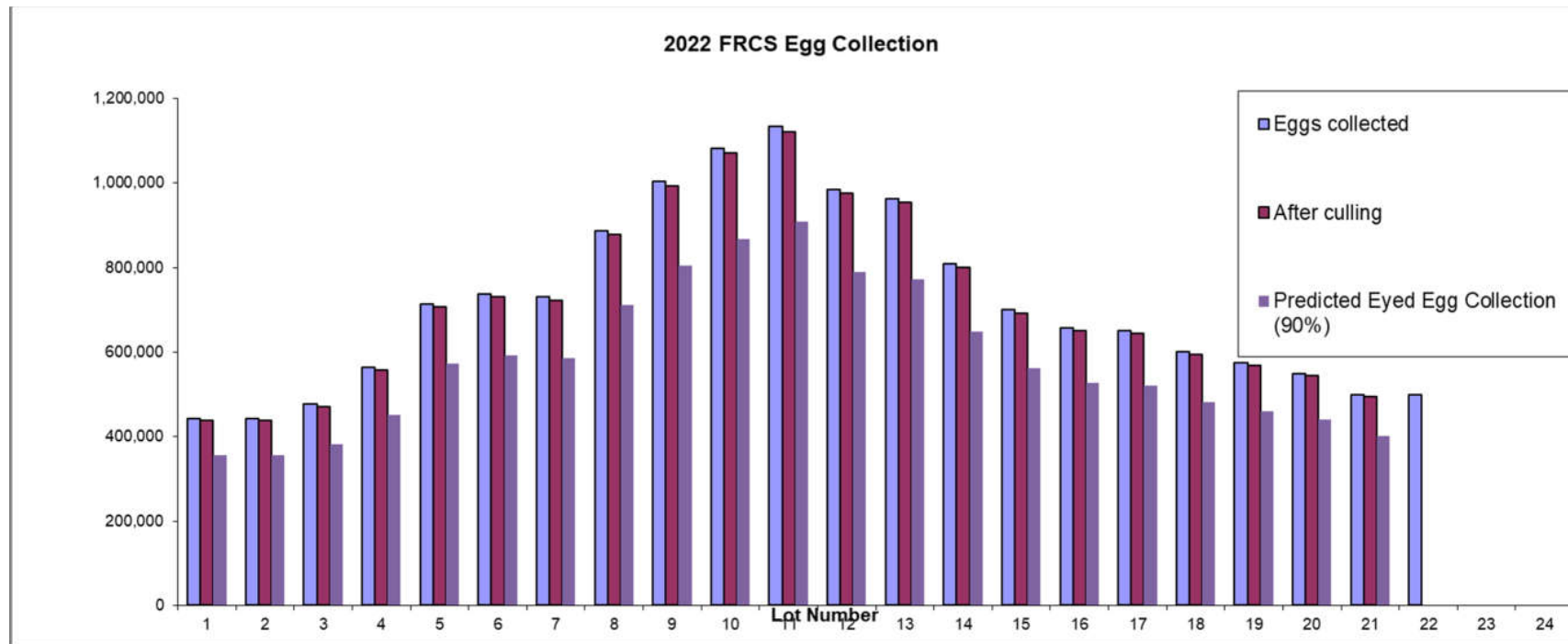
different from these estimates, these estimates allow the hatchery to account for unanticipated mortality and culling if necessary. After adding, eggs above the daily eyed egg goals listed in Table 3 and Figure 2 will be culled. When culling, an equal proportion of eggs will be removed from each tray to maintain groups similar size and development, which helps feeding, growth, and timing of releases.

Table 1. 2022 Fall-run Chinook Salmon egg collection model and survival projections

Feather River Hatchery 2022											
Fall-run Eyed Egg		7,750,000 (6,000,000 mitigation)									
Date	Status	Expected Green Eggs Collection (assumes 4500 eggs/female)	Predicted Percent culling rate	Predicted Egg Collection after culling	Assumed 80% Survival to eyed after culling based on Predicted Egg collection	Assumed 85% Survival to eyed after culling	90% Survival to eyed after culling	Assumed 80% Survival to eyed after culling based on actual Egg collection	Assumed 90% Survival from eyed egg to ponded fish based on column L Predicted Egg collection	Assumed 90% Survival from eyed egg to ponded fish based on column M Predicted Egg collection	Assumed 95% Survival from eyed to ponded fish based on Predicted Egg collection
10/10	Expected	443,175	1%	438,743	350,995	372,932	394,869	0	335,639	355,382	375,125
*	Expected	443,712	1%	439,275	351,420	373,384	395,347	0	336,045	355,813	375,580
*	Expected	476,652	1%	471,885	377,508	401,103	424,697	0	360,992	382,227	403,462
*	Expected	563,376	1%	557,742	446,194	474,081	501,968	0	426,673	451,771	476,870
*	Expected	713,272	1%	706,139	564,911	600,218	635,525	0	540,197	571,973	603,749
*	Expected	737,760	1%	730,382	584,306	620,825	657,344	0	558,743	591,610	624,477
*	Expected	730,474	1%	723,169	578,535	614,694	650,852	0	553,224	585,767	618,310
*	Expected	886,618	1%	877,752	702,201	746,089	789,977	0	671,480	710,979	750,478
*	Expected	1,003,656	1%	993,619	794,896	844,577	894,257	0	760,119	804,832	849,545
*	Expected	1,081,620	1%	1,070,804	856,643	910,183	963,723	0	819,165	867,351	915,537
*	Expected	1,133,076	1%	1,121,745	897,396	953,483	1,009,571	0	858,135	908,614	959,092
*	Expected	985,072	1%	975,221	780,177	828,938	877,699	0	746,044	789,929	833,814
*	Expected	963,247	1%	953,615	762,892	810,572	858,253	0	729,515	772,428	815,340
*	Expected	808,400	1%	800,316	640,253	680,269	720,284	0	612,242	648,256	684,270
*	Expected	700,000	1%	693,000	554,400	589,050	623,700	0	530,145	561,330	592,515
*	Expected	657,533	1%	650,958	520,766	553,314	585,862	0	497,983	527,276	556,569
*	Expected	650,000	1%	643,500	514,800	546,975	579,150	0	492,278	521,235	550,193
*	Expected	600,000	1%	594,000	475,200	504,900	534,600	0	454,410	481,140	507,870
*	Expected	575,000	1%	569,250	455,400	483,863	512,325	0	435,476	461,093	486,709
*	Expected	550,000	1%	544,500	435,600	462,825	490,050	0	416,543	441,045	465,548

[illegible]

Figure 1. 2022 Fall-run Chinook Salmon Egg Collection Model



Chinook Feeding Strategy

When 90-100% of the fish in incubation stacks have buttoned-up, they will be transferred to outdoor concrete raceways. Fry will be hand fed Bio- Pro 2 to satiation at each feeding, 4-8 times per day depending on age and size. All FRCS will be fed Bio- Pro 2 until release. FRCS being released into the San Pablo or San Francisco Bay will be switched to Bio-Supreme transfer diet at least 6 weeks prior to release. Bio-supreme transfer diet has been formulated to help ease osmoregulatory stress associated with smoltification. Recent studies have shown return rates of Bio-supreme fed fish up to 42% higher than controls in Central Valley Chinook. Medicated and antibiotic feeds will be used, if necessary, as prescribed by CDFW pathologists.

Table 2. Feed manufacturer recommended feeding scheduled for Chinook salmon

Fish size (fish/lb.)	Feed Size	Fish Food Type	Fed Times a day
3000 to 570	#0	Bio-Pro2	7-8
570 to 300	#1	Bio-Pro2	7-8
300 to 150	#2	Bio-Pro2	4-6
350 to 150	#2	Bio-Pro2	4-6
150 to 60	#3	Bio-Pro2	4-6
140 to 60	1.2	Bio-Pro2	4-6
140 to 60	1.2	Bio-Pro2	4-6

Chinook Salmon Ponding, Marking and Tagging

Chinook salmon will be ponded into 5 raceways shortly after reaching a button-up fry stage or approximately 1,200 fish/lb. During marking and tagging operations and based on proposed release strategies, fish will be sorted such that each raceway will contain approximately 1 million fish and the rearing channel will contain 3 million fish.

Fish will be marked and tagged (adipose fin-clip and a CWT inserted) at the standard constant fractional marking rate of 25% when they reach a minimum of 120 fish/lb. Seventeen different tag codes will be used to differentiate between brood years and release locations.

Fall-run Release Strategy

One million juvenile FRCS, a portion of the mitigation production, will be released into the Feather River in late-April when reaching a minimum of 90 fish per pound or approximately 83 millimeters. This in-river release will be used to assess the behavior, condition, and survival of outmigrating smolts as well as their subsequent adult return and stray rates of in-river in comparison to off-site release. All fish will be loaded and transported in accordance with FRH SOP's 007 through 013. The remainder of the mitigation production, approximately 5 million smolts, and the drought enhancement production of 1.75 million smolts will be released into the San Francisco and San Pablo Bays using either a net pen acclimation or nighttime direct release strategy during the months of April – June when reaching a minimum of 60 fish per pound or approximately 96 millimeters.

The release location and strategy of tag groups released into San Francisco or San Pablo Bays will be selected depending on weather, availability of net pens, and CDFW management review. Time of plant, temperature of receiving water and transport tank water, and the condition of the fish during release will be recorded on planting receipts and summarized in annual reports.

All releases will consist of full tag groups. Weight counts will be taken as fish are being loaded into transport trucks and recorded on release receipts following standard hatchery practices. Salt will be added to a level of ten parts per thousand to transport tanks prior to loading fish for transport.

All releases will be conducted on the outgoing tide and timed such that no more than two days of releases are scheduled in a row from the same location when logistically feasible. If necessary due to logistical constraints, groups of 1.0 million like CWT fish may be split and released over two consecutive days from the same location as necessary to meet hatchery logistical constraints.

Release Contingencies

Criteria and Contingencies In coordination with National Marine Fisheries Service (NMFS), CDFW has developed the following criteria and triggers that will be used to inform decisions on the release strategy to be implemented in 2022/2023. These criteria and triggers were developed based on review of water temperature, river flow, Delta Cross Channel Gate operations. Each of the criteria indicated below are intended to be independent of the others, meaning that if any one or more of the criteria are anticipated to be met then an alternative release location will be coordinated with the Feather River Hatchery Operations Team. If none of the triggers are forecast to be met, then juveniles will be released into Feather River, as describe above in section 5.2.

Delta Cross-channel Gates operations – Survival of juvenile salmon are known to be significantly reduced when gates are open and increased numbers of fish are diverted into the interior Delta (Perry et al 2015).

Cross-channel gates are forecast* to be open within 21 days of the date when the hatchery salmon are to be released.

Water Temperature – Prolonged exposure to increased water temperatures above 70 F are thought to result in juvenile salmon survival approaching zero. (Nobriga et al, 2021).

Sustained Daily Average Water temperatures are expected to be greater than 68 F at Verona within 21 days of the date when the hatchery salmon are to be released.

Sustained Daily Average Water temperatures are expected to be greater than 68 F at Freeport within 21 days of the date when the hatchery salmon are to be released.

Flow – Flows in the Sacramento River below 12,000 cubic feet per second upstream of the Delta Cross Channel junctions can lead to significantly reduced survival of juvenile salmon because of reduced travel times, exposure to increased predation and increased risk of diversion into the interior Delta. (Perry et al, 2015; NMFS Biological Opinion on Long-term Operation of the Central Valley Project and the State Water Project Section 8.6.3.3.3, 2019)

A Sacramento River flow at Verona of less than 4,000 cfs is forecast* to occur within 21 days of the date when the hatchery salmon are ready to be released.

A Sacramento River Flow of less than 12,000 cfs at Freeport is forecast to occur within 21 days of the date when the hatchery salmon are ready to be released.

Delta Outflow is forecast* to be less than 3,000 cfs within 21 days of the date when the hatchery salmon are ready to be released.

If during any of these assessments, existing/predicted conditions are expected to meet the criteria triggering consideration of the alternative release strategy, then preparations will begin, continue, or be implemented to truck appropriate groups of fish to be release following the release strategies described in this document in the San Francisco or San Pablo Bays.

Appendix G: Fall-Run Coded-Wired Tagged Returns to Feather River Hatchery between July 1, 2022, and June 30, 2023.

CWT Number	Total Recovered	Brood Year	Hatchery of Origin	Release Location
0601080602	2	2018	Feather River Hatchery	Yolo Bypass Conway
060653	4	2017	Feather River Hatchery	Mare Island Net Pen
060655	1	2017	Feather River Hatchery	Mare Island Net Pen
061461	1	2017	Feather River Hatchery	Fort Baker Minor Pt.
061530	45	2019	Feather River Hatchery	Mare Island Net Pen
061588	168	2019	Feather River Hatchery	Mare Island Net Pen
061589	105	2019	Feather River Hatchery	Mare Island Net Pen
061590	81	2019	Feather River Hatchery	Mare Island Net Pen
061591	193	2019	Feather River Hatchery	Mare Island Net Pen
061592	221	2019	Feather River Hatchery	Mare Island Net Pen
061593	154	2019	Feather River Hatchery	Mare Island Net Pen

061594	122	2019	Feather River Hatchery	Mare Island Net Pen
061595	79	2019	Feather River Hatchery	Mare Island Net Pen
061596	35	2019	Feather River Hatchery	Mare Island Net Pen
061978	52	2018	Feather River Hatchery	Mare Island Net Pen
061979	10	2018	Feather River Hatchery	Mare Island Net Pen
061980	129	2018	Feather River Hatchery	Mare Island Net Pen
061981	8	2018	Feather River Hatchery	Mare Island Net Pen
061982	8	2018	Feather River Hatchery	Mare Island Net Pen
061983	5	2018	Feather River Hatchery	Mare Island Net Pen
061984	12	2018	Feather River Hatchery	Mare Island Net Pen
061985	15	2018	Feather River Hatchery	Mare Island Net Pen
061986	28	2018	Feather River Hatchery	Mare Island Net Pen
061987	12	2018	Feather River Hatchery	Mare Island Net Pen
061988	16	2018	Feather River Hatchery	Mare Island Net Pen

061989	24	2018	Feather River Hatchery	Mare Island Net Pen
061990	22	2018	Feather River Hatchery	Mare Island Net Pen
061991	38	2018	Feather River Hatchery	Mare Island Net Pen
061992	25	2018	Feather River Hatchery	Mare Island Net Pen
061993	24	2018	Feather River Hatchery	Mare Island Net Pen
062048	79	2019	Feather River Hatchery	Feather River Boyd's Pump Ramp
062049	238	2019	Feather River Hatchery	Mare Island Net Pen
062050	272	2019	Feather River Hatchery	Mare Island Net Pen
062294	46	2020	Feather River Hatchery	Mare Island Net Pen
062295	32	2020	Feather River Hatchery	Mare Island Net Pen
062296	24	2020	Feather River Hatchery	Mare Island Net Pen
062297	13	2020	Feather River Hatchery	Mare Island Net Pen
062298	3	2020	Feather River Hatchery	Mare Island Net Pen
062299	9	2020	Feather River Hatchery	Mare Island Net Pen

062340	18	2020	Feather River Hatchery	Wickland Oil Terminal
062341	14	2020	Feather River Hatchery	Wickland Oil Terminal
062342	39	2020	Feather River Hatchery	Mare Island Net Pen
062343	123	2020	Feather River Hatchery	Fort Baker Minor Pt.
062344	119	2020	Feather River Hatchery	Wickland Oil Terminal
062345	189	2020	Feather River Hatchery	Pt. San Quentin
062371	10	2020	Feather River Hatchery	Mare Island Net Pen
062376	9	2020	Feather River Hatchery	Mare Island Net Pen
056288	1	2018	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056296	1	2018	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056318	2	2018	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056401	6	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056402	6	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056403	8	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery

056404	4	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056405	3	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056406	4	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056407	4	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056408	3	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056409	3	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056410	3	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056411	6	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056412	1	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056413	1	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056414	2	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056415	2	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056416	5	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056417	3	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery

056418	1	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056419	2	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056420	3	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056422	1	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056423	1	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056429	9	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056430	1	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056431	4	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056432	6	2019	Coleman National Fish Hatchery	Coleman National Fish Hatchery
056568	1	2020	Coleman National Fish Hatchery	Point San Quentin Net Pens
056569	1	2020	Coleman National Fish Hatchery	Point San Quentin Net Pens
062006	6	2019	Merced River Fish Facility	San Joaquin Sherman Island Net Pen
061499	1	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen

061531	1	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
061578	3	2019	Mokelumne River Hatchery	Santa Cruz Harbor
061580	4	2020	Mokelumne River Hatchery	Monterey Major Port
061581	3	2020	Mokelumne River Hatchery	Santa Cruz Harbor
062058	4	2019	Mokelumne River Hatchery	Half Moon Bay Pillar Point Harbor Johnson Pier Net
062059	4	2019	Mokelumne River Hatchery	Fort Baker Minor Pt.
062060	1	2019	Mokelumne River Hatchery	Fort Baker Minor Pt.
062062	3	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062063	1	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062064	3	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062066	2	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062067	1	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen

062068	1	2019	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062350	1	2020	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062351	1	2020	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062352	1	2020	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062354	1	2020	Mokelumne River Hatchery	San Joaquin Sherman Island Net Pen
062358	6	2020	Mokelumne River Hatchery	Half Moon Bay Pillar Point Harbor Johnson Pier Net
062359	1	2020	Mokelumne River Hatchery	Fort Baker Minor Pt.
062361	5	2020	Mokelumne River Hatchery	Fort Baker Minor Pt.
060461	2	2020	Nimbus Fish Hatchery	Mare Island Net Pen
061995	1	2018	Nimbus Fish Hatchery	American River at Sunrise
061999	1	2018	Nimbus Fish Hatchery	Mare Island Net Pen
062053	1	2019	Nimbus Fish Hatchery	American River at Sunrise

062054	1	2019	Nimbus Fish Hatchery	Mare Island Net Pen
062055	1	2019	Nimbus Fish Hatchery	Mare Island Net Pen
062056	3	2019	Nimbus Fish Hatchery	Mare Island Net Pen
062375	1	2020	Nimbus Fish Hatchery	Wickland Oil Terminal

Appendix H: Brood Year 2022 Fall-Run Chinook Salmon Releases

Date	Location	Mark and CWT Code	Fish Size (Fish per Pound)	Fork Length (mm)	Released with CWT and AdClip	Released with AdClip and No CWT	Released with CWT and adipose fin intact	Released with no CWT and adipose fin intact	Non-CWT Released	Total Tagged released	Total Released	Production Type
3/15/2023	Sutter Bypass, at Sacramento Avenue	VIE - Yellow (Snout)	533	47	0	0	0	0	0	8,601	266,540	Drought Enhancement (Pre-smolt)
4/11/2023	Feather River, Gridley Boat Launch	Ad-Clip 06-06-60	135	73	126,502	432	0	0	381,177	126,934	508,111	Drought Enhancement (Pre-smolt)
4/21/2023	Feather River, Gridley Boat Launch	Ad-Clip 06-28-83	134	73	123,756	2268	0	0	378,314	126,024	504,338	Drought Enhancement (Pre-smolt)
4/21/2023	Feather River, Boyd's Pump Boat Launch	Ad-Clip 06-00-21	81	87	249,039	1503	0	0	753,639	250,542	1,004,181	Mitigation
5/1/2023 & 5/2/2023	San Pablo Bay, Mare Island Net Pen	Ad-Clip 06-00-20	68	92	249,311	1253	0	0	752,699	250,564	1,003,263	Mitigation
5/8/2023	San Pablo Bay, Conoco	Ad-Clip 06-00-19	63	95	251,093	1008	0	0	756,983	252,101	1,009,084	Mitigation
5/11/2023	San Francisco Bay, Estuary and Ocean Science Center, Tiburon	Ad-Clip 06-09-73	61	96	248,521	748	0	0	748,163	249,269	997,432	Drought Enhancement (Smolt)

5/24/2023	San Pablo Bay, Conoco	Ad-Clip 06-00-07	64	94	83,488	2582	0	0	258,330	86,070	344,400	Mitigation
5/24/2023	San Pablo Bay, Conoco	Ad-Clip 06-00-08	64	94	82,863	753	0	0	252,117	83,616	335,733	Mitigation
5/24/2023	San Pablo Bay, Conoco	Ad-Clip 06-00-09	64	94	83,432	1013	0	0	254,254	84,445	338,699	Mitigation
5/26/2023	San Francisco Bay, Estuary and Ocean Science Center, Tiburon	Ad-Clip 06-00-11	63	95	84,085	109	0	0	252,788	84,194	336,982	Mitigation
5/26/2023	San Francisco Bay, Estuary and Ocean Science Center, Tiburon	Ad-Clip 06-00-14	64	94	82,379	1510	0	0	251,985	83,889	335,874	Mitigation
5/31/2023	San Pablo Bay, Mare Island Net Pen	Ad-Clip 06-00-13	61	96	82,763	1454	0	0	252,798	84,217	337,015	Mitigation
5/31/2023	San Pablo Bay, Mare Island Net Pen	Ad-Clip 06-00-15	61	96	83,438	1125	0	0	253,914	84,563	338,477	Mitigation
6/3/2023	San Pablo Bay, Mare Island Net Pen	Ad-Clip 06-00-10	61	96	84,334	595	0	0	255,016	84,929	339,945	Mitigation

6/3/2023	San Pablo Bay, Mare Island Net Pen	Ad-Clip 06-00-12	61	96	81,115	1825	0	0	249,096	82,940	332,036	Mitigation
6/7/2023	San Pablo Bay, Conoco	Ad-Clip 06-20-70	65	93	95,132	0	0	0	285,545	95,132	380,677	Mitigation
6/7/2023	San Pablo Bay, Conoco	Ad-Clip 06-15-50	65	93	95,585	0	0	0	286,687	95,585	382,272	Mitigation
6/12/2023	San Francisco Bay, Estuary and Ocean Science Center, Tiburon	Ad-Clip 06-00-16	60	96	83,993	763	0	0	254,532	84,756	339,288	Drought Enhancement (Smolt)
6/12/2023	San Francisco Bay, Estuary and Ocean Science Center, Tiburon	Ad-Clip 06-00-17	60	96	81,026	489	0	0	244,704	81,515	326,219	Drought Enhancement (Smolt)
6/12/2023	San Francisco Bay, Estuary and Ocean Science Center, Tiburon	Ad-Clip 06-00-18	60	96	83,439	0	0	0	250,488	83,439	333,927	Drought Enhancement (Smolt)
6/24/2023	San Francisco Bay, Brickyard Cove (Richmond)	Ad-Clip 06-00-22	47	105	200,828	604	0	0	0	201,432	201,432	Drought Enhancement (Smolt)
Total Released:											10,295,925	

2022 Feather River Hatchery Steelhead Spawning and Release Protocol

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Background

The Feather River Hatchery (FRH) conducts two artificial propagation programs for Central Valley (CV) Chinook salmon: CV spring-run and CV fall-run and one artificial propagation program for CV steelhead. CV steelhead are listed as threatened under the Federal Endangered Species Act.

In 2012, the California Hatchery Scientific Review Group (HSRG) released the California Hatchery Review Report that establishes specific recommendations for all California hatcheries, including the FRH. (See Attachment A) The report states, “Most hatcheries were producing fish for harvest primarily to mitigate for past habitat loss (rather than for conservation of at-risk populations) and were not considering the effects of their programs on naturally spawning populations (CA HSRG 2012). With numerous species listed as threatened or endangered under the Endangered Species Act, Congress identified salmon conservation as a high priority.” The document further states, “The goal of this hatchery program review initiative is to ensure that hatchery programs are managed and operated to meet one or both primary purposes for hatcheries:

Helping recover and conserve naturally spawning salmon and steelhead populations, and

Supporting sustainable fisheries with little or no deleterious consequence to natural populations.”

Since 2012, spawning practices at FRH have been refined and reviewed annually to further meet HSRG recommendations and to specifically minimize introgression between runs on the Feather River.

The FRH steelhead program is implemented as an integrated hatchery mitigation program for loss of spawning and rearing habitat due to construction of Oroville Dam. This is an integrated production program and provides recreational fishing opportunities. Both hatchery and natural origin steelhead from the Feather River are considered part of the Central Valley steelhead ESU (NOAA 2006).

Standard operating procedures for spawning and releasing of Chinook salmon and steelhead by Feather River Hatchery will capture any necessary changes associated

with the most current COVID guidance provided by the Department. The FRH continues to increase routine cleaning, use of personal protective equipment (PPE), and increase availability of hand sanitizer and hand cleaning supplies. While it is generally accepted that these measures will not eliminate all risk of contracting and spreading COVID-19, it is believed these measures will reduce the risk of doing so.

Steelhead Broodstock Collection

The FRH ladder was opened on September 15, 2022. The ladder will remain open until the end of June 2022. Adult steelhead begin returning to the hatchery starting in late-October and are released to the river until late November, then they are held in round tanks until they are ready to spawn.

The HSRG provided several recommendations for the FRH generally and for steelhead specifically. CDFW continues to incorporate those recommendations when possible. To limit the use of resident (non-anadromous) fish, the current 16- inch minimum length for broodstock will be continued. We acknowledge that resident *Oncorhynchus mykiss* may occasionally exceed 16” in length but this target has been refined using otolith markers and represents the best balance of broodstock availability and reduction of resident fish. Per HSRG recommendations, FRH steelhead program will target at least 10% natural origin broodstock. Historically FRH incorporation of natural origin (NO) fish is typically between 1-10% because of a lack of availability of NO fish at the hatchery. If the hatchery has more broodstock than are necessary to meet egg take goals, preference will be given to utilizing NO fish.

Out-of-sub-basin importation of eggs, juveniles or adults will not occur, unless from Mokelumne River, which historically on several occasions was heavily supplemented with, and thus genetically similar to, Feather River steelhead. To catalog genetic and age information, all spawned fish will be immediately brought to the sampling station where they are prepared for genetic tissue and scale sampling. Fish condition, adipose status, sex, and fork length will be recorded. A caudal fin clip (other fin may be used if caudal is covered in fungus or otherwise unusable, fin type will be recorded in comments field on data sheet) will be collected from each spawned fish and given a unique sample ID. A scale sample will be collected from a percentage of fish and given a unique sample ID. The percentage is determined at the beginning of season and is dependent on the number of fish returning to the hatchery for spawning. The goal is to collect scales from 20% of the spawning steelhead in the hatchery or at least 100 individuals. There are no specific goals for the number of adult steelhead produced by

this program; however, the juvenile production goal is to release 450,000 yearling steelhead annually at three fish/pound during February.

Egg collection occurs throughout the spawning season to collect eggs from the entire run. If escapement appears to be low, as many eggs as possible will be collected on each spawning day. Otherwise, eggs will be collected on an as-needed basis to represent a run curve with the maximum number of eggs collected within the mean of the run. As eggs develop, culling of eggs from each lot will commence in such a way as to mimic the natural bell-shaped curve of the abundance and timing of escapement as well as to maximize the number of family groups. Data will be collected to allow evaluation of the actual egg collection schedule and its possible effect on shifting migration and spawn timing.

All natural-origin steelhead are returned to the river (spawned or unspawned), all hatchery- origin females are returned to the river (spawned or eggs removed), and all hatchery-origin males are released back to Feather River at Verona or into the Thermalito Afterbay to supplement the recreational fishery. In years where excess production occurs (greater than 450,000 smolts), the additional smolts may be put in the Thermalito Afterbay for additional recreational opportunity. If additional yearlings are available in Spring 2023, up to 100 will be acoustic tagged prior to release. This study will help managers track behavior and survival of hatchery origin steelhead released into the Thermalito Afterbay.

California Central Valley Steelhead Production Release Size Goals

The prioritized production goals for this season are as follows:

Steelhead production goal: 450,000 yearlings

The FRH expects to produce and release 450,000 steelhead yearlings. To meet this goal, an estimated 1.5 million green eggs will be collected to account for mortality that occurs during the incubation and rearing phases (Table 1).

Table 1. Egg take table for FRH Fish Hatchery steelhead spawning in 2022.

Date	Lot	Numbers of eggs
12/30/2022	1	424,293
1/6/2023	2	292,740

1/13/2023	3	281,424
1/20/2023	4	210,000
1/27/2023	5	160,000
2/3/2023	6	100,000
total		1,468,457

Spawning Protocol

Spawning of adult steelhead occurs once weekly beginning in the second or third week of December and will continue until late February. HSRG recommendation 3.13 states that a smaller population of less than 250 females should implement factorial spawning by splitting female eggs into two or more lots and each lot be fertilized from a different male. Because of low steelhead broodstock returns, since winter 2016, a partial factorial mating scheme implemented at FRH for the steelhead spawning program to help improve the effective size and hedge against infertile males and females. To accomplish this, eggs from one female are split in to two equally sized groups. Each group is fertilized with the sperm of one male (Figure 1). Additionally, genetic sampling occurs to gather genetic relatedness data on the parents. FRH staff will eliminate the reuse of males, as much as possible.

Table 2. 2022 Steelhead 2x2 factorial mating scheme

		Males	
		A	B
Females	1	1A	1B
	2	2A	2B

The following mating scheme will be used:

Spawning incorporates a 2x2 partial factorial mating scheme:

Assuming two males and two females are available and ripe, the eggs from each female are divided into two separate pans. Each male is used to fertilize a separate pan. Thus, for two females (female 1 and 2) and two males (male A and B), a total of four pans are used, creating four individual families (1A, 2A, 1B, and 2B). The individual matings are recorded.

If there are an unequal number of males and females, FRH will perform a 2x3 or 3x2 partial factorial mating system.

Individual crosses are separated and tracked in egg trays if time and space permit (estimated 30-45 days post-fertilization).

FRH measures the approximate number of juveniles produced per family so that an accurate estimate of effective size can be calculated.

Limit male re-use:

The number of times each male fish is spawned is documented and tracked. The re-use of males is limited wherever possible.

Steelhead Feeding Strategy

When 90-100% of the fish in incubation stacks have buttoned-up, they will be transferred to four deep tanks and are feed and kept there until they are around 300-500 fish per pound. At that size, they are moved to the outdoor concrete raceways. Fry will be hand-fed Bio-Oregon Bio- Pro 2, or Bio- Supreme diet, to satiation at each feeding, 4-8 times a day depending on age and size. All steelhead will be fed Bio-Pro 2 until release. Medicated and antibiotic feeds will be used, if necessary, as prescribed by CDFW pathologists.

Table 3. Feed manufacturer recommended feeding scheduled for steelhead

Fish size (fish/lb.)	Feed Size	Fish Food Type	Fed Times a day
3000 to 570	#0	Bio-Pro2	7 to 8
570 to 300	#1	Bio-Pro2	7 to 8
300 to 150	#2	Bio-Pro2	4 to 6
150 to 90	#3	Bio-Pro2	5 to 6
90 to 60	1.5mm	Bio-Pro2	6 to 6
60 to 11	2.5mm	Bio-Pro2	7 to 6

11 to 4	3.5mm	Bio-Pro2	8 to 6
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Pathology Protocols

Thiamine Deficiency Complex (TDC) has been observed in Chinook salmon populations throughout the Central Valley. To date, steelhead trout populations have not been fully analyzed for TDC, though there is concern they too are affected by the deficiency. CDFW hatchery managers and Fish Health Lab staff are evaluating the need to treat steelhead trout for TDC, but there currently is no plan to treat steelhead eggs for TDC.

Green eggs will be disinfected with a 100-ppm solution of iodine for 20 mins while water hardening in incubator trays (vertical stacks). Eggs will then be flushed with water by pushing the trays into the vertical stacks.

Pathologists will take ovarian fluid samples from 60 fish throughout the spawning season to check for infectious hematopoietic necrosis (IHN). If IHN appears to be present in eggs, pathology lab personnel will plate smears and send samples to a contracted lab for virology testing.

Steelhead Release

All FRH steelhead are marked with an adipose fin-clip prior to release. Yearling production of brood year 2022 steelhead, spawned December 2021 through February 2022, total approximately 409,000, 41,000 below the production target. Approximately 409,000 will be released into the Feather River at the Boyd's Pump Boat Launch. In response to HSRG recommendations to release steelhead as far upstream as possible upstream (i.e., Gridley boat launch) in-river release locations will be considered in future years.

Yearling production of brood year 2023 steelhead, spawned December 2022 through February 2023, is targeted at 450,000. Releases of brood year 2023 FRH steelhead are planned for February 2024 at the Feather River at the Boyd's Pump Boat Launch. If the FRH survival is good and production is greater than the production goal, additional yearlings will be stocked into the Thermalito Afterbay. Up to 100 steelhead yearlings may be tagged with acoustic tags to track behavior and survival.

