



**SNAKE RIVER SOCKEYE SALMON
CAPTIVE BROODSTOCK PROGRAM
OPERATION AND MAINTENANCE ELEMENT**

**ANNUAL PROGRESS REPORT
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**Snake River Sockeye Salmon
Captive Broodstock Program
Operation and Maintenance Element**

Project Progress Report

2021 Annual Report

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TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	1
INTRODUCTION	3
Snake River SOckeye Captive Broodstock Objectives	3
Objectives and Tasks	4
FACILITIES.....	5
Eagle Fish Hatchery.....	5
Springfield Fish Hatchery	5
Sawtooth Fish Hatchery / Trap.....	6
Redfish Lake Creek Trap	6
METHODS.....	7
Fish Culture	7
Anadromous Sockeye Salmon Trapping	7
Spawning Activities	7
Fish Health Investigations	8
Genetic Investigations.....	9
Laboratory Protocol.....	9
Analyses	10
Eyed Egg and Fish Transfers.....	10
Eyed Egg and Fish Supplementation	11
RESULTS AND DISCUSSION.....	11
Fish Culture	11
Brood Year 2017 Broodstock	12
Brood Year 2018 Broodstock	12
Brood Year 2019 Broodstock	12
Brood Year 2019 Production	13
Brood Year 2020 Broodstock	13
Brood Year 2020 Production	13
Anadromous Sockeye Salmon Trapping	13
2021 Spawning Activities	14
Fish Health Investigations	15
Viral Pathogens.....	15
Bacterial Pathogens	16
Parasitic Pathogens	16
Genetic Investigations.....	16
Eyed Egg and Fish Transfers.....	17
Fish Reintroductions	17
Adult Releases	17
Smolt Releases.....	18
Transfer of Program Information	18
Facility Improvements and Future Projects	18
2021 Facility Improvements.....	18
Future Projects.....	19
ACKNOWLEDGMENTS.....	19
LITERATURE CITED	20

LIST OF TABLES

	<u>Page</u>
Table 1. Summary of losses and magnitude of mortality in Snake River Sockeye Salmon captive broodstock at Eagle Fish Hatchery during 2021.....	23
Table 2. Summary of losses and magnitude of mortality in Snake River Sockeye Salmon production groups during 2021.....	24
Table 3. Calendar year 2021 anadromous Snake River Sockeye Salmon adult return summary.....	25
Table 4. Summary information for 2021 Snake River Sockeye Salmon spawning activities at Eagle Fish Hatchery.	26
Table 5. Parent family and number of Snake River Sockeye Salmon eyed eggs retained for brood year 2021 captive broodstock development at Eagle Fish Hatchery.	27
Table 6. Number of <i>Oncorhynchus nerka</i> samples genotyped during 2021.	28
Table 7. Snake River Sockeye Salmon releases made to Sawtooth Valley waters in 2021.....	29

LIST OF FIGURES

Figure 1. Sawtooth Valley study area.....	30
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EXECUTIVE SUMMARY

The Snake River Sockeye Captive Broodstock Program was initiated to recover Snake River Sockeye in the Sawtooth Valley. Program objectives are shared with cooperating agencies (Idaho Department of Fish and Game, NOAA Fisheries, and Shoshone-Bannock Tribes), with program funding provided by Bonneville Power Administration. The cooperators meet quarterly, Stanley Basin Sockeye Technical Oversight Committee, updating current findings and planning for future activities. Objectives for the Snake River Sockeye Captive Broodstock Program are summarized below:

1. Develop captive broodstocks from Redfish Lake Sockeye Salmon; culture broodstocks and produce progeny for reintroduction.
2. Determine the contribution hatchery-produced Sockeye Salmon make toward avoiding population extinction and increasing population abundance.
3. Describe *O. nerka* population characteristics for Sawtooth Valley lakes in relation to carrying capacity and broodstock program reintroduction efforts.
4. Utilize genetic analysis to discern the origin of wild and hatchery produced Sockeye Salmon to provide maximum effectiveness in their utilization within the broodstock program.
5. Transfer technology through participation in the technical oversight committee process, provide written activity reports, and participate in essential program management and planning activities

The Snake River Sockeye Captive Broodstock Operation and Maintenance Element covers activities related to maintaining a Sockeye Salmon captive broodstock at Eagle Fish Hatchery. This report covers program activities during calendar year 2021. Five year classes (brood years) of captive broodstock and three unique production groups were in culture at Idaho Department of Fish and Game's Eagle Fish Hatchery in 2021. Three of the five brood years of captive broodstock were incorporated into the 2021 spawning design.

A total of 6,494 *Oncorhynchus nerka* genetic samples were genotyped during 2021. These genetic samples were collected from Eagle Fish Hatchery captive broodstock (n = 1,447), NOAA captive broodstock (n = 1,429), juveniles at Lower Granite Dam (n = 128), anadromous returns (n = 332), out-migrating smolts from Pettit Lake (n = 1,083), out-migrating smolts from Redfish Lake (n = 1,494), out-migrating smolts from Alturas Lake (n = 167), trawling (n = 210), Pettit Lake gill netting (n = 128), and re-clips (n = 76) which represent captive broodstock fish that shed tags or for quality assurance checks.

Two hundred forty anadromous Sockeye Salmon were trapped at three locations during 2021. The Sawtooth Fish Hatchery weir on the upper Salmon River intercepted five Sockeye Salmon adults; the Redfish Lake Creek trap intercepted 50 Sockeye Salmon adults; and 185 Sockeye Salmon adults were trapped at Lower Granite Dam and transferred to Eagle Fish Hatchery. The adult Sockeye Salmon (115 females and 125 males) originated from a variety of release strategies, as evidenced by mark types and genetic parentage analysis. One hundred fifty-one anadromous Sockeye Salmon (70 females and 81 males) remained at Eagle Fish Hatchery and were incorporated into the spawning matrix.

Four hundred thirty-seven female Sockeye Salmon (70 anadromous females, 365 BY18, and two BY19 captive females) were spawned at the Eagle Fish Hatchery in 2021. Spawn pairings produced approximately 873,813 green eggs. Egg survival to the eyed stage of development averaged 57.1% (498,948 eyed eggs).

Smolts (1,013,340) and adults (1,226) were released into Sawtooth Valley waters in 2021. Reintroduction strategies involved releases to Redfish Lake, Pettit Lake, Redfish Lake Creek, and the upper Salmon River.

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INTRODUCTION

Numbers of Snake River Sockeye Salmon *Oncorhynchus nerka* (*O. nerka*) declined over the course of the 20th century, dramatically so from the 1950s until and subsequent to the 1991 ESA listing of the stock. In Idaho, only the lakes of the upper Salmon River (Sawtooth Valley) remain as potential sources of production (Figure 1). Historically, five Sawtooth Valley lakes (Redfish, Alturas, Pettit, Stanley, and Yellowbelly) supported Sockeye Salmon (Bjornn et al. 1968; Chapman et al. 1990). Currently, only Redfish Lake receives a remnant anadromous run.

On April 2, 1990, the National Oceanic and Atmospheric Administration Fisheries Service (NOAA, formerly National Marine Fisheries Service) received a petition from the Shoshone-Bannock Tribes (SBT) to list Snake River Sockeye Salmon as endangered under the United States Endangered Species Act (ESA) of 1973. On November 20, 1991, NOAA declared Snake River Sockeye Salmon endangered.

In 1991, the SBT, along with the Idaho Department of Fish and Game (IDFG), initiated the Snake River Sockeye Salmon Sawtooth Valley Project (Sawtooth Valley Project) with funding from the Bonneville Power Administration (BPA). The goal of this program is to conserve genetic resources and to rebuild Snake River Sockeye Salmon populations in Idaho. Coordination of this effort is conducted under the guidance of the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), a team of biologists representing the agencies involved in the recovery and management of Snake River Sockeye Salmon. National Oceanic and Atmospheric Administration Fisheries Service ESA Permit Nos. 1454, 1124-6R, and Fishery Management and Evaluation Plan (FMEP) authorize IDFG to conduct scientific research on listed Snake River Sockeye Salmon.

Initial steps to recover Snake River Sockeye Salmon included the establishment of a captive broodstock program at the Idaho Department of Fish and Game's Eagle Fish Hatchery. Broodstock and fish culture responsibilities for the listed stock are shared with the National Oceanic and Atmospheric Administration's Manchester Research Station and Burley Creek Fish Hatchery adjacent to Puget Sound in Washington State. Activities conducted by the Shoshone-Bannock Tribes and the National Oceanic and Atmospheric Administration are reported separately. Idaho Department of Fish and Game monitoring and evaluation activities associated with captive broodstock program fish releases are reported separately (in an annual report to the Bonneville Power Administration for the Monitoring and Evaluation element of the program). Captive broodstock program activities conducted between January 1, 2021 and December 31, 2021 for the Operation and Maintenance element of the program are presented in this report. Past Program annual reports for the Snake River Sockeye Salmon Project go to Columbia Basin Fish and Wildlife Program's website at: cbfish.org - [Columbia Basin Fish & Wildlife Program](http://cbfish.org)

SNAKE RIVER SOCKEYE CAPTIVE BROODSTOCK OBJECTIVES

The immediate goal of the program is to utilize captive broodstock technology to conserve the population's remaining genetic diversity. Long-term goals include increasing the number of individuals in the population to address delisting criteria and to provide sport and treaty harvest opportunities. Below are the objectives and tasks covered in this report:

Objectives and Tasks

1. Rear Snake River Sockeye Salmon captive broodstocks.
 - a. Monitor rearing metrics; survival, growth, maturation, fish health, densities, and water quality.
 - b. Produce captive reared adults for spawning and reintroduction to Sawtooth Valley lakes.
2. Trap anadromous adults to incorporate into captive broodstock spawning design.
 - a. Trap anadromous returning adults in the Sawtooth Valley.
 - b. Transport anadromous adults to Eagle FH.
 - c. Release anadromous adults to Sawtooth Valley lakes.
3. Individually identify captive broodstock and anadromous returns to aid in the development of adult release and spawning plans.
 - a. Genetically sample and PIT tag captive broodstock juveniles.
 - b. Genetically sample and PIT tag anadromous returning adults.
 - c. Analyze genetic information.
 - d. Develop adult release plan.
 - e. Develop spawning plan.
4. Spawn Sockeye Salmon captive and anadromous broodstock.
 - a. spawning
 - b. egg care
 - c. broodstock selection
 - d. egg distribution
5. Transfer technology through participation in the technical oversight committee process, provide written activity reports, and participate in essential program management and planning activities.
 - a. FINS database maintenance
 - b. AOP/SOP planning
 - c. quarterly SBSTOC meetings
 - d. participation in IDFG and AFS meetings
6. Eagle Fish Hatchery annual maintenance projects.
 - a. improvements made during 2021
 - b. future facility improvements

Idaho Department of Fish and Game's participation in the Snake River Sockeye Salmon Captive Broodstock Program includes two areas of effort: 1) Sockeye Salmon captive broodstock culture and smolt production, and 2) Sockeye Salmon monitoring and evaluation. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to Sockeye Salmon captive broodstock monitoring and evaluation will appear under a separate cover. This report covers activities associated with operation and maintenance of the captive broodstock program including; fish culture, anadromous trapping, genetic evaluations, broodstock spawning, program reporting, and facility improvements.

FACILITIES

Eagle Fish Hatchery

Eagle FH is the primary Idaho site for the Sockeye Salmon captive broodstock program. Artesian water from three wells is currently in use. Artesian flow is augmented with three separate pump/motor systems. Water temperature remains a constant 13.5°C and total dissolved gas averages 100% after degassing. The main captive broodstock building receives water from wells #1 and #2 (up to 1,000 gallons per minute). Up to 300 gallons per minute (gpm) can be chilled to 8°C allowing the program to rear at a variety of water temperatures. Rearing capacity for the main building is approximately 1,500 fish per brood year. Isolated holding and spawning of anadromous Sockeye Salmon is conducted in the original hatchery building. Up to 500 gpm of water is supplied from well #3. Approximately 150 gpm can be chilled to 7°C and mixed to provide a variety of rearing temperatures. Backup and system redundancy is in place for degassing, pumping, and power generation. An automated alarm system monitors flow at nine locations with two alarms tied to the chiller operations. Mountain Alarm provides alarm service for the facility. Three on-site residences provide housing for full-time hatchery personnel. A dormitory is available to house temporary staff.

Facility layout at Eagle FH accommodates culture activities ranging from egg incubation through adult rearing and spawning. Egg incubation uses a combination of vertical stack incubators and small isolation upwellers. Thirty-six vertical stack incubators, each holding eight trays, will incubate up to 1,000,000 green eggs. Each tray contains four smaller baskets to maintain family group separation during incubation. An additional 250,000 green eggs can be incubated using isolated upwellers. Incubation in these small containers specifically designed for the program (Heindel et al. 2005) allow for separation of individual subfamilies. These incubators are designed to distribute both upwelling and downwelling flow to accommodate pre- and post-hatch life stages.

Fiberglass tanks of several sizes are used to culture Sockeye Salmon from fry to adult life stages, including: 1) 0.7 m diameter semi-square tanks (0.09 m³); 2) 1.0 m diameter semi-square tanks (0.30 m³); 3) 2.0 m diameter semi-square tanks (1.42 m³); 4) 3.0 m diameter circular tanks (6.50 m³); and, 5) 4.0 m diameter semi-square tanks (17.6 m³). Typically, 0.7 m and 1.0 m tanks are used for rearing fry from ponding to approximately 10.0 g fish. Two-meter tanks are used to rear juveniles to approximately 50.0 g and to temporarily hold mature adults during spawning operations. Three- and four-meter tanks are used to rear fish to maturity for broodstock production (spawning) or releasing to Sawtooth Valley waters for volitional spawning. Flows to all tanks are maintained at no less than 1.5 exchanges per hour. Shade covering (70%) and jump screens are used where appropriate. Discharge standpipes are external on all tanks and assembled in two sections (“half-pipe” principle) to prevent tank dewatering during tank cleaning.

Springfield Fish Hatchery

Springfield Fish Hatchery is located in Bingham County, Idaho near the town of Springfield. Construction of the facility was completed in 2013 from funding provided by BPA through the Idaho Fish Accords. A confined aquifer underlying the Springfield FH site supplies groundwater for hatchery operations. The facility has a water right for 50 cfs. There are nine artesian wells located on the northern section. Six of the wells (wells 5, 7, 8, 10, 11, and 12) supply groundwater for hatchery production operations. These six wells feature a dual-head design that allows water delivery by both artesian flow and pumping. Due to elevation differences, artesian flow cannot supply the hatchery building, but can supply outdoor raceways. The ambient water

temperature remains a constant 9.9°C and ambient temperature total dissolved gas (TDG) levels currently range from 100% - 101% after aeration and degassing. Additionally, a chiller supplies up to 110 gpm of water chilled to 5.0°C for use in incubation or early rearing. Backup and system redundancy is in place for degassing, pumped water delivery, chilled water supply, and power generation. Springfield FH facilities are designed to rear up to one million Sockeye Salmon smolts annually for release to Redfish Lake Creek. Rearing protocols are established cooperatively among IDFG personnel and reviewed by the SBSTOC.

Eyed eggs, received by Springfield FH from Eagle FH and NOAA Fisheries, are incubated in vertical stack incubators. Swim-up fry are ponded into fiberglass vats and reared indoors for five to six months. Juveniles are transferred (during ad-clipping) to outdoor raceways in July and reared through release as smolts the following May. Juvenile Sockeye Salmon reared at Springfield FH are released as smolts into Redfish Lake Creek following acclimation at Sawtooth Fish Hatchery. No adult holding or spawning is planned at Springfield FH. For additional information, Springfield Fish Hatchery Annual (Progress) Reports to Bonneville Power Administration can be found on Columbia Basin Fish and Wildlife Program's website at: cbfish.org

Sawtooth Fish Hatchery / Trap

Construction of the Sawtooth Fish Hatchery (Sawtooth FH) was completed in 1985 as part of the U.S. Fish and Wildlife Service Lower Snake River Compensation Plan and is located on the Salmon River, 3.5 km upstream from the confluence of Redfish Lake Creek. Between 1991 and 2021 Sawtooth FH personnel and facilities were utilized for various aspects of the Sockeye Salmon captive broodstock program, including 1) prespawn anadromous adult trapping and holding, 2) egg incubation, and 3) juvenile rearing for presmolt and smolt releases. Currently, only adult collection and smolt acclimation occurs at Sawtooth FH. Beginning in 2018, Sockeye Salmon smolts are transferred to Sawtooth FH for acclimation before releasing to Redfish Lake Creek in May. Sawtooth FH personnel assist with many field activities, including, 1) fish trapping and handling, 2) smolt feeding and monitoring during acclimation, and 3) fish transportation and release.

Prespawn anadromous adults captured at the Sawtooth FH trap are transferred to Eagle FH, released upstream of the Sawtooth FH intake, or transported and released directly to Pettit Lake for volitional spawning. Sockeye Salmon trapped at Sawtooth FH may be temporarily held (two days maximum) in adult holding facilities at Redfish Lake Creek prior to transfer to the Eagle FH.

Redfish Lake Creek Trap

The Redfish Lake Creek trap is located approximately 1.4 km downstream from the lake outlet. It is operated for adult trapping from early July through mid-October. Sockeye Program personnel stationed at the trap monitor trapping activities during the trapping season. On-site personnel provide security at the site and are responsible for transporting anadromous Sockeye Salmon to Eagle FH. Construction to replace the old weir was completed in 2018. The new weir and trap includes a streamside trap/holding area for adults, along with a smolt/adult work-up area, and a dormitory for staff operating the trap.

Prespawn anadromous adults captured at the Redfish Lake Creek trap are transferred to Eagle FH or released to Redfish Lake Creek above the weir. Sockeye Salmon may be temporarily held (two days maximum) in adult holding facilities at Redfish Lake Creek prior to transfer to the Eagle FH.

METHODS

Fish Culture

Fish culture methods used in the captive broodstock program follow accepted, standard practices (for an overview of standard methods, see Leitritz and Lewis 1976; Piper et al. 1982; Erdahl 1994; McDaniel et al. 1994; Bromage and Roberts 1995; Pennell and Barton 1996; Wedemeyer 2001) and conform to the husbandry requirements detailed in ESA Section 10 Propagation Permit Number 1454 for IDFG rearing of ESA-listed Snake River Sockeye Salmon. Additionally, considerable coordination was carried out between NOAA and IDFG culture experts, as well as program cooperators on the SBSTOC.

Fish were fed a commercial diet produced by EWOS® Canada LTD (EWOS). Rations were weighed daily and feeding rates follow manufacturer recommendations. The product's palatability and levels of natural pigments were enhanced by the addition of natural flavors from fish and krill.

Fish sample counts were conducted as needed to ensure that actual growth tracked with projected growth. In general, fish were handled as little as possible. Age-1 and age-2 Sockeye Salmon rearing densities were maintained at levels not exceeding 8.0 kg/m³. Age-3 and age-4 rearing densities were maintained at levels not exceeding 16.0 kg/m³.

Incubation and rearing water temperature was maintained between 7.0°C and 13.5°C. Chilled water (7.0°C to 11.0°C) was used during incubation and early rearing to equalize development and growth differences that resulted from a protracted spawning period. Rearing water temperature varied as a function of demand, but was generally maintained between 10.0°C and 12.0°C throughout much of the age-2, age-3, and age-4 culture history.

Passive integrated transponder (PIT) tags were used to track Sockeye Salmon retained in the program as broodstock fish; these fish were PIT tagged at approximately 14 months of age. The PIT tag procedures followed accepted, regional protocols (Prentice et al. 1990).

Anadromous Sockeye Salmon Trapping

Two adult traps were used to capture returning anadromous Sockeye Salmon in the Sawtooth Valley. The first trap was located on Redfish Lake Creek approximately 1.4 km downstream from the lake outlet. The second trap was located on the upper Salmon River at the Sawtooth FH weir.

Anadromous Sockeye Salmon may also be collected at the Lower Granite Dam adult trap. During years of extremely poor migration conditions, the Sockeye Program and cooperators will review migration parameters to determine if trap and haul is warranted. If Emergency Sockeye Trap and Haul is implemented, Sockeye Program staff will coordinate with Lower Granite Dam operators and develop a trapping protocol to address the current operations of the LGD trap and develop a Standard Operation Procedure (SOP) for the current trapping season. Sockeye Salmon adults collected during trap and haul are transferred to Eagle FH.

Spawning Activities

Hatchery spawning of Snake River Sockeye Salmon has occurred at Eagle FH each year since 1994 (BPA Annual (Progress) Reports covering spawning activities for the Snake River Sockeye Salmon Program can be found on the Columbia Basin Fish and Wildlife Program's

website at: cbfish.org). Before 1994, adult Sockeye Salmon returns were spawned at the Sawtooth FH (Johnson 1993). Spawning activities in 2021 followed accepted, standard practices as described by Erdahl (1994) and McDaniel et al. (1994). Prior to spawning adults at Eagle FH, the Idaho Department of Fish and Game is required by NOAA Permit No. 1454 to discuss proposed broodstock spawning matrices with SBSTOC members.

Historically, the broodstock program used pedigree information to pool eyed eggs developed from hatchery spawning into broodstock rearing groups. Identification of familial groups was maintained by tank segregation until juveniles were large enough to PIT tag. From 2005 through 2017, breeding protocols relied on DNA microsatellite genotypes to assign individuals to a pedigree. Microsatellite data were generated from DNA samples at 16 loci. Kinship coefficients and mean kinship coefficients were used to determine relative founder contribution in the population, genetic importance, and relative relatedness. Beginning in 2018, the genetics program transitioned from microsatellites to single nucleotide polymorphisms (SNP's). The IDFG Eagle Genetics Lab genotypes each individual with up to 382 SNP loci to determine parentage and relatedness to individuals within the captive broodstock. Spawning plans also considered heterozygosity and genetic diversity among and within individuals. Genetic-based spawning plans provide a higher level of resolution than was possible with the initial tank-based pedigree information, which can minimize the loss of heterozygosity and inbreeding.

Fish Health Investigations

When required, the captive broodstock rearing program has utilized various disinfectants, antibiotics, vaccinations, and antifungal treatments to control pathogens. When used, the dosage, purpose of use, and method of application were as follows:

1. Antibiotic therapies: Erythromycin treatments are administered orally in feed to produce a dose of 100 mg/kg of bodyweight for up to 28 days. When oral administration is not feasible, as with anadromous adults, an intraperitoneal injection of erythromycin is given to fish at a dose of 20 mg/kg of body weight. In addition, fish may be fed oxytetracycline as needed to control outbreaks of pathogenic myxobacteria, as well as aeromonad and pseudomonad bacteria.
2. Egg disinfection: Newly fertilized eggs are water hardened in 100 mg/L solution of buffered Iodophor for 20 minutes to inactivate viral and bacterial pathogens on the egg surface and in the perivitelline space. In addition, eyed eggs transferred to IDFG facilities are disinfected in a 100 mg/L buffered Iodophor solution for ten minutes upon receipt, prior to loading of incubators.
3. Anadromous adult formalin treatments: Anadromous adults transferred from the Sawtooth Valley are treated with formalin in a static bath for one hour at 167 parts per million (ppm) to control *Ichthyophthirius* spp. In addition, formalin treatments are administered three to five times per week to control *Saprolegnia*.
4. Egg formalin treatments: Developing eggs are treated three to five times per week with formalin to control *Saprolegnia*. This is a flow-through treatment administered at 1,667 ppm for 20 minutes.

Captive broodstock female spawners were analyzed for bacterial kidney disease (BKD) *Renibacterium salmoninarum* and the viral pathogen infectious hematopoietic necrosis virus (IHNV). In addition to the above, anadromous adult Sockeye Salmon were screened for bacterial

gill disease *Flavobacterium branchiophilum*, Coldwater disease *Flavobacterium psychrophilum*, motile aeromonad septicemia *Aeromonas* spp, the causative agent of whirling disease *Myxobolus cerebralis* (up to 20 head wedges), furunculosis *Aeromonas salmonicida*, *Parvicapsula minibicornis* (up to 30 males and 30 females sampled), infectious pancreatic necrosis virus, and the North American strain of viral hemorrhagic septicemia. Tissue samples were collected from the kidney and spleen of each fish and the Eagle FH staff collected ovarian fluid samples from each spawned female for analysis at the Eagle Fish Health Laboratory. Results of fish health analysis of spawners were used by IDFG and the SBSTOC to determine disposition of eggs and subsequent juveniles.

Fish health was monitored daily by observing feeding response, external condition, and behavior of fish in each tank as initial indicators of developing problems. In particular, fish culturists looked for signs of lethargy, spiral swimming, side swimming, jumping, flashing, unusual respiratory activity, body surface abnormalities, or unusual coloration. Presence of any of these behaviors or conditions was immediately reported to the program fish pathologist.

Presence of moribund fish was immediately reported to the fish pathologist for blood and parasite sampling; the fish pathologist routinely monitors captive broodstock mortalities to try to determine cause of death. American Fisheries Society (AFS) "Bluebook" procedures were employed to isolate bacterial or viral pathogens and to identify parasite etiology (Thoesen 1994). Moribund fish were routinely analyzed for common bacterial and viral pathogens (e.g., bacterial kidney disease, infectious hematopoietic necrosis virus, etc.). When a treatable pathogen was either detected or suspected, the program fish pathologist prescribed appropriate therapeutic drugs to control the problem. Select carcasses were appropriately preserved for pathology, genetic, and other analyses. After necropsy, carcasses that were not vital to further analysis were disposed of as per language contained in the ESA Section 10 permit for the program.

Genetic Investigations

Laboratory Protocol

Genomic DNA from samples was extracted following the methods for the Nexttec Genomic DNA Isolation Kit from XpressBio (Thurmont, Maryland). Protocols of library preparation for next-generation genotyping followed Campbell et al. (2015) using Genotyping-In-Thousands by sequencing (GT-Seq) technology. Briefly, library preparation begins with an initial multiplex polymerase chain reaction (PCR) that ligates sequencing primers to the target sequences that are known to contain single-nucleotide polymorphisms (SNPs). Samples were processed using a panel of 363 SNPs targeting sequences described by Hasselman et al. (2018). In a subsequent PCR, the sample was "barcoded" by ligating an additional sequence to the target that identifies the sample's tray of origin (i7 barcode) and its position on the tray (i5 barcode). After barcoding, the quantity of DNA was normalized for each sample using a SequalPrep™ Normalization Plate Kit (Applied Biosystems) that binds a standard amount of amplicon product to allow for normalization of concentrations. All samples per tray were then pooled into a single 'plate library' that was quantified by a Qubit fluorometer (Thermo Fisher). Concentrations were normalized again before being pooled. Loci were genotyped by sequencing the target location on an Illumina NextSeq. A custom bioinformatics pipeline was used to assign resulting sequences and the genotypes back to individual samples using the unique combination of i5 and i7 barcodes. Standardized genotypes were stored on a Progeny database server (www.progenygenetics.com) housed at the Eagle Fish Genetics Laboratory (EFGL).

Analyses

Selection of broodstock for spawning follows internationally recognized standards for captive breeding programs. The primary threat to the genetic health of captive populations is the loss of genetic diversity (Ballou et al. 2010) and maintaining a large effective population size (N_e) is the best approach to preserving existing genetic variation (Wright 1931). Therefore, selection of broodstock for spawning uses methods that maximize N_e . The genetic parameter of 'mean kinship' is the foundation of the Sockeye Salmon broodstock selection process. Mean kinship (MK) is a measure of an animal's relatedness to that of the entire current population. Selecting individuals for breeding with low MK values has been demonstrated to maximize genetic diversity, minimize the rate of adaptation to the captive environment, minimize the rate of random genetic drift (and therefore, by definition, maximize N_e), and minimize long-term accumulation of inbreeding (Lacy 2009, Fernandez and Toro 1999, Montgomery et al. 1997, and Ballou and Lacy 1995). Equalizing representation from family groups in which each family member has an equal MK value is also an important step in maximizing N_e (Allendorf 1993, Borlase et al. 1993). The combination of MK values and parentage assignments were used to identify individuals that are prioritized for spawning.

Genetic analyses comprise a two-step process. The first step performs parentage analysis of the maturing broodstock so that individuals can be placed within the existing, long-term pedigree of the captive breeding program. The second step analyzes the updated pedigree in order to select individual broodstock in a manner that maximizes the retention of genetic diversity.

Parentage Analysis: Parentage assignment using SNP genotypes was performed using the program SNPPIT (Anderson 2010). We allowed up to 10% missing genotype data for a sample before excluding the sample from consideration in parentage. We used an estimated SNP genotyping error rate of 1% or a per allele rate of 0.5%. SNPPIT assesses the confidence of parentage assignments using several parameters and parentage assignments are accepted only if LOD scores are ≥ 14 , false discovery rate (FDR) $< 1\%$, and posterior probability relationship identifies a parent-offspring trio (C_Se_Se).

Pedigree Analysis: The program PMx (Ballou et al. 2011) provides tools to support the genetic management of pedigreed populations and was used for analysis of the updated pedigree of the captive broodstock. The program provides summary statistics for the maturing individuals including 'Mean Kinship', which can be interpreted as measure of the genetic importance of each individual. The rankings of mean kinship values, along with parentage assignments for each individual, were used to select broodstock for spawning or release.

Eyed Egg and Fish Transfers

Eggs were shipped at the eyed stage of development between NOAA and IDFG facilities using a commercial air service. Iodophor-disinfected (100 ppm) eggs were packed at a conservative density in perforated tubes, then capped and labeled. Tubes were wrapped with hatchery water-saturated cheesecloth and packed in small coolers. Ice chips were added to ensure proper temperature maintenance, and coolers were sealed with packing tape. Personnel from IDFG and NOAA were responsible for shuttling coolers to and from air terminals. Eyed eggs destined for production at Springfield FH were placed in egg shipping tubes at approximately 2,500 eggs per tube. Eyed eggs were then placed in 40-quart, water filled, transport coolers and tempered to 6° Celsius. Ice was added to the cooler to keep eggs cool during transport to Springfield FH.

Containers used to transport fish varied by task. In all cases, containers of the proper size and configuration were used. Appropriate temperature, oxygen, and chemical composition was maintained during the handling and transfer phases of transportation. Containers varied from five-gallon plastic buckets and coolers for short-term holding and inventory needs to truck-mounted tanks. Truck-mounted tanks, used for long distance transfers, were available to the program with 1,514 L (400 gallon), 3,785 L (1,000 gallon), 7,570 L (2,000 gallon), 11,355 L (3,000 gallon), and 18,926 L (5,000 gallon) capacities. Transport density guidelines were in place not to exceed 120 grams/liter (1.00 pounds/gallon).

Eyed Egg and Fish Supplementation

Multiple release strategies are implemented to reintroduce Sockeye Salmon back to Sawtooth Valley waters. During this reporting period, Sockeye Salmon were released as smolts and pre-spawn adults.

Sockeye Salmon smolts are distributed to Sawtooth Valley waters using truck-mounted transportation tanks. This group is first transferred from Springfield FH to Sawtooth FH and acclimated for approximately one to two weeks before release to Redfish Lake Creek. Smolt releases take place in early May. Smolts were released into the Salmon River during this reporting period.

Prespawn adult Sockeye Salmon are distributed to Sawtooth Valley waters using truck-mounted transportation tanks. Adults are released to Sawtooth Valley lakes in in mid-September. Transport tanks are tempered to receiving water temperatures prior to the release of fish. Prespawn adults were released into Sawtooth Valley lakes during this reporting period.

RESULTS AND DISCUSSION

Fish Culture

Captive broodstock in culture at Eagle FH were represented by brood years 2017, 2018, 2019, 2020, and 2021. Three production groups in culture at IDFG facilities in 2021 were represented by brood years 2019, 2020, and 2021. Culture groups developed to meet future spawning needs are designated as “broodstock” groups. Culture groups developed primarily for reintroduction to Sawtooth Valley waters are designated as “production” groups. The year of development for specific culture groups may be abbreviated (e.g., BY17 refers to brood year 2017).

Fish health of captive reared Sockeye salmon remained good with no pathogens of concern identified from samples analyzed. Survival of captive broodstock reared at Eagle Hatchery was 92.4% across all brood years during 2021. Captive broodstock representing brood years BY17, BY18, and BY19 matured during 2021 and were released to spawn volitionally in Redfish Lake or remained at Eagle FH and incorporated into the broodstock spawning design. Of the 1,174 captive broodstock that matured, 477 were released to Redfish Lake and 697 were spawned at Eagle FH.

Brood Year 2017 Broodstock

Four hundred eighty-one females and 450 males were spawned at Eagle FH between September 29 and November 7, 2017, yielding 998,949 green eggs. Nine hundred sixty-one unique subfamilies were developed from BY17 spawn crosses at Eagle FH. (Baker et al. 2018).

Approximately 3,008 eyed eggs representing 955 subfamilies (479 unique females and 450 unique males) were selected from specific spawn crosses described above to represent BY17 captive broodstock. Two similar groups were selected (1,504 eyed eggs each), with one group remaining at Eagle FH and the other transferred to NOAA Fisheries for incubation and rearing.

The 2021 starting inventory for the BY17 captive broodstock at Eagle FH was 11 fish. Of the 11 age-4 adults, five adults were immature mortalities and six fish were determined to be maturing during ultrasound activities in August. Of the six maturing age-4 adults, four males were spawned and two females were unproductive and culled. Ending inventory for the BY17 captive broodstock was zero fish (Table 1).

Rearing of the BY 17 captive broodstock cohort was completed in 2021. This group had an overall survival from eyed egg to adult of 77.46%. Mature adults were either released or incorporated into the Eagle FH spawning design. From this group, 335 captive reared adults were released to Redfish Lake and 830 captive reared adults were incorporated into spawning designs. Age at maturation for the BY17 cohort was 3.4% age two, 96.1% age 3, and 0.5% age 4.

Brood Year 2018 Broodstock

Four hundred twenty-seven females and 440 males were spawned at Eagle FH between September 27 and November 6, 2018, yielding 862,957 green eggs. Eight hundred fifty-two unique subfamilies were developed from BY18 spawn crosses at Eagle FH. (Baker et al. 2019).

Approximately 3,013 eyed eggs representing 811 subfamilies (410 unique females and 432 unique males) were selected from specific spawn crosses described above to represent BY18 captive broodstock. Two similar groups were selected, with 1,508 eyed eggs retained at Eagle FH and a second group of 1,505 eyed eggs transferred to NOAA Fisheries, for incubation and rearing.

The 2021 starting inventory for the BY18 captive broodstock at Eagle FH was 1,305 fish. Mortality for the year was 186 fish and 1,113 matured. Of the 1,113 maturing fish, 627 (262 males and 365 females) were incorporated into the spawning matrix, nine fish were culled as unproductive and 477 maturing Sockeye Salmon were released to Redfish Lake. Ending inventory for the BY18 captive broodstock was six fish (Table 1).

Brood Year 2019 Broodstock

Four hundred sixty-nine females and 347 males were spawned at Eagle FH between September 20 and November 7, 2019, yielding 1,005,762 green eggs. Nine hundred thirty-four unique subfamilies were developed from BY19 spawn crosses at Eagle FH. (Baker et al. 2020).

Approximately 3,000 eyed eggs representing 918 subfamilies (463 unique females and 345 unique males) were selected from specific spawn crosses described above to represent BY19 captive broodstock. Two similar groups were selected, with 1,500 eyed eggs retained at Eagle

FH and a second group of 1,500 eyed eggs transferred to NOAA Fisheries, for incubation and rearing.

The 2021 starting inventory for the BY19 captive broodstock at Eagle FH was 1,448 fish. Mortality for the year was 66 fish and 70 matured (68 males and 2 females). Of the maturing fish, 66 (64 males and 2 females) were incorporated into the spawning matrix and four males were culled as unproductive. Ending inventory for the BY19 captive broodstock was 1,329 fish (Table 1).

Brood Year 2019 Production

The 2021 starting inventory for the BY19 smolt production group at Springfield FH was 1,073,948 fingerlings. A total 1,013,340 smolts were released on April 30, 2021. (Table 2). Cumulative mortality from eyed egg to smolt for the Springfield FH smolt release group was 150,585 juveniles (88.2% survival to release).

Brood Year 2020 Broodstock

Four hundred sixty-four females and 504 males were spawned at Eagle FH between September 24 and November 12, 2020 yielding 958,562 green eggs. Nine hundred twenty-five unique subfamilies were developed from BY20 spawn crosses at Eagle FH. (Baker et al. 2021).

Approximately 3,001 eyed eggs representing 870 subfamilies (440 unique females and 496 unique males) were selected from specific spawn crosses described above to represent BY20 captive broodstock. Two similar groups were selected, with 1,501 eyed eggs remaining at Eagle FH and a second group of 1,500 eyed eggs transferred to NOAA Fisheries, for incubation and rearing.

The 2021 starting inventory for the BY20 captive broodstock at Eagle FH was 1,501 eyed eggs/developing fry. The BY20 captive broodstock group was marked/tagged (adipose clipped, PIT tagged, and genetically sampled) in December 2021. Mortality for the year was 89 fry. Ending inventory for the BY20 captive broodstock was 1,412 fingerlings (Table 1).

Brood Year 2020 Production

A total of 972,338 BY20 eyed eggs from production spawn crosses at Eagle FH and Burley Creek FH were transferred to Springfield FH. Inventory for this production group at Springfield FH for the end of the year was 910,183 fish. Juvenile rearing for the production group at Springfield FH will continue until smolts are released in 2022 (Table 2).

Anadromous Sockeye Salmon Trapping

Two adult traps were used to capture returning anadromous Sockeye Salmon in the Sawtooth Valley in 2021, and additional adults were trapped and hauled at Lower Granite Dam. The first trap is located on Redfish Lake Creek, approximately 1.4 km downstream from the lake outlet and was operated from July 20 to October 14, 2021. The second trap is located on the upper Salmon River at the Sawtooth FH weir and was operated from June 15 to September 24, 2021.

A number of metrics have been developed to monitor anadromous Sockeye Salmon migration conditions and identify potential fish passage delays and blockages (Crozier et al.

2014). During 2021, low river flows and high water temperatures in the Snake and Salmon rivers warranted implementation of Emergency Sockeye Trap and Haul from Lower Granite Dam to Eagle FH. Between July 6 and July 28, 185 Snake River Sockeye Salmon anadromous returning adults were trapped at the Lower Granite Dam Adult trap and transferred to Eagle FH.

Program cooperators from United States Army Corps of Engineers, NOAA Fisheries, Idaho Fish and Game, Nez Perce Tribes, Shoshone-Bannock Tribes, Washington Department of Fish and Wildlife all worked cooperatively to develop and modify Lower Granite Dam Adult trapping protocols, approving transport permits, certification of transport staff to access the LGD adult trap, addressing transport schedules, and temporary Sockeye holding plans.

Sockeye salmon adults were collected during normal sampling activities at Lower Granite Dam from Monday through noon on Thursday. Trapping operations were temporarily adjusted to target Sockeye observed ascending the ladder on Tuesday and Thursday mornings while transport vehicles were preparing to return to Eagle FH. Sockeye were transported twice per week (Tuesday and Thursday) with fish collected on Monday and Wednesday held for one day in steelhead kelt recovery tanks.

An additional 55 anadromous Sockeye Salmon were trapped and collected in the Sawtooth Valley between August 7 and October 7, 2021. The weir on the upper Salmon River at the Sawtooth FH intercepted five Sockeye Salmon adults and the Redfish Lake Creek trap intercepted 50 Sockeye Salmon adults. Mark type and genetic parentage analysis were used to determine that adult Sockeye Salmon captured during trapping activities originated from a variety of release strategies (Table 3).

Three anadromous Chinook salmon *O. tshawytscha* adults were trapped at the Redfish Lake Creek trap. All were hatchery reared (ad-clipped) and transferred to Sawtooth FH to be incorporated into the spawning program.

2021 Spawning Activities

Results from 2021 Eagle FH spawning activities are reviewed below. Results from spawning activities conducted by NOAA Fisheries personnel at Burley Creek FH will appear separately and can be found on the Columbia Fish and Wildlife website at: cbfish.org - [Columbia Basin Fish & Wildlife Program](http://cbfish.org). The year of development for specific broodstocks may be abbreviated (e.g., BY17 refers to brood year 2017).

Four hundred thirty-seven females and 411 males were spawned at Eagle FH between September 28 and November 16, 2021 yielding 873,813 green eggs. Eight hundred seventy-three unique subfamilies were developed from BY21 spawn crosses at Eagle FH. To simplify tracking, families were grouped under one production group title: BY21. The BY21 captive broodstock group was developed using male Sockeye Salmon from the BY17 (four males), BY18 (262 males) BY19 (64 males), and 81 anadromous males that were collected during 2021 trapping activities (ANH21). Female Sockeye Salmon represented in spawn crosses for 2021 included captive broodstock from BY18 (365 females), BY19 (two females), and 70 anadromous females (ANH21) that were collected during trapping activities in 2021. Specific crosses performed to develop this production group included: 1) ANH21 females x ANH21 males; 2) ANH21 females x BY18 males; 3) ANH21 females x BY19 males; 4) BY18 females x ANH21 males; 5) BY18 females x BY17 males; 6) BY18 females x BY18 males; 7) BY18 females X BY19 males; 8) BY19 females X ANH21 males, and 9) BY19 females X BY18 males (Table 4). Spawn crosses produced approximately 873,813 green eggs and 498,948 eyed eggs. Brood year 2018 female fecundity

averaged 1,963 green eggs per female, BY19 female fecundity averaged 1,262 green eggs per female, and ANH21 female fecundity averaged 2,213 green eggs per female. Egg survival to the eyed stage of development for the BY21 production group averaged 57.10% (median 57.67%, Table 4). In 2021, of the 118 anadromous adults sampled at Eagle FH, infectious hematopoietic necrosis virus (IHNv) was not detected.

Approximately 3,003 eyed eggs representing 850 subfamilies (428 unique females and 410 unique males) were selected from specific spawn crosses described above to represent BY21 captive broodstock. Two similar groups were selected, with 1,502 eyed eggs remaining at Eagle FH and a second group of 1,501 eyed eggs transferred to NOAA Fisheries, for incubation and rearing.

Historically, broodstock families were kept separated in individual tanks until PIT tagging and then pedigree information for the familial line was utilized to make spawn crosses. Genetic identification of BY21 captive broodstock will be determined by utilizing SNP's DNA markers. Spawn crosses represented in the Eagle FH BY21 captive broodstock are presented in Table 5.

A total of 897,828 BY21 eyed eggs were transferred to Springfield FH for smolt production rearing. Production spawn crosses at Eagle FH provided 493,762 eyed eggs and Burley Creek FH provided 404,066 eyed eggs. Egg incubation and juvenile rearing for the BY21 production group will continue at Springfield FH until smolts are released in May 2023.

Fish Health Investigations

The IDFG Eagle Fish Health Laboratory processed samples for diagnostic and inspection purposes from captive broodstock and production groups of Sockeye Salmon, including anadromous adults that were retained for hatchery spawning and smolts obtained from out-migrant traps. One hundred twenty-five laboratory accessions involving 1,079 individual fish were processed in 2021. Laboratory accessions included samples from Eagle FH (97 accessions), Springfield FH (four accessions), NOAA Fisheries (23 accessions) and Redfish Lake natural out-migrants (one accession). Total fish sampled (1,079) included; 591 fish from Eagle FH (429 BY18, 35 BY19, one BY20, and 126 ANH21), 42 fish from Springfield FH (12 BY19 and 30 BY20), 441 fish from NOAA Fisheries, and five fish from Redfish Lake. Observations made from previous years prioritized the pathogens that were most important for these examinations. All female adults used for captive broodstock purposes were examined for viruses and bacterial kidney disease (BKD). Anadromous adults were examined for a broad array of pathogens, since these pose the greatest threat of introduction of an exotic pathogen to the captive broodstock program. All production lots were examined prior to release as juveniles. The Eagle Fish Health Lab also summarized pathology findings to satisfy the needs of adjacent state agencies for issuance of Sockeye Salmon transport permits.

Viral Pathogens

Viral pathogens were not detected in Sockeye Salmon (captive broodstocks, production groups, natural out-migrants, or anadromous adults) during calendar year 2021. Samples were collected at Eagle FH from captive broodstock and anadromous adults representing BY18, BY19, BY20, and ANH21 (97 accessions and 591 fish). These samples were analyzed at IDFG's Eagle Fish Health Lab. Eagle Fish Health Lab began sampling NOAA Fisheries captive broodstock in 2015 (previously these samples were collected and analyzed by NOAA Fisheries staff) and continued sampling in 2021. Samples were collected from spawned captive broodstock at Burley Creek FH representing BY17, BY18, and BY19 (18 accessions and 373 fish sampled) and from

Manchester Research Station representing BY17, BY18, and BY19 (5 accessions and 68 fish sampled). Two production groups (BY19 and BY20) from Springfield FH were sampled (four accessions and 42 fish) and analyzed at Eagle Fish Health Lab in 2021. Natural out-migrants were sampled at Redfish Lake Creek smolt trap (one accession and five fish sampled) during 2021. All virology samples from these groups resulted in negative detection of viral pathogens for 2021.

Bacterial Pathogens

Fish health sampling for *Renibacterium salmoninarum*, the causative agent for bacterial kidney disease (BKD), is a standard fish health sampling protocol for broodstock, production, and out-migrant groups of Redfish Lake Sockeye Salmon. A total of 1,079 fish from calendar year 2021 were sampled for BKD via enzyme-linked immunosorbent assay (ELISA) techniques at Eagle Fish Health Lab. Three broodstock females (one anadromous female at Eagle FH and two captive females at Burley Creek FH) tested positive for BKD. Eggs from the positive female with a high ELISA value (≥ 0.40) were culled (one female; 2,183 eggs) in 2021. Sockeye Salmon smolts from Springfield FH were sampled prior to release, and out-migrating smolts from Redfish Lake were sampled. Bacterial Kidney Disease was not detected in these smolt groups during 2021.

Parasitic Pathogens

The myxosporean parasite *Myxobolus cerebralis* (*M. cerebralis*), the causative agent of whirling disease in salmonid fish, is present in the upper Salmon River. *Oncorhynchus nerka* samples obtained by emigrant smolt trapping and from trawl efforts in Redfish, Pettit, and Alturas lakes are routinely examined for *M. cerebralis*. Juvenile *O. nerka* were not sampled in 2021. Positive results have been confirmed in returning anadromous adults tested for *M. cerebralis* via Pepsin-trypsin digest (PTD) testing; this is consistent with positive detections in 16 of the last 19 return years. Samples collected from anadromous adults (118 samples) were grouped in five fish pools. During 2021, five pools tested positive for *M. cerebralis*.

Eggs and adult anadromous Sockeye Salmon were treated with formalin to control Saprolegnia. Eggs were treated at 1,667 ppm for 20 minutes three times per week. Anadromous adults were treated at 167 ppm for one hour after arrival at Eagle FH and five times per week during adult holding at Eagle FH.

Genetic Investigations

A total of 6,494 *O. nerka* genetic samples were genotyped during 2021. These genetic samples were collected from Eagle FH captive broodstock (1,447 samples), NOAA captive broodstock (1,429 samples), anadromous returns (332 samples), juveniles sampled at Lower Granite Dam (128 samples), out-migrating smolts from Pettit Lake (1,083 samples), Redfish Lake (1,494 samples), Alturas Lake (167 samples), basin lake trawling (210 samples), and Pettit Lake gill netting (128 samples). An additional 76 samples were genotyped and designated as re-clips representing samples taken from fish that shed PIT tags or for quality assurance checks.

All captive broodstock spawned at Eagle FH and Burley Creek FH in 2021 successfully genotyped and received a parentage assignment. The pedigrees for the captive broodstock were expanded by another generation and rankings of 'Mean Kinship' along with parentage assignments were used to select individuals to keep for spawning or release for volitional spawning in Sawtooth Valley lakes.

Eyed Egg and Fish Transfers

In all cases, the required State transfer permits were acquired before transport of eggs or fish in the Snake River Sockeye Salmon program. Specific details, by date, for all transfers are described below.

Eagle FH and NOAA Fisheries transferred 897,828 eyed eggs to Springfield FH for the BY21 smolt production group. Eyed eggs from NOAA Fisheries were first transferred to Eagle FH and then delivered the next day to Springfield FH with eyed eggs from Eagle FH. Springfield FH received six shipments of eyed eggs in 2021. The first shipment of 99,716 eyed eggs was transferred on November 17, 2021 (99,716 from Eagle FH). The second shipment was transferred to Springfield FH on November 24, 2021 totaling 155,166 eyed eggs (78,669 from Eagle FH and 76,497 from Burley Creek FH). The third shipment was transferred to Springfield FH on December 1, 2021 totaling 154,341 eyed eggs (34,549 from Eagle FH and 119,792 from Burley Creek FH). The fourth shipment was transferred to Springfield FH on December 8, 2021 totaling 317,709 eyed eggs (145,568 from Eagle FH and 172,141 from Burley Creek FH). The fifth shipment was transferred to Springfield FH on December 15, 2021 totaling 94,249 eyed eggs (58,613 from Eagle FH and 35,636 from Burley Creek FH). The sixth shipment was transferred to Springfield FH on December 21, 2021 totaling 76,647 eyed eggs (76,647 from Eagle FH). Eagle FH transferred 493,762 and Burley Creek FH transferred 404,066 eyed eggs during 2021. Burley Creek FH received 1,501 eyed eggs from Eagle FH production for replacement captive broodstock for the NOAA Fisheries program. Brood Year 2021 eyed eggs were transferred to Burley Creek FH on November 23 (621 eyed eggs), November 30 (97 eyed eggs), December 7 (461 eyed eggs), December 14 (138 eyed eggs), and December 21 (184 eyed eggs) during 2021.

Fish Reintroductions

Sockeye Salmon eyed eggs and fish were transferred and/or released to various locations in 2021. In all cases, the required State transfer permits were acquired prior to shipping. Additionally, pursuant to Special Condition B. 13. of Permit No. 1454, IDFG received authorization from NOAA Fisheries to conduct all production releases of Sockeye Salmon made in 2021 (Table 7). All Sockeye Salmon juveniles and adults released to Sawtooth Valley waters in 2021 were marked/tagged prior to release.

Adult Releases

Captive reared adult Sockeye Salmon not required to meet egg production goals were released from IDFG and NOAA Fisheries facilities (Table 7). Eagle FH staff released 477 (252 females, 223 males, and two unknown) adult Sockeye Salmon to Redfish Lake on September 9, 2021. Mean weight of the Eagle FH captive reared Sockeye Salmon was 1.68 kg/fish. Sockeye Program staff assisted with the transfer and release of 588 (301 females and 287 males) Sockeye Salmon adults from Burley Creek FH to Redfish Lake on September 14, 2021. Mean weight of the Burley Creek FH captive reared Sockeye Salmon was 1.43 kg/fish.

Captive reared adult Sockeye Salmon from Burley Creek FH were released into Pettit Lake for volitional spawning during 2021 (Table 7). Ninety-seven captive reared Sockeye Salmon (57 females and 40 males) were released on September 14 into Pettit Lake (mean weight 1.42 kg/fish).

Three natural anadromous adult Sockeye Salmon were released to Pettit Lake for volitional spawning. These three adults (one female and two males) were released September 15, 2021 (Table 7).

Smolt Releases

The BY19 production group reared at Springfield FH was released on April 30, 2021. This group was first transferred to Sawtooth FH beginning April 19 and finishing April 28 to start a 10 to 17 day acclimation period. Due to an early high water event at Sawtooth FH, smolts were released directly to the Salmon River and totaled 1,013,340 smolts averaging 38.7 grams/fish. All smolts reared at Springfield FH were adipose fin clipped. A smolt survival study initiated in 2009 continued in 2021, maintaining an increased number of PIT-tagged fish in the Springfield FH release group. A total of 51,457 PIT-tagged smolts were released from Springfield FH (Table 7).

Transfer of Program Information

Sockeye Captive Broodstock Program information is shared throughout the year, internally with IDFG biologists, with Sockeye Program cooperators, data requests from biologists outside the Department, and through shared databases and annual meetings. The Sockeye Program continues to provide culture related data into the Fish Inventory System (FINS) database. This database has six modules containing trapping, holding, spawning, incubation, rearing, and release data for the program. The Salmon River Annual Operating Plan was updated covering upcoming releases and expected returns. Changes in program protocols were updated in the Salmon River Standard Operating Plan and the plans were reviewed by cooperating biologists working in the Salmon River drainage. The Stanley Basin Sockeye Technical Oversight Committee continues to meet quarterly each year. All meetings in 2021 were virtual meetings due to Covid-19 travel restrictions. These meetings serve as a forum to share cooperator updates and discuss program goals and objectives. Sockeye Program information was also shared through IDFG's Anadromous Managers meeting, Hatchery Managers meeting, and through bi-weekly Sockeye coordination calls (virtual meetings) with IDFG Sockeye Program staff.

Facility Improvements and Future Projects

The Sockeye captive broodstock Operation and Maintenance (O&M) contract provides funding for routine service and maintenance on facility buildings and equipment. Two service agreements are in place to address chillers and generators. Carrier Corporation provides semi-annual service on the two chillers in operation at Eagle FH. This includes operational diagnostic checks and annual coil cleaning. Northwest Power Systems provides semi-annual service on the three hatchery generators used to backup water supply wells and the Ultra-violet water treatment system for the anadromous building.

2021 Facility Improvements

A number of projects were completed during 2021 under the Sockeye Salmon captive broodstock O&M contract. Additional BPA funding was received through BPA's Asset Management Program and a grant from the Idaho Fish and Wildlife Foundation. Two, 50hp well pump and motor units were replaced during 2021. Well #3 was pulled and replaced on June 23rd. This was a routine service of this well. The pump/motor unit was refurbished and stored for backup. Well #1 failed and was replaced August 1st. The failed pump/motor unit was replaced with the refurbished pump/motor from Well #3. Funding received through an Idaho Fish and

Wildlife Foundation grant was used to construct an information kiosk at the Redfish Lake Creek trapsite.

Future Projects

Fiscal Year 2021 funding from BPA's Asset Management Program will be used to enclose the chilled water supply system for the Sockeye Captive Rearing building. The insulated enclosure will protect the water lines from freezing during the winter months of operation. The heat exchanger for the anadromous building chiller is scheduled to be rebuilt and plates added to enhance performance. This work will be completed as part of the funding received through BPA's FY22 Asset management Program.

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Table 1. Summary of losses and magnitude of mortality in Snake River Sockeye Salmon captive broodstock at Eagle Fish Hatchery during 2021.

Captive Broodstock Groups					
	BY17	BY18	BY19	BY20	BY21
Starting Inventory (January 1, 2021)	11	1,305	1,448	1,501	3,003 ^a
<u>Eyed egg to Fry</u>					
Undetermined ^b	n/a	n/a	n/a	26	n/a
<u>Mechanical Loss</u>					
Handling	0	0	0	0	n/a
Jump-out	0	0	0	0	n/a
Transportation	0	0	0	0	n/a
<u>Noninfectious</u>					
Lymphosarcoma	0	0	0	0	n/a
Nephroblastoma	0	0	0	0	n/a
Other ^c	6	186	66	63	n/a
<u>Infectious</u>					
Bacterial	0	0	0	0	n/a
Viral	0	0	0	0	n/a
Other	0	0	0	0	n/a
<u>Maturation Spawners</u>					
Mature Males	4	262	64	0	n/a
Mature Females	0	365	2	0	n/a
<u>Maturation Nonspawners</u>					
Mature Males	0	4	4	0	n/a
Mature Females	1	5	0	0	n/a
<u>Relocation</u>					
Transferred In	0	0	0	0	n/a
Transferred Out	0	0	0	0	1,501
Planted/Released	0	477	0	0	n/a
Ending Inventory (December 31, 2021)	0	6	1,312	1,412	1,502 ^a

^a December 2021 developing fry and egg numbers.

^b Typical egg to fry mortality includes non-hatching eggs, abnormal fry, and swim-up loss (April 1 inventory). Includes culling associated with cultural abnormalities, non-maturing, and all undetermined noninfectious mortality.

Table 2. Summary of losses and magnitude of mortality in Snake River Sockeye Salmon production groups during 2021.

	BY19 Springfield	BY20 Springfield	BY21 Springfield
Starting Inventory (January 1, 2021)	1,073,948	972,338	897,828 ^a
<u>Eyed egg to Fry</u>			
Undetermined ^b	n/a	37,647	n/a
<u>Mechanical Loss</u>			
Handling	0	0	n/a
Jump-out	0	0	n/a
Transportation	0	0	n/a
<u>Noninfectious</u>			
Lymphosarcoma	0	0	n/a
Nephroblastoma	0	0	n/a
Other ^c	60,608	24,508	n/a
<u>Infectious</u>			
Bacterial	0	0	n/a
Viral	0	0	n/a
Other	0	0	n/a
<u>Maturation</u>			
Mature Males	0	0	n/a
Mature Females	0	0	n/a
Other	0	0	n/a
<u>Relocation</u>			
Transferred In	0	0	n/a
Transferred Out	0	0	n/a
Planted/Released	1,013,340	0	n/a
Ending Inventory (December 31, 2021)	0	910,183	897,828 ^a

^a December 2021 developing fry and egg numbers (combined NOAA and Eagle FH numbers).

^b Typical egg to fry mortality includes non-hatching eggs, abnormal fry, and swim-up loss (April 1 inventory).

^c Culling associated with cultural abnormalities, fish health sampling, special studies, and all undetermined, noninfectious mortality.

Table 3. Calendar year 2021 anadromous Snake River Sockeye Salmon adult return summary.

Summary category	Total number trapped	Number trapped at RFLC ^a weir	Number trapped at SFH ^b weir	Number trapped at LGD ^c trap	Number trapped at other ^d traps
All anadromous adults	240	50	5	185	0
Anadromous males	125	29	4	92	0
Anadromous females	115	21	1	93	0
Unmarked adults	13	4	0	9	0
AD-clipped adults ^e	227	46	5	176	0

^a RFLC = Redfish Lake Creek.

^b SFH = Sawtooth Fish Hatchery.

^c LGD = Lower Granite Dam

^d Other = East Fork Salmon River Trap, Yankee Fork Trap, Hell's Canyon Dam adult trap.

^e AD = adipose fin clip.

Table 4. Summary information for 2021 Snake River Sockeye Salmon spawning activities at Eagle Fish Hatchery.

Spawning Cross*		No. of Green Eggs Taken	No. of Eyed eggs	Mean Egg Survival to Eyed-Stage	Median Egg Survival to Eyed-Stage
Female	Male				
ANH21	ANH21	119,104	100,973	84.78%	95.35%
ANH21	BY18	19,412	17,783	91.61%	96.54%
ANH21	BY19	16,418	15,622	95.15%	96.04%
BY18	ANH21	51,012	23,841	46.74%	40.18%
BY18	BY17	5,850	3,505	59.91%	62.62%
BY18	BY18	548,124	273,970	49.98%	48.09%
BY18	BY19	111,370	61,112	54.87%	55.43%
BY19	ANH21	1,135	999	88.02%	88.00%
BY19	BY18	1,388	1,143	82.35%	82.32%
TOTALS		873,813	498,948	57.10%	57.67%

Note:* ANH21 refers to anadromous adults returning in 2021.
 BY17 refers to captive adults produced in spawn year 2017.
 BY18 refers to captive adults produced in spawn year 2018.
 BY19 refers to captive adults produced in spawn year 2019.

Table 5. Parent family and number of Snake River Sockeye Salmon eyed eggs retained for brood year 2021 captive broodstock development at Eagle Fish Hatchery.

Family Cross*		No. of Eyed eggs Retained for Eagle FH Broodstock
Female	Male	
ANH21	ANH21	218
ANH21	BY18	32
ANH21	BY19	31
BY18	ANH21	94
BY18	BY17	11
BY18	BY18	936
BY18	BY19	173
BY19	ANH21	4
BY19	BY18	3
TOTAL		1,502

Note:* ANH21 refers to anadromous adults returning in spawn year 2021.
 BY17 refers to captive adults produced in spawn year 2017.
 BY18 refers to captive adults produced in spawn year 2018.
 BY19 refers to captive adults produced in spawn year 2019.

Table 6. Number of *Oncorhynchus nerka* samples genotyped during 2021.

Sample Group	No. of Genetic Samples Genotyped
Eagle BY18 Captive Brood	1,447
NOAA BY18 Captive Brood	1,429
Re-clips Captive Broodstock	76
Anadromous adults sampled at LGD	76
Out-migrants Sampled at LGD	128
Anadromous Returns (ANH21)	256
Pettit Lake Out-migrants	1,083
Redfish Lake Out-migrants	1,494
Alturas Lake Out-migrants	167
Trawling	210
Pettit Lake Gill Netting	128
TOTAL:	6,494

Note: ANH21 refers to anadromous adults returning in spawn year 2021.
 BY18 refers to captive adults produced in spawn year 2018.

Table 7. Snake River Sockeye Salmon releases made to Sawtooth Valley waters in 2021.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Number PIT Tagged	Marks^a	Release Weight (grams)	Rearing Location
Salmon River	smolt 2019	4/30/2021	1,013,340	51,457	Ad	38.7	IDFG: Springfield FH
Redfish Lake	adult 2017	9/14/2021	182	182	Ad	2,465	NOAA: Burley Cr. FH
	2018	9/14/2021	406	406	Ad	963	NOAA: Burley Cr. FH
Redfish Lake	adult 2018	9/9/2021	477	477	Ad	1,677	IDFG: Eagle FH
Pettit Lake	adult 2017	9/14/2021	71	71	Ad	962	NOAA: Burley Cr. FH
	2018	9/14/2021	26	26	Ad	2,690	NOAA: Burley Cr. FH
Redfish Lake	anadromous ANH21 ^b	9/13/2021	40	0	Mix	1,270	Anadromous
	ANH21 ^b	9/18 - 10/7/2021	21	0	Mix	1,270	Anadromous
Pettit Lake	anadromous ANH21 ^b	9/15/2021	3	0	No	1,749	Anadromous

^a Ad = adipose fin clip.

^b ANH21 refers to anadromous returning Sockeye Salmon in 2021; representing brood year 2017.

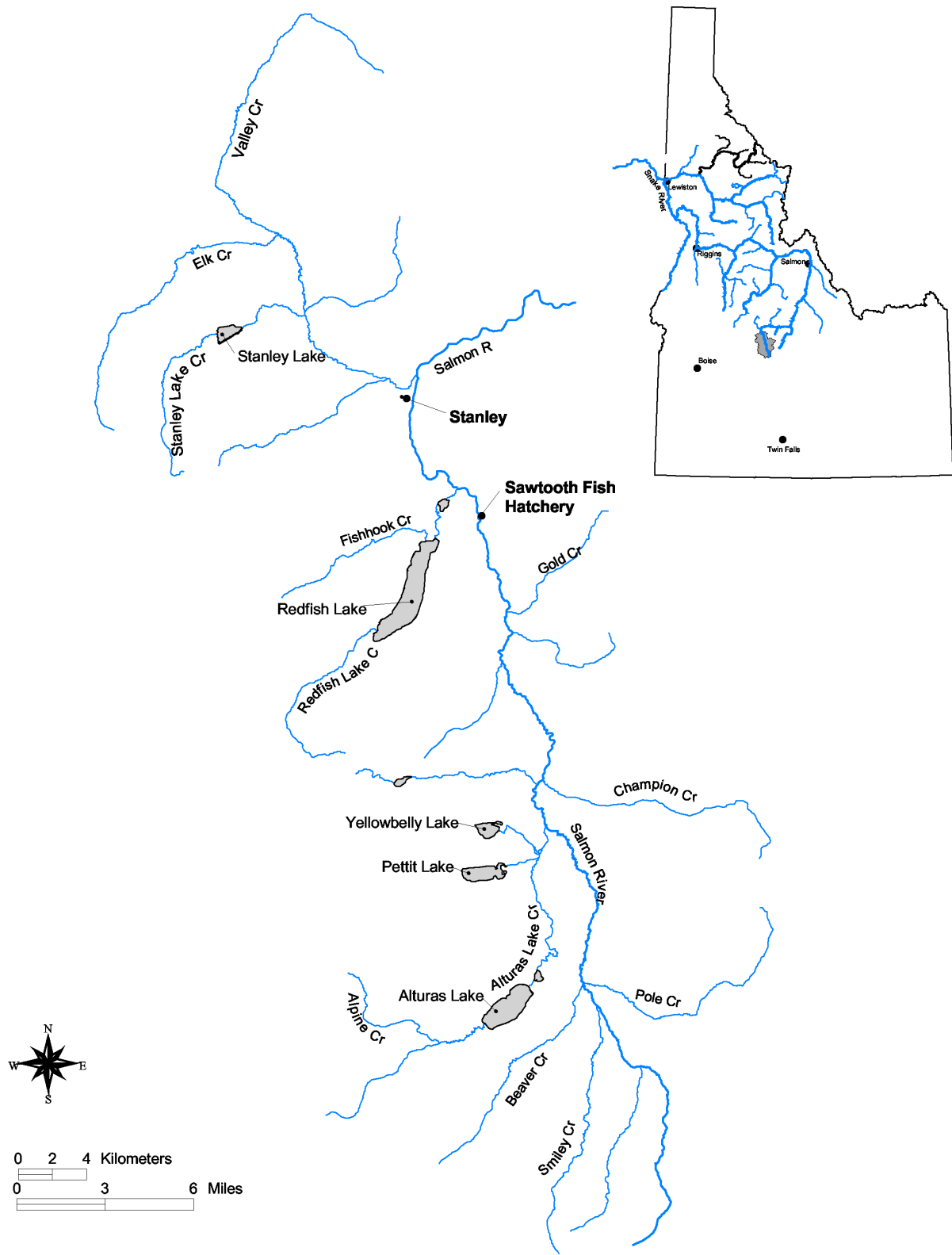


Figure 1. Sawtooth Valley study area.

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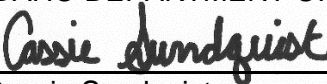
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