U.S. Fish and Wildlife Service

Monitoring and Evaluation of the Leavenworth National Fish Hatchery Spring Chinook Salmon Program, 2019

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***On the cover**: Leavenworth National Fish Hatchery, 1942. USFWS.*

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MONITORING AND EVALUATION OF THE LEAVENWORTH NATIONAL FISH HATCHERY SPRING CHINOOK PROGRAM, 2019.

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Executive Summary- This report summarizes Leavenworth National Fish Hatchery's (LNFH) spring Chinook Salmon (*Oncorhynchus tshawytscha*) production program for 2019. Also, reported are complete broodyear performance metrics (e.g. smolt to adult return, SAR) through broodyear 2013. The goal of the program is to provide harvest opportunities with minimal impacts to natural-origin fish populations and their habitats. In 2019, LNFH released 1,248,910 juvenile spring Chinook Salmon into Icicle Creek, meeting the production goal of 1,200,000. Juvenile release was conducted as planned and as described in the programs Biological Opinions. The 2019 adult return was 27% of the 12-year average, with an estimated 1,404 adult spring Chinook Salmon returning to Icicle Creek. This report documents the comprehensive evaluation of program performance as well as to consolidate reporting requirements identified under the Biological Opinions for LNFH.

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Introduction

Leavenworth Fisheries Complex

Entiat, Leavenworth, and Winthrop National Fish Hatcheries are mitigation hatcheries established by the Grand Coulee Fish Maintenance Project (1937) to compensate for anadromous fish losses above Grand Coulee Dam. The Columbia River Fisheries Management Plan under the U.S. v. Oregon decision of 1969 sets production goals for the facilities. The three hatcheries, along with the Mid-Columbia Fish & Wildlife Conservation Office (MCFWCO), comprise the Leavenworth Fisheries Complex (Complex). Comprehensive background information on the Complex can be found at: www.fws.gov/leavenworthfisheriescomplex.

Leavenworth National Fish Hatchery

LNFH is located adjacent to Icicle Creek near the town of Leavenworth in central Washington State (47º33'32.12" N, 120º40'29.12" W, Figure 1). Icicle Creek is a tributary to the Wenatchee River, which enters the Columbia River at river kilometer (rkm) 754, in the city of Wenatchee, Washington. LNFH is approximately 800 rkm from the Pacific Ocean, and upstream of seven Columbia River hydroelectric dams.

LNFH uses 59 outdoor rectangular raceways and two outdoor rectangular adult holding ponds for current production (Figure 2). There are also 53 historic Foster-Lucas style ponds that are no longer used for spring Chinook Salmon but support the Yakama Nation's Mid-Columbia Coho Reintroduction Program. Indoor facilities include: 540 Heath type incubation trays in 36 stacks and 122 starter tanks.

Historic Operations

Since production began in 1940 LNFH has produced several trout and salmon species including, spring and summer/fall Chinook Salmon (*Oncorhynchus tshawytscha*), steelhead and Rainbow Trout (*O. mykiss*), and Sockeye Salmon (*O. nerka*).

Although spring Chinook have been produced annually (except **b**rood years 1967 and 1968) at LNFH since 1940, Sockeye Salmon were the primary species produced 1940–1970. Beginning in the early 1970's, due to the limited benefits and significant disease risk, Sockeye were phased out and spring Chinook became the primary species produced at LNFH (USFWS 1986).

From 1940-1943, spring Chinook were collected from upriver-bound stocks captured at Rock Island Dam. Additionally, some early imports of spring Chinook to LNFH originated from the lower Columbia River (1942) and McKenzie River, Oregon (1941) were part of homing studies, and probably few, if any, contributed to future production. Occasionally, eggs were imported from other Columbia River hatcheries, including Cowlitz Salmon Hatchery, Carson NFH and Little White Salmon NFH. Prior to the 2019 return, fish and/or gametes had not been imported to LNFH since 1985.

Current Operations

LNFH operates a segregated harvest supplementation program producing spring Chinook Salmon, and aids in the production of Coho Salmon (*O. kisutch*) for the Yakama Nation Mid-Columbia Coho Reintroduction Program, however only spring Chinook production will be discussed in this report. The stock used by LNFH is not included in the ESA-listed Upper Columbia River spring Chinook Evolutionarily Significant Unit (ESU). Genetic analysis indicates that the current stock is more closely related to the lower Columbia River stocks than the natural population in the Wenatchee River (Ford et al. 2001). Spring Chinook produced at LNFH are commonly referred to as "Carson stock", referring to the Carson National Fish Hatchery, where the majority of imported eggs originated. However, considering the number of generations that this stock has been propagated at LNFH, it is increasingly being referred to as an "Icicle Creek" or "Leavenworth" stock.

The goal of the LNFH program is to provide harvest opportunities while minimizing impacts to natural populations and the habitats they occupy.

LNFH strives to achieve the following objectives;

1. Consistently produce fish that contribute to harvest fisheries.
2. Protect indigenous fish populations by minimizing interactions through proper rearing, release, and adult collection management strategies.
3. Produce healthy, externally marked spring Chinook smolts for on-station release as per U.S. vs OR agreement.
4. Maintain stock integrity and genetic diversity of the hatchery and wild stocks through proper management of genetic resources.
5. Prevent introduction, spread, or amplification of fish pathogens.
6. Conduct environmental monitoring to ensure that hatchery operations comply with water quality standards.
7. Investigate, design and implement projects to improve quality of production at LNFH.
8. Effectively communicate with other salmon producers and managers in the Columbia River Basin.

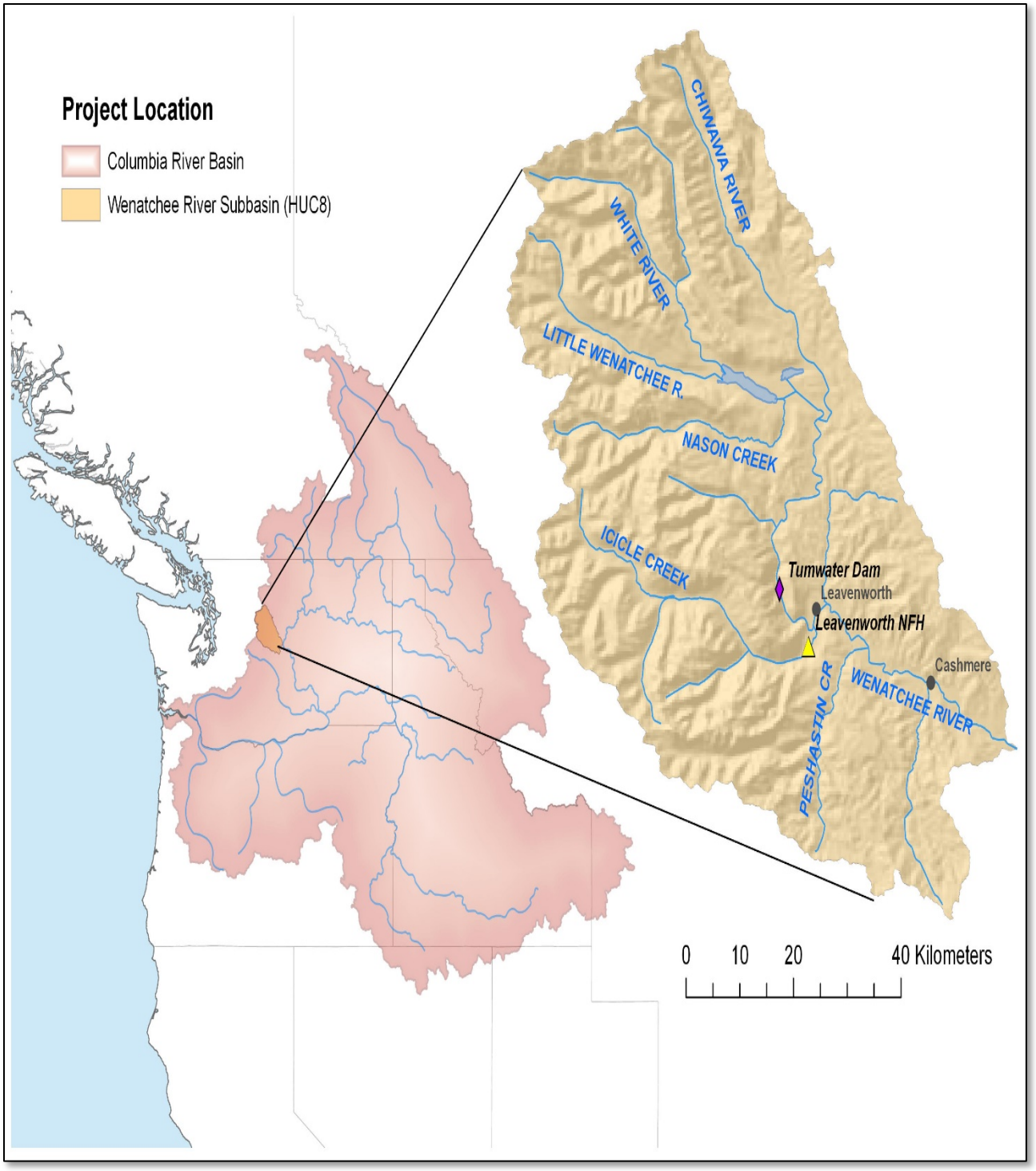

Figure 1. Leavenworth National Fish Hatchery location.

A. Well 5
B. Nursery Building
C. Small Foster-Lucas Ponds
D. Pollution Abatement Ponds
E. Adult Holding Ponds and Adult Return Ladder
F. Well 6
G. Large Foster-Lucas Ponds
H. 10x100 Raceways
I. 8x80 Raceways
J. Structure 5
K. Well 4
L. Sand Settling Basin
M. Well 1
N. Wells 2 and 7
O. Well 3
P. Hatchery Channel
Q. Structure 2
R. Spillway Pool and Barrier Dam

Figure 2. Primary structures of LNFH * Surface water intake not pictured

Water Sources

LNFH has four water right certificates and two water right claims, allowing a maximum water withdrawal of 56.9 cubic feet per second (cfs) or 25,550 gallons per minute (gpm). Surface water rights allow access for up to 42 cfs (18,850 gpm) and groundwater withdrawals are authorized for 14.9 cfs (6,700 gpm). The average combined water use is 41.22 cfs (18,500 gpm). Water use varies seasonally and is dependent on the number of fish on station.

Icicle Creek, a fifth-order stream draining high relief mountains, provides the majority of the water throughout the year for hatchery operations and serves as the release and collection point for cultured fish. During the low flow months (July - September) LNFH actively manages Upper Snow Lake to supplement and cool Icicle Creek upstream of LNFH's water intake. Water is released from Upper Snow Lake into Nada Lake via a tunnel and control valve with a targeted discharge of 50 cfs (22,442 gpm, Table 1). From Nada Lake water flows into Snow Creek and then into Icicle Creek (8.8 rkm). The 50 cfs summer supplementation that enters Icicle Creek serves to ensure the availability of the 42 cfs surface water withdrawal that occurs downstream at the LNFH intake (7.1rkm).

Seven wells at LNFH provide pathogen-free water. Wells 5 and 6 withdraw water from a deep cool water aquifer on the north side of the LNFH property. Four wells, extract water from a shallow aquifer on the south side of the property. Well 4A withdraws water from both aquifers. The shallow aquifer has hydrologic continuity with Icicle Creek and is directly influenced by the saturation of the hatchery channel identified in Figure 2. All well pumps are equipped with variable frequency drives which allow operation at lower flow rates and maintain water levels in the aquifer. When water levels in the shallow aquifer are depleted, the wells start "competing" for water. Competition for water significantly constrains pumping capacity for multiple wells.

Table 1. Summary of water sources at LNFH.

Source	Depth (casing)	Annual Temp. °F	Average gpm	Min gpm	Max gpm	Storage Capacity ac-ft	Average Release Volume ac-ft
Icicle	Surface	42.3 - 53.9	18,484*				
Snow/Nada	Surface	42.3 - 53.9	22,442*			12,450	6,500
Well No. 1	80 (40-80')	42.3 - 53.9	300	175	400		
Well No. 2A	203 (70-90')	47.0 - 49.4	225	175	300		
Well No. 3A	120 (63-98')	44.0 - 49.8	288	200	325		
Well No. 4A	333 (64-94')	43.1 - 48.3	300	200	400		
Well No. 5	300 (250-300')	<52.0	675	350	900		
Well No. 6	195 (102-170')	50.5 - 52.5	700	350	850		
Well No. 7	192 (102-110')	43.3 - 46.7	270	260	330		

*estimated

Hatchery Evaluation

The Mid-Columbia Fish and Wildlife Conservation Office (MCFWCO) assists the LNFH spring Chinook program under its Hatchery Evaluation (HE) program. The HE program strives to use monitoring, evaluation, and targeted research to assist LNFH in effectively meeting both its mitigation goals and ESA responsibilities. Additionally, HE assists the hatchery in making decisions that balance the benefits of artificial production against risks to natural populations and their habitats.

The goals of the HE program can be characterized into three main areas of focus:

1. Evaluate hatchery operations and practices with respect to facilitating program optimization.
2. Research, assess and recommend methods to minimize impacts of hatchery production and operations on natural fish populations and their environment.
3. Facilitate coordination with the various managers involved in artificial production, evaluation and management of fisheries within the upper Columbia River basin.

Monitoring Objectives– Annual monitoring and coordination by the HE program assesses whether LNFH met mitigation objectives while working within acceptable levels of risk to natural-origin fish populations and their habitat. Monitoring and evaluation goals are broadly categorized as hatchery rearing metrics, post-release performance, and risk assessment to natural populations and habitat.

HE program objectives specific to LNFH include the following:

1. Effectively guide harvest and brood management.
2. Annually coordinate marking and tagging of production.
3. Monitor the effects of hatchery operations on natural populations.
4. Assess whether juveniles are reared and released in a manner that minimizes freshwater residence and early maturation while maximizing outmigration survival and homing fidelity.
5. Determine population characteristics of returning adults including: harvest contribution, straying, run timing, smolt-adult survival, genetics, and gender and age composition.

The following set of LNFH specific tasks are attempted annually to meet objectives:

1. Develop predictive models to forecast preseason adult return estimates for managers.
2. Adequately tag and use PIT tag interrogation to track the adult migration of Chinook and provide weekly in-season forecasts to managers.
3. Describe fishery contribution and stray rates using data from coded-wire tag recoveries, harvest estimates, spawning ground recoveries and hatchery returns.
4. Sample a statistically valid representation of the hatchery return to adequately describe population characteristics.

5. Operate PIT tag antennas in adult fish ladders at LNFH.
6. Monitor in hatchery rearing environment to meet survival, size and production targets.
7. Coordinate marking and tagging programs to assure that hatchery produced fish are identifiable for harvest management, escapement/fidelity goals and evaluation studies.
8. Monitor smolt outmigration metrics of survival and timing through the Columbia River corridor.
9. Monitor rates of precocial maturation in release groups.
10. Support Parental Based Tagging (PBT) genetic marking objectives (via DNA markers) as identified by the Columbia River Inter-Tribal Fish Commission (CRITFC).

Data used for evaluation came from direct collection, collection by other management agencies, and/or industry-specific databases. Most of the data used in this report are directly collected by HE and hatchery staff. Other commonly used data sources include:

RMIS- Regional Mark Information System (RMIS) is an online database operated by the Pacific States Marine Fisheries Commission and designed to house Coded Wire Tag (CWT) data for the west coast of North America and the northern Pacific Ocean. When a group of fish is tagged with a CWT, the tag code and number of fish tagged are submitted to RMIS by the tagging entity. Subsequently, if/when a fish is lethally sampled, either for scientific or commercial purposes, the tag code and location information is submitted. RMIS allows managers to calculate survival and contribution metrics for the fisheries they are evaluating. More information can be found at www.rmpc.org.

PTAGIS- PIT Tag Information System (*PTAGIS*) is an online database operated by the Pacific States Marine Fisheries Commission, and designed to house Passive Integrated Transponder (PIT) tag data. When a group of fish is tagged with a PIT tag, the tag codes and tagging event metadata are submitted to PTAGIS by the tagging entity. Subsequently, if/when the PIT tag is read remotely by a transceiver antenna ("interrogated"), the tag code and location information is also submitted. These data can be collected non-lethally, and fixed interrogation stations can be set up at any location with constant electricity, such as hatcheries and hydroelectric facilities. PTAGIS allows managers to track movement of the tagged fish. More information can be found at www.ptagis.org.

DART- Columbia River Data Access in Real Time (DART) is an online database operated by the Columbia Basin Research Department of the School of Aquatic and Fishery Sciences at the University of Washington. DART uses data from RMIS and PTAGIS to provide summaries of juvenile fish survival and counts fish passing hydroelectric facilities on the Columbia River and its tributaries. More information can be found at www.cbr.washington.edu/dart/.

At LNFH, CWT's, adipose fin clipping, and PIT tags are administered by the US Fish and Wildlife Service's Columbia River Fish and Wildlife Conservation Offices' hatchery marking team (https://www.fws.gov/CRFWCO/). This team marks and tags for a majority of the National Fish Hatcheries in the Columbia River basin, as well as other hatchery facilities in the region.

Fish Health Program

The Pacific Region Fish Health Program staff support the spring Chinook program fish health goals at the LNFH as part of the Complex. The focus of the fish health program is to support the release of healthy smolts through a preventative medicine ethos. Regular monthly examination of fish at the hatchery aims at the identification and treatment of disease issues early in their course to both mitigate potential future disease losses and to optimize in hatchery rearing conditions. In addition to following USFWS National Fish Health Policy, disease surveillance and party notification of regulated pathogens is conducted in concordance with "The Salmonid Disease Control Policy of the Fisheries Co-managers' of Washington State" 2006. Sample collection and laboratory testing follows nationally recognized standards outlined in the American Fisheries Society "Blue Book" (AFS, 2014). Any disease treatments are performed under the veterinary guidance.

Legal Authorities

Construction of LNFH was authorized by the Grand Coulee Fish Maintenance Project April 3, 1937, and reauthorized by the Mitchell Act (52 Stat. 345) May 11, 1938. The Mitchel Act authorized the construction and operation of LNFH fish culture facilities, biological surveys and experiments related to fish conservation. Production, marking and tagging goals for the facility are determined through the management framework established as an outcome of the *U.S. v Oregon* decision and are described in the 2018-2027 *U.S. v Oregon* Management Agreement.

Endangered Species Act - LNFH operates within the requirements of the Endangered Species Act (ESA) of 1973. Though the stock produced at LNFH is not ESA-listed, Biological Opinions (BiOp) are issued for ESA listed Upper Columbia River spring Chinook Salmon and steelhead by the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries), and ESA listed Bull Trout (*Salvelinus confluentus*) by the USFWS, all of which may reside in Icicle Creek. Permits are issued for any incidental "take" of listed species through impacts from LNFH operations and/or production. The Terms and Conditions outlined by each BiOp for LNFH operations are located in Appendix A and B.

Hatchery and Genetic Management Plan - The Hatchery and Genetic Management Plan (HGMP) is a Biological Assessment provided by LNFH and MCFWCO to describe the effects of LNFH operations and production upon ESA listed species. The HGMP sets broad performance standards that are used by the National Marine Fisheries Service for the purpose of evaluating hatchery programs under the ESA.

Performance Goals

To accurately monitor and evaluate the spring Chinook Salmon program at LNFH, specific performance goals are tracked throughout the year (Table 2). Performance goals are derived from the legal authorities, HGMP's, Pacific Region Fish Health Program recommendations, peer-reviewed literature, and the Hatchery Evaluation Team. They are intended to give a point of comparison between cohorts and amongst similar hatchery programs. Performance goals are divided into three broad categories: Release Year, Adult Return, and Brood Year.

Release Year - Release year performance goals apply to the rearing of juveniles from egg eye-up through smolt release. A release year cohort is on-station for 1.5 years.

Adult Return - The adult return/broodstock collection performance goals reflect the ability of LNFH to collect, hold, and spawn adults. These goals cover the adult life stage from upstream migration through egg eye-up, and occur during one calendar year.

Brood Year- Brood year performance goals apply to adult fish, assessing survival and contribution to harvest. Assessment of brood year performance goals cannot be accurately completed until all of the adults have returned and all of the various tag recovery programs have compiled their data. Because of these delays, reporting on the brood year performance goals is 7 years behind the actual brood year.

Table 2. LNFH production practices goals by life stage in 2019

Life Stage	Attribute	Current Practices and Goals
Adults	*collection*	Hatchery ladder
	ladder operation	Pulsed
	brood target	1000 for LNFH, additional 640 for Chief Joseph Hatchery
	prophylaxis	Formalin treat ADHP
	Stock	Hatchery returns
	spawning	male:female = 1:1 (back up male)
	health monitoring	BKD 100% females, virology/bacteriology
	adult monitoring	Sex/age/length/Tag ID
	adult holding temperature	< 58º F (14.4ºC)
	adult pre-spawn survival	88%
Eggs	*green egg target*	1,740,000 eggs
	prophylaxis	Disinfect, water harden, formalin treat
	incubation units	Heath trays
	water source	Well-chilled to delay hatch date
	water quality monitoring	temperature, flow rates, and gases if suspect
	culling	15% by ELISA rank unless high number of moderate risk
	post culling egg total	>85% / 1,480,000 eggs
	shocking	Eggs pooled by rank / take and inventoried, 3,500 eggs/tray

Table 2. continued

Life Stage	Attribute	Current Practices and Goals
Fry	*% green egg to eyed egg*	≥90% / 1,330,000 eggs
	% eyed egg to fry	≥95% / 1,260,000 fry
	rearing unit	Starter tanks
	water source	Well, river water as emergency backup
	water quality monitoring	temperature and flow rates, dissolved gases when needed
	feeding frequency	6-8 times/day
	feed amount (%BW/Day)	1.0-2.0% BW/Day
	cleaning frequency	Daily
	monitoring	Weekly fish/pound counts, Monthly biometrics
Sub-yearlings	*rearing units*	8X80 raceways, 10x100's (covered) after CWT tagging
	water source	Well/river
	water quality monitoring	Temperature, dissolved gases when needed, & flow rates
	feeding frequency	4-6 times/day
	feed amount	1.0-2.0% BW/Day
	feed application	Hand
	cleaning frequency	1-3/week
	marking	17% CWT, 100% Ad-clip, inventory, 20K PIT's
	monitoring	Monthly fish health & biometrics, CWT & PIT retentions
Yearlings	*rearing units*	8X80's, 10X100's (covered), adult holding ponds
	water source	River/well/1 pass re-use in adult holding ponds when used for rearing
	water quality monitoring	Temp., dissolved gases when needed, & flow rates
	feed amount (%BW/Day)	1.0-2.0% BW/Day
	feed application	Hand
	cleaning frequency	Brushed 1-2 times/ week
	monitoring	Monthly fish health & biometrics
	rearing parameters	Temp <68^{0}F $d0^2$ <80% saturation & 5ppm Turnover rate≤ hour Density index ≤ 0.20 Flow index ≤ 0.60
	condition factor	1
	size	17 fish per pound
	early male maturation	< 20%
	release type	forced pumped
	release time	3rd week of April
	travel time to McNary Dam	≥ 28 days
	coefficient of varation	<10%
	release goal	1,200,000
Survival Targets	*green egg to smolt survival*	81%
	fry to smolt survival	≥95%
	release to McNary Dam survival	>55%
	smolt to adult survival	0.35%-0.40%
	hatchery return rate	>2

Release Year 2019

Juvenile Rearing

Spring Chinook Salmon smolts released in 2019 were derived from 1,558,607 eggs collected from adults that returned to LNFH in 2017. This was 10% below the green egg goal of 1,740,000. After culling, the green egg to eyed egg survival from the 2017 broodstock collection was 96.8% meeting the performance goal of >90%. Juvenile rearing of this cohort began in December 2017, when 1,267,829 fry were placed into 122 starter tanks. This was 106% of the release number and on target for the ponding performance goal of 1,260,000. The highest mortality (23%) occurred when 289,383 eggs were culled. Of the culled eggs 195,732 (68%) eggs were culled due to Enzyme-Linked Immunosorbent Assay (ELISA) results, 55,832 (19%) were due to bad fertilization, and 37,819 (13%) eggs were surplus production. (Table 3) The ELISA tests are used to detect the relative prevalence of Bacterial Kidney Disease (BKD) from females used in propagation. ELISA testing aids in determining the degree of risk for vertical transmission of BKD from mother to progeny.

Throughout the rearing cycle, the density of fish per rearing vessel, and the flow of water through the rearing vessel were monitored. Reduced densities and increased flow are desired as a disease risk reduction strategy; however, this has to be balanced against rearing space and water availability. For the release year 2019 rearing cycle, monthly Density Index (DI) was within the performance goal for all months. The Flow Index (FI) performance goal was exceeded in the month before transferring fry out of the nursery tanks and again just prior to release (Table 3).

Density Index (DI) was calculated as described by Piper et al. (1982):

$$\frac{\text{Total weight of fish in pond (lbs.)}}{\text{(Mean length of fish (in.) x volume of vessel (cubic feet))}}$$

Likewise, a Flow Index (FI) is calculated as:

$$\frac{\text{Total weight of fish in pond (lbs.)}}{\text{(Mean length of fish (in.) x flow (gallons per minute))}}$$

In March 2018, the fry were moved from the nursery into 30 of the 8x80 raceways, each receiving approximately 21,000 fish. The raceways receive a mixture of well and river water, and approximately 50% of the fish receive second-pass reuse water due to limited water supply.

Marking and tagging was conducted using an AutoFish System® (Northwest Marine Technology, Inc, http://www.nmt.us/products/afs/afs.shtml). The automatic tagging trailers annually provide a census of the rearing group and provide the first inventory update since the eyed egg stage. The HE program the uses the census to back calculate the monthly inventory prior to marking. The back calculation is done to address years where the marking inventory shows a major increase or decrease in production numbers, compared to the prior month. The fish were 100% adipose clipped and CWT's were implanted into

203,835 fish in mid-May (Appendix C). The success of marking is maximized if the fish meet a critical size target (75-190 fish per pound, fpp) with limited variation in size (<6.0% CV, J. Rivera pers. comm). At the time of marking and tagging the fish were 96 fpp with a CV of 6.8% which met tagging size criteria. This size helped achieve a post mark CWT retention rate of >99.8% (target >98%) based on a sample of 1,028 fish 30 days post-tagging.

As part of the Fish Passage Centers' Smolt Monitoring Program, PIT tags were implanted into 19,985 fish in late October of 2018 (Table 4). PIT tag data are used to assess post-release metrics including: outmigration survival rates, outmigration travel times, in season abundance estimates for returning adults and adult migration timing. At the time of PIT tagging, the fish were 25.7 fpp, which was 15% smaller than the performance goal of 22 fpp for the end of October. Immediately after tagging, 759 fish were held in the indoor nursery for a tag shed assessment. Fish were collected after 35 days and scanned for a PIT tag. Of the 756 remaining fish, eight were without a tag resulting in a tag loss of 1.05%. Expanding the results of this assessment to the entire population of PIT-tagged fish resulted in 209 shed PIT tags. Additionally, mortalities were removed from the dataset during rearing, however total tag loss due to sheds and predation is difficult to definitively ascertain.

Table 3. Juvenile rearing performance for release year 2019

Year-Month	Life Stage	Production Inventory[a]	Fish per Pound	% Mort.[b]	Cumulative Survival %	Temp (^{0}F) Ave[c]	Flow GPM[d]	Flow Index (lbs./in*GPM)[d]	Density Index (lbs./in*ft^3)[d]
2017-September	Egg	1,558,607	NA	NA	NA	50.0	135	NA	NA
October	Egg (Cull)	1,269,224	NA	22.80	NA	46.0	155	NA	NA
November	Egg	1,268,336	NA	0.07	99.93	46.0	155	NA	NA
December	SacFry	1,267,829	NA	0.04	99.89	48.1	155	NA	NA
2018- January	Fry	1,267,322	1,054.87	0.04	99.85	48.1	2,562	0.32	0.07
February	Fry	1,266,182	306.75	0.09	99.76	46.1	2,562	0.73*	0.17*
March	Fingerling	1,265,423	184.60	0.06	99.70	47.0	6,600	0.40	0.07
April	Fingerling	1,265,170	115.10	0.02	99.68	45.7	6,600	0.55	0.10
May	Fingerling	1,264,538	96.33	0.05	99.63	44.2	12,600	0.32	0.07
June	Fingerling	1,262,927	63.42	0.02	99.61	49.8	17,080	0.31	0.06
July	Fingerling	1,262,476	44.14	0.03	99.58	59.1	17,960	0.38	0.07
August	Fingerling	1,261,854	27.00	0.04	99.54	58.0	17,950	0.52	0.11
September	Fingerling	1,261,025	25.81	0.06	99.48	51.5	18,395	0.52	0.11
October	Fingerling	1,260,619	25.69	0.03	99.45	45.0	17,950	0.54	0.11
November	Yearling	1,260,247	25.14	0.02	99.43	37.5	17,950	0.55	0.11
December	Yearling	1,259,932	25.02	0.02	99.41	33.8	17,950	0.55	0.11
2019-January	Yearling	1,259,194	25.02	0.05	99.36	34.4	17,950	0.55	0.11
February	Yearling	1,258,114	25.02	0.08	99.28	33.1	17,950	0.55	0.11
March	Yearling	1,253,410	22.51	0.37	98.91	34.4	17,790	0.59	0.12
April	Smolt	1,248,910	21.90	0.35	98.56	39.4	19,110	0.56	0.12

Unless otherwise indicated, all values are for end of the month totals or values obtained for the last ten days of the month and not daily averages for the month.

[a]N is corrected or "back calculated" from time of marking.

[b]Includes monthly picking. Does not include predation.

[c]Temperature data is electronically measured every two hours and averaged for the month.

[d]Calculated from values taken at the end of each month.

*Exceeds rearing parameter goals

Release

During the early afternoon hours of April 17th through April 19rd, 1,248,910 yearling spring Chinook smolts were force-released via a Heathro Fish Pump into Icicle Creek (Table 4 and 5). This was 104% of the release target of 1,200,000. Released fish were 22 fpp which was below the release size goal of 17 fpp, the mean fork length was 142mm with a CV of 11.3%.

For release year 2019, the MCFWCO contracted the Idaho Fish and Wildlife Conservation office (IFWCO) to use two portable PIT tag arrays to interrogate fish for tags while being released. Twelve raceways were interrogated for PIT tags during the release. Of the estimated 19,603 PIT tags, 19,174 unique tags were scanned at release. Estimates based on PIT tag expansions suggest an undocumented mortality rate up to 1.4% from October to April.

Table 4. LNFH release dates, release numbers and tagging information for 2008–2019.

Release Year	Date Released	Total Released	# CWT	% CWT	% Adipose Clip	# PIT
2019	Apr. 17, 18, and 19	1,248,910	203,835	16%	100	19,603
2018	Apr. 17 and 23	1,252,307	206,197	16%	100	19,713
2017	Apr 18	1,131,913	206,598	18%	100	19,528
2016[a]	Apr 21	945,277	200,632	16%	100	19,679
2015	Apr 15	1,139,567	196,151	17%	100	14,994
2014	Apr 23	1,239,025	198,913	16%	99	13,380
2013	Apr 24	1,289,293	207,443	16%	100	14,951
2012	Apr 19	1,186,622	218,977	18%	98	14,901
2011	Apr 20	1,189,442	216,791	18%	100	14,875
2010	Apr 26	1,284,653	217,492	17%	100	14,948
2009	Apr 28	1,685,038	196,529	12%	100	14,931
2008	Apr 28	1,539,668	389,100	25%	100	15,968

[a] accidental release occurred in January, 2016, beginning in 2016 an additional 5k PIT tags were added by MCFWCO to the existing SMP 15k effort.

Smolt Outmigration

Survival and travel time data were provided by DART and PTAGIS using PIT tagged fish as representatives of the population. Survival and travel time of out-migrating smolts produced at LNFH are customarily measured at McNary Dam, as it is the first in-stream structure encountered with dedicated juvenile PIT tag monitoring facilities. McNary Dam is 205 rkms downstream from LNFH,

roughly half way to the Pacific Ocean. Multiple juvenile monitoring facilities downstream of McNary Dam enable mark-recapture methodologies to derive survival estimates at McNary Dam.

In 2019 LNFH smolts arrived and passed McNary Dam throughout early to mid-May on the ascending limb of the hydrograph (Figure 3). For the 2019 smolt release, the average travel time to McNary Dam was 25.2 days or 8.1 rkms (5 river miles) traveled per day (Table 5). This was a day slower than the 12-year average of 24 days and did not meet LNFH 2017 NMFS BiOp Term and Condition 2k (Appendix A) that requires average smolt emigration rates faster than 9.4 river miles/day. The slower travel time could have been the combined effect of 9% lower than average Columbia River flow and a smaller smolt size of 22 fpp. The survival of this cohort to McNary Dam was estimated at 52% which meets the performance goal of >50% and but does not exceed the long term average of 57%. The 2019 LNFH survival was higher compared to the spring Chinook programs at Chief Joseph Hatchery (CJH) on the mainstem Columbia River, Winthrop NFH on the Methow River, Chiwawa Rearing Ponds (CRP) in the upper Wenatchee River. The relative survivals between these four facilities have been highly variable over the years (Figure 4).

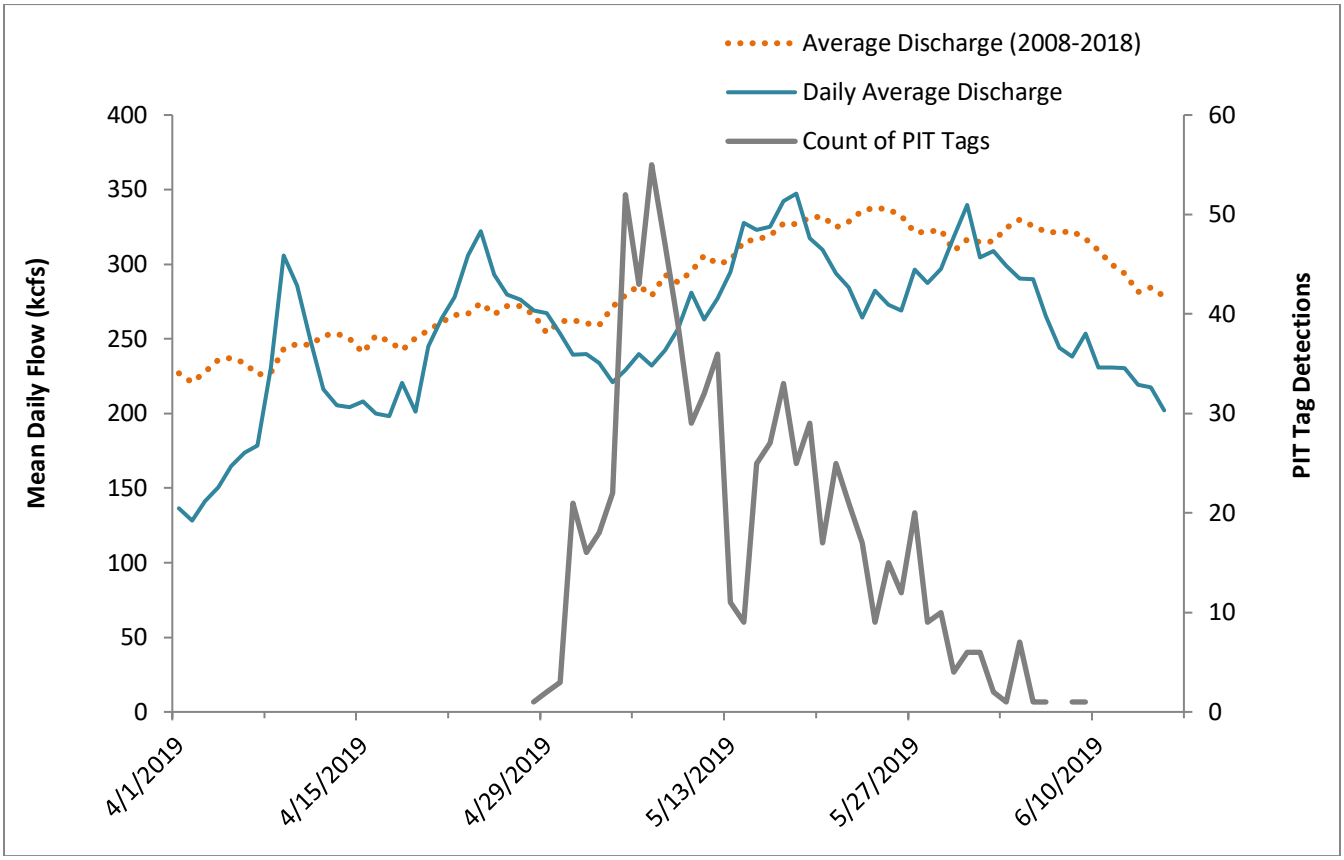

Figure 3. Daily passage of LNFH-origin spring Chinook Salmon smolts at McNary Dam.

Table 5. LNFH-origin spring Chinook Salmon smolt out-migration metrics to McNary Dam, 2008–2019.

Release Year	Release Day	McNary Dam Mean Travel Time (Days)	McNary Dam Median Travel Time (Days)	Survival to McNary Dam (95% confidence limits)
2019	Apr. 17, 18, and 19	25.2	23.0	0.52 (0.49-0.56)
2018	Apr. 17 and 23	18.6	17.7	0.66 (0.62-0.70)
2017	Apr. 18	28.2	23.1	0.54 (0.52-0.59)
2016[a]	Apr. 21	17.4	17.3	0.49 (0.48-0.50)
2015	Apr. 15	24.7	23.8	0.57 (0.54-0.60)
2014	Apr. 23	21.5	22.0	0.57 (0.52-0.62)
2013	Apr. 24	24.8	24.8	0.67 (0.54-0.81)
2012	Apr. 24	28.7	28.8	0.59 (0.55-0.63)
2011	Apr. 20	27.5	28.2	0.43 (0.39-0.47)
2010	Apr. 26	25.3	22.2	0.66 (0.60-0.72)
2009	Apr. 28	25.7	25.4	0.48 (0.44-0.52)
2008	Apr. 28	21.1	19.9	0.58 (0.53-0.62)
Mean (08–18)		24.0	23.0	0.57 (0.53-0.61)
St. Dev. (08–18)		3.81	3.77	0.08 (0.08-0.10)

[a] 380 PIT tags removed from Travel Time and Survival estimates, due to early escape

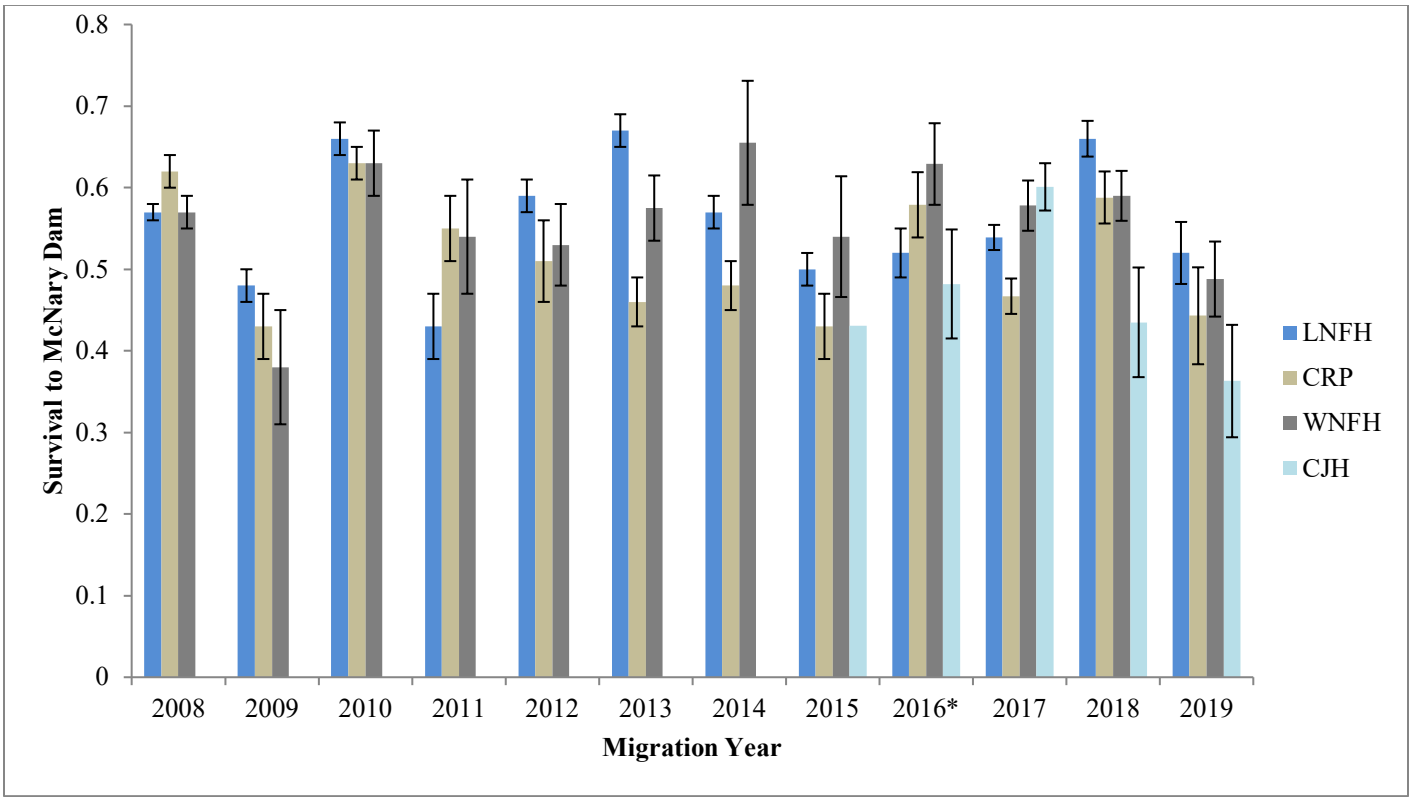

Figure 4. Upper Columbia River spring Chinook Salmon smolt survival (standard deviation) for LNFH, Chief Joseph Hatchery (CJH), Winthrop National Fish Hatchery (WNFH) and Chiwawa Rearing Ponds (CRP) to McNary Dam, 2008–2019. *380 PIT tags removed from LNFH survival estimates based on accidental early release.

Early Maturation

Spring Chinook Salmon most commonly mature in the ocean (after outmigration) at age 3 or older. Early maturation of spring Chinook is defined as the complete development of primary sexual characteristics (gonads) primarily during freshwater rearing and/or the expression of reproductive behavior before age 3. Commonly referred to as "precocial parr" or "minijacks" these fish are typically male. In a hatchery, these fish may initiate maturation prior to release and remain near the point of release, or they may start to migrate toward the ocean, then reverse course and travel upstream and attempt to spawn (Mullan et al. 1992, Beckman and Larsen 2005).

The proportion of minijacks produced in a cohort represents hatchery effort that results in non-harvestable fish. They may also pose ecological risks (predation and competition) as well as risk of straying and spawning with natural origin populations. Because minijacks are too small to be trapped effectively in the LNFH adult holding ponds they are often difficult to quantify or remove from the river system.

Research has shown that early male maturation may be induced through hatchery practices, particularly the promotion of rapid growth and high adiposity (Clarke and Blackburn 1994; Silverstein et al. 1998; Beckman et al. 1999, 2000; Shearer and Swanson 2000; Larsen et al. 2004; Shearer et al. 2006). LNFH attempts to minimize the occurrence of early maturation through dietary regulation and the minimal use of warm, growth-promoting well water in the winter.

Beckman and Larsen (2005) suggested estimating the occurrence of minijacks post-release by monitoring the upstream migration of PIT tagged juveniles (via PIT detections at dams) during the year of release. Within the 2019 release year cohort there were eight PIT tagged fish that were detected at mainstem Columbia River dams and displayed upstream migration (Table 6). Using this method, the rate of migratory minijack maturation for LNFH-origin fish is <1% for release years 2007–2019.

Determining early maturation using PIT tags is plagued by low sample sizes, confounded by mortality, and does not account for non-migrating minijacks. To accurately address rates of residualism (LNFH 2017 NMFS BiOp Appendix A), the HE program implemented pre-release male early-maturation sampling using a Gonadosomatic Index (GSI) as described by Larsen et al., 2004. GSI is the proportion of gonad weight to the total weight of the fish and was calculated for all males held for the study. Of the 151 males that were sampled, 16 (9.4%) were showing signs of precocity within recently documented values (2016- 2018 range 5.5% – 9.5%, avg. 7.9%), and precocity increased proportionally for juveniles greater than 140mm of fork length (Figure 5). It is important to note that the consistently lower PIT tag detection method estimates % maturation for the entire population while the GSI sampling estimates only male maturation. For direct comparison of the two methods divide the GSI % maturation in half, assuming an equal sex ratio of the smolts released.

Table 6. Rate of early maturation (minijacks and precocity by GSI) of LNFH-origin fish by release year, 2008–2019.

Release Year	Release Number	# PIT	PIT Ratio Non-Tag/Tag	Observed Minijacks	Expanded Minijacks[a]	Minijack Rate (%)	Release Precocity Rate from GSI (%)
2019	1,248,910	19,603	64	8	510	0.04	9.4
2018	1,252,307	19,713	64	13	826	0.07	5.5
2017	1,131,913	19,528	62	2	124	0.01	9.5
2016	945,277	19,679	54	2	108	0.01	8.6
2015	1,139,567	14,994	76	4	306	0.03	na
2014	1,239,025	13,380	93	13	1,206	0.10	na
2013	1,289,293	14,951	87	13	1,127	0.09	na
2012	1,186,622	14,901	80	9	718	0.06	na
2011	1,189,400	14,875	83	9	751	0.06	21.4*
2010	1,284,653	14,948	86	41	3,533	0.28	22.0*
2009	1,685,038	14,931	113	21	2,370	0.14	16.2*
2008	1,539,668	15,968	96	36	3,471	0.23	28.8*
Min	945,277	13,380	54	2	108	0.01	5.5
Max	1,685,038	19,713	113	41	3,533	0.28	28.8
Mean (08-18)	1,262,069	16,170	81	15	1,322	0.10	16.0

*From Harstad et al. 2014.

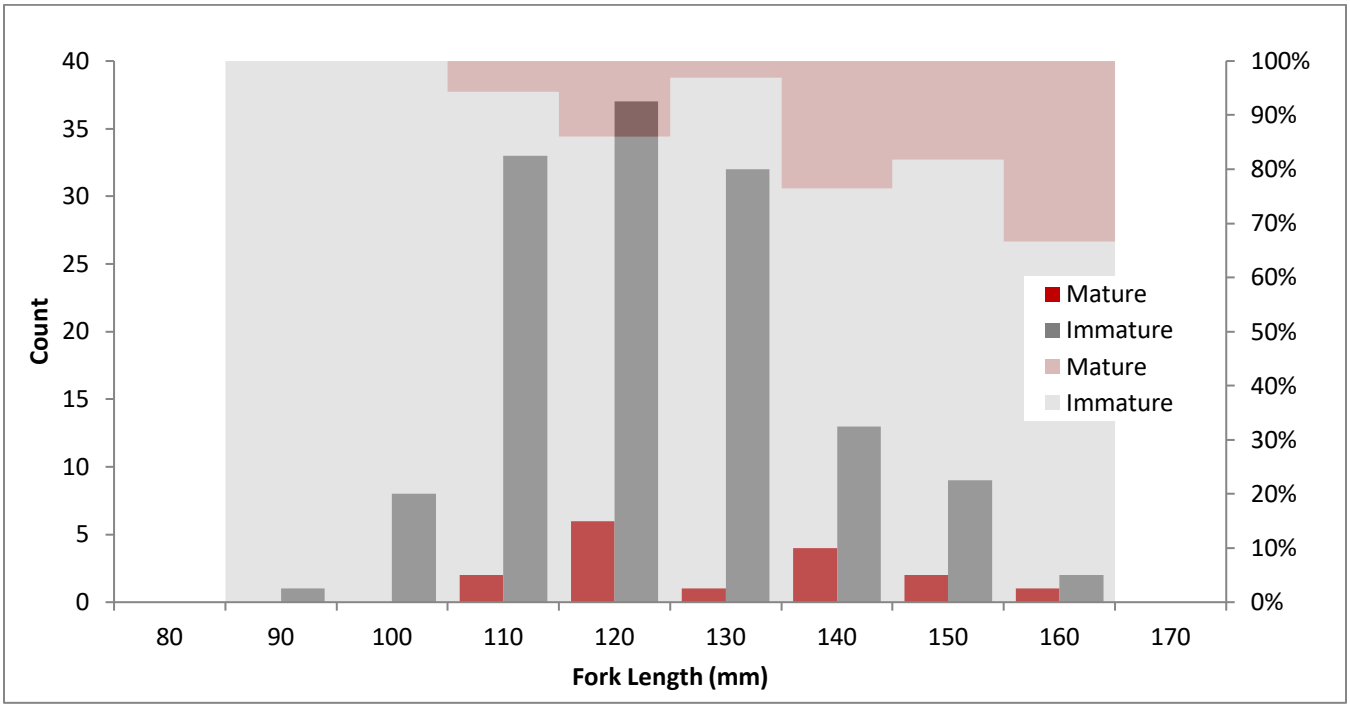

Figure 5. Precocity in sampled males by fork length, at LNFH, at release in 2019.

Adult Return 2019

Run Forecast

Hatchery Evaluation staff use predictive models to forecast the return of LNFH-origin spring Chinook Salmon to Icicle Creek. The pre-season forecast model predicted a return of 760 (665-831), (Fraser et al. 2019). As most models indicated that the return may not be sufficient to meet both broodstock and Icicle Creek harvest needs weekly in-season forecasts were closely followed utilizing PIT tag expansion, run timing and conversion rate estimates from Bonneville Dam. Run forecast models have been utilized for a number of years at LNFH. In general, pre-season estimates exhibit higher variability and over-forecast (121% ± 37%), while in-season estimates tend to consistently under forecast with lower variability the actual return (73% ± 18%) to Icicle Creek (Table 7).

Table 7. A comparison of LNFH spring Chinook return forecast and accuracy to Icicle Creek, 2008 – 2019.

Return Year	Icicle Creek Adult Return	Pre-season Forecast	Pre-season Accuracy	In-season Forecast	In-season Accuracy
2019	1,404	760	0.54	648	0.46
2018	976	1,944	1.99	892	0.91
2017	1,417	2,416	1.71	756	0.53
2016	5,277	6,872	1.30	4,130	0.78
2015	8,149	7,307	0.90	4,599	0.56
2014	6,005	5,975	1.00	5,802	0.97
2013	3,309	4,844	1.46	2,197	0.66
2012	7,074	7,668	1.08	5,387	0.76
2011	6,990	6,003	0.86	6,130	0.88
2010	13,862	9,592	0.69	11,283	0.81
2009	4,977	4,980	1.00	3,969	0.8
2008	4,692	5,897	1.26	3,687	0.79
Average (08-18)			1.20		0.77
StDev			0.39		0.14

Run Timing

Returning LNFH-origin spring Chinook were first detected at Bonneville Dam on May 2nd with the 50% passage date occurring on May 30th. The returning adults were a month later compared to the long-term (12 year) average and slow to ascend Bonneville Dam reaching the 90% passage date on July 9th (Table 8). This was the third consecutive year of delayed returns to Bonneville Dam.

The detection efficiency of the PIT tag antenna arrays at Bonneville Dam are reported to be greater than 99% (Tenney et al 2017) and assumed nearly complete interrogation census of returning tagged adults. Adults took an average of 45 days to travel from Bonneville Dam to the LNFH adult ladder in 2019 (Figure 6). The travel time between Bonneville and Icicle Creek, was nine days faster than the average

(31 days) for the previous seven years. Fish were stalled in lower Icicle Creek, with an average of 23 days between PIT tag detections at the lower Icicle Creek PIT tag array to the array in the adult ladder. The cause of the delay is unknown as temperature and flow were within a normal range.

In 2019, an estimated 1,404 spring Chinook returned to Icicle Creek. In-basin estimates were generated from harvest estimates, spawning ground surveys, and LNFH adult holding pond counts. The 2019 adult return was 25% of the 11-year (2008-2018) average (Table 9).

Table 8. Passage dates for LNFH-origin spring Chinook Salmon at Bonneville Dam, 2008–2019.

	Passage Dates								
Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
2019	2-May	2-May	3-May	8-May	30-May	3-Jul	9-Jul	11-Jul	12-Jul
2018	28-Apr	1-May	5-May	8-May	20-May	1-Jul	7-Jul	12-Jul	19-Jul
2017	27-Feb	27-Feb	1-May	5-May	17-May	23-May	1-Jul	5-Jul	5-Jul
2016	2-Apr	16-Apr	21-Apr	27-Apr	30-Apr	7-May	15-May	24-May	10-Jul
2015	9-Apr	12-Apr	16-Apr	20-Apr	28-Apr	9-May	25-May	27-Jun	27-Aug
2014	7-Apr	18-Apr	20-Apr	25-Apr	30-Apr	7-May	25-Jun	10-Jul	8-Aug
2013	5-Mar	23-Apr	25-Apr	29-Apr	6-May	24-Jun	7-Jul	18-Jul	4-Aug
2012	7-Apr	20-Apr	23-Apr	2-May	8-May	14-May	4-Jul	6-Jul	17-Jul
2011	20-Apr	26-Apr	28-Apr	3-May	9-May	18-May	6-Jul	15-Jul	27-Jul
2010	29-Mar	13-Apr	15-Apr	21-Apr	28-Apr	6-May	3-Jul	11-Jul	19-Jul
2009	22-Apr	24-Apr	26-Apr	2-May	8-May	16-May	28-Jun	9-Jul	17-Jul
2008	2-Mar	15-Apr	19-Apr	27-Apr	11-May	5-Jul	14-Jul	17-Jul	1-Aug
Mean (08-18)	31-Mar	15-Apr	23-Apr	29-Apr	6-May	25-May	25-Jun	5-Jul	25-Jul

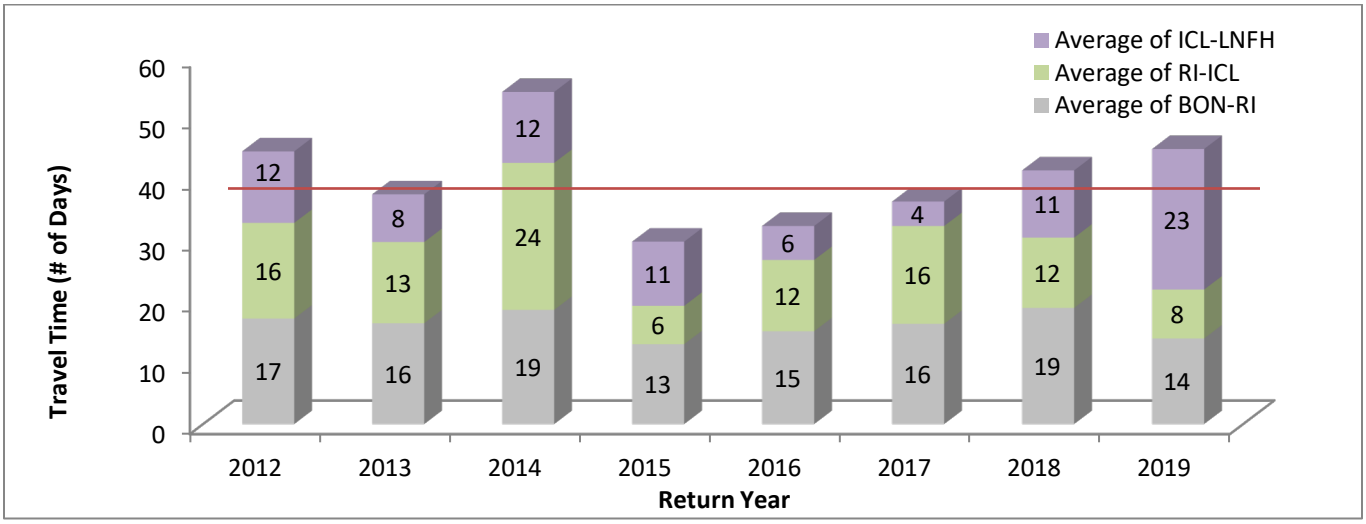

Figure 6. Travel time of adult LNFH-origin spring Chinook Salmon returns from Bonneville to Rock Island Dam (BON -RI), Rock Island Dam to the Lower Icicle array (RI-ICL) and the Lower Icicle Array to LNFH (ICL-

LNFH). The average number of days is given for each reach in the data bars, with red line indicating mean travel time between BON to LNFH from 2012–2019.

Fish Ladder Operation

Standard operation of the ladder is to trap a representative sample throughout the run, while providing harvest opportunities, and minimizing stray rates. In 2019, due to the low return predictions, the fish ladder was opened continuously from May 17th through July 2nd to assure adequate broodstock was collected to meet LNFH production goals. During this time, 1,189 spring Chinook adults ascended the fish ladder and entered the adult holding pond (Figure 7). This was 30% of the recent 11-year (2008-2018) average of 4,064 fish.

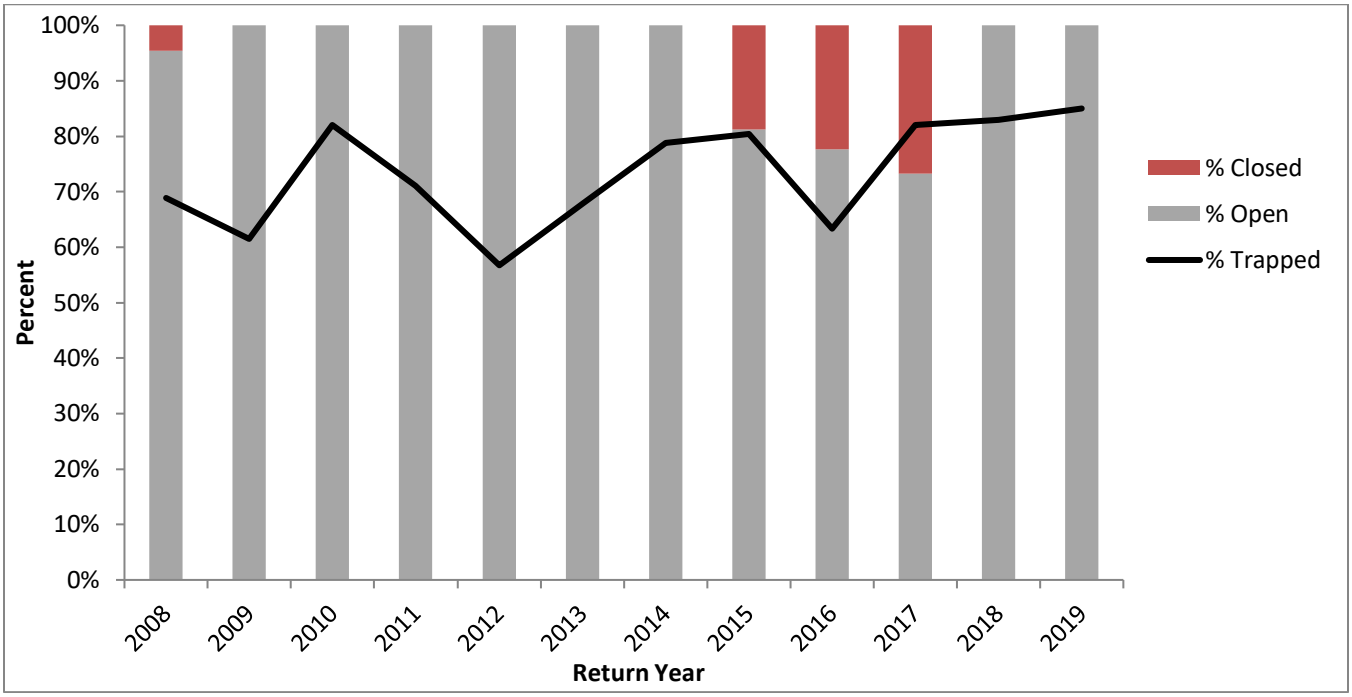

Figure 7. LNFH fish ladder operations and percent of Icicle Creek returning spring Chinook Salmon trapped in LNFH adult holding pond, 2008-2019.

Harvest

Washington Department of Fish and Game and tribal partners elected to keep the Icicle Creek fishery closed until LNFH notified that broodstock goals were likely to be met (Table 9). LNFH and MCFWCO projected that broodstock collection goals were likely to be met by mid-June providing a limited harvest fishery by both sport and tribal partners.

It was estimated that a total of 213 Chinook Salmon were harvested from Icicle Creek in 2019. This was 15% of the 2008-2018 average of 1,455 (Table 9).

Table 9. Abundance and fate of LNFH-origin adult spring Chinook Salmon returning to Icicle Creek from 2008–2019.

Return Year	Total Run to Icicle Cr.	Returned to LNFH		Sport Harvest		Tribal [a]		Remaining in River	
	N	N	%	N	%	N	%	N	%
2019	1,404	1,189	84.5	13	0.9	200	14.4	2	0.1
2018	976	799	81.9	NA		172	17.6	5	0.5
2017	1,417	1,156	81.6	41	2.9	144	10.2	76	5.4
2016	5,277	3,241	61.4	303	5.7	1,550	29.4	130	2.5
2015	8,149	6,557	80.5	433	5.3	908	11.1	251	3.1
2014	6,005	4,375	72.9	390	6.5	818	13.6	422	7.0
2013	3,309	2,094	63.3	323	9.8	678	20.5	214	6.5
2012	7,074	3,749	53.0	971	13.7	2,036	28.8	318	4.5
2011	6,990	4,970	71.1	873	12.5	805	11.5	342	4.9
2010	13,862	11,307	81.6	993	7.2	1,314	9.5	248	1.8
2009	4,977	3,232	64.9	640	12.9	910	18.3	195	3.9
2008	4,692	3,229	68.8	347	7.4	833	17.8	283	6.0
Min	976	799	53.0	13	0.9	144	9.5	2	0.1
Max	13,862	11,307	84.5	993	13.7	2,036	29.4	422	7.0
Mean (08–18)	5,703	4,064	71.0	531	8.4	924	17.1	226	4.2

[a] Estimated tribal harvest, 2009-2016

Wenatchee and Entiat River Strays

Nearly all natural spawning of spring Chinook in the Wenatchee Subbasin occurs upstream of Tumwater Dam (Figure 1), which WDFW uses to collect broodstock and conduct adult management.

In 2009, LNFH partnered with WDFW to remove potential stray LNFH-origin and other non-target hatchery adults attempting to migrate above Tumwater Dam. Presumed LNFH-origin adults were identified for removal at Tumwater Dam if the fish was adipose clipped and did not have a CWT. Each year approximately 80% of LNFH-origin returning adults are marked and tagged in this manner. In 2019, a preliminary estimate of 12 (4 adult males, 6 adult females, and 2 age-3 jacks) presumably LNFH-origin spring Chinook were removed at Tumwater Dam, euthanized and discarded (M. Hughes pers. comm.). Due to treatment with MS-222 (anesthesia), the removed fish were not suitable for consumption.

Contribution of LNFH-origin spring Chinook to the upper Wenatchee River subbasin spawning population was evaluated using CWT recoveries expanded by the estimated recovery rate (number of carcass recovered/estimated spawning escapement) and by the percentage of marked fish representing each CWT release group. This methodology is conservative as the expanded recovery estimate does not

take into account the removal of potential LNFH untagged adults at Tumwater Dam. The proportion of LNFH-origin spawners (partial pHOS) in the upper Wenatchee River subbasin has remained very low (average 0.6% since 2006).

All adipose clipped, non-CWT fish removed at Tumwater Dam are presumed to be LNFH-origin; however, it is possible some of these fish could originate from the upper Wenatchee River spring Chinook acclimation programs (CWT loss) or low CWT rate harvest mitigation programs in the Snake River Basin (e.g., Dworshak NFH). These fish are commonly encountered at LNFH and on the Entiat River spawning grounds. Further analysis of the true rearing origin of these adipose clipped/non-CWT fish within the returning population may be needed if apparent stray rate/contribution rates begin to exceed permitted levels.

In 2019, one LNFH-origin tag was recovered in the upper Wenatchee River (Table 10) and none were recovered on the spawning grounds in the Entiat River (Table 11), meeting LNFH 2017 NMFS BiOp Term and Condition 1a (Appendix A).

Table 10. Escapement abundance of spring Chinook Salmon to the upper Wenatchee River (WR), sampling rates, LNFH-origin fish data and expansions 2008–2019.

Return Year	WR SCS Escapement	WR SCS Carcass Recoveries	Percent Carcasses Sampled[a]	LNFH-origin CWT Recoveries	LNFH-origin Estimated Recoveries[b]	LNFH-origin Expanded Recoveries[c,d]	Proportion of LNFH-origin adults (partial pHOS) in WR[e]
2019	TBD	TBD	TBD	1	TBD	TBD	TBD
2018	882	365	41.4	0	0	0	0.0
2017	649	230	35.4	0	0	0	0.0
2016	848	337	39.7	0	0	0	0.0
2015	1,391	380	27.3	1	4	20	1.4
2014	1,389	430	31.0	0	0	0	0.0
2013	2,022	588	29.1	0	0	0	0.0
2012	2,436	792	32.5	0	0	0	0.0
2011	2,990	290	9.7	0	0	0	0.0
2010	1,761	382	21.7	2	9	20	1.1
2009	2,195	409	18.6	2	11	17	0.8
2008	2,141	765	35.7	5	14	42	2.0
Min	649	230	9.7	0	0	0	0.0
Max	2,990	792	41.4	5	14	42	2.0
Mean (08-18)	1,700	452	29.3	1	3	9	0.5

[a] Carcass Recoveries/ Escapement

[b] LNFH-origin CWT Recoveries/Percent Carcasses Sampled

[c] LNFH-origin Estimated Recoveries/CWT rate (CWT rate not shown)

[d] This estimate should be considered a maximum impact as this does not include removal of adipose-clipped, non-CWT'd SCS removals at Tumwater Dam from 2009-2018.

[e] LNFH-origin Expanded Recoveries/ Escapement

Table 11. Escapement abundance of spring Chinook Salmon to the Entiat River, sampling rates, LNFH-origin fish data and expansions 2008–2019.

Return Year	Entiat SCS Escapement[a]	Entiat SCS Carcass Recoveries	Percent Carcasses Sampled[a]	LNFH-origin CWT Recoveries	LNFH-origin Estimated Recoveries[b]	LNFH-origin Expanded Recoveries[c]	Proportion of LNFH-origin spawners (pHOS) in Entiat [d]
2019	TBD	TBD	TBD	0	0	0	0.0
2018	92	28	30.4	1	3	22	23.8
2017	101	19	18.8	0	0	0	0.0
2016	343	52	15.2	0	0	0	0.0
2015	406	137	33.7	0	0	0	0.0
2014	189	26	13.8	0	0	0	0.0
2013	189	22	11.6	0	0	0	0.0
2012	403	125	31.0	0	0	0	0.0
2011	505	173	34.3	2	6	50	9.9
2010	345	93	27.0	0	0	0	0.0
2009	198	79	39.9	1	3	7	3.5
2008	228	80	35.1	0	0	0	0.0
Min	92	19	11.6	0	0	0	0.0
Max	505	173	47.2	2	6	50	23.8
Mean (08-18)	258	72	27.1	0	1	7	3.5

[a] Carcass Recoveries/ Escapement
[b] LNFH-origin CWT Recoveries/Percent Carcasses Sampled
[c] LNFH-origin Estimated Recoveries/CWT rate (CWT rate not shown)
[d] LNFH-origin Expanded Recoveries/ Escapement

Hatchery Returns

Of the 1,189 adults that returned to the LNFH holding pond 376 (32%) were randomly sampled to determine population characteristics. In addition to the random sample all fish were scanned for the presence of a PIT tag and CWT and inspected for the presence of an adipose fin. Those with a positive detection of a tag were also sampled and used for additional population biometrics. If a CWT was detected, the snout was collected and age and hatchery origin verified using tag information reported to RMIS. Presumed natural origin fish with intact adipose fins and no other tags had their scales examined to determine rearing origin. In 2019, no natural origin fish were identified in the adult holding ponds at LNFH.

Age composition for LNFH-origin returns was based on 147 CWT recoveries and 188 ages from scale samples. The run was dominated by age-4 adults, however, this was proportionally below the average for the past 11 years due to a higher than average age-3 component. (Table 12). The male-female ratio of returns was 0.86, with fewer males having returned than females (Table 13). With the exception of the generally rare age-3 females, fork lengths for returning adult spring Chinook were within the standard deviation for all age classes (Table 14).

Table 12. LNFH-origin spring Chinook Salmon age compositions by sex and return year, 2008–2019.

	% MALE AGE				% FEMALE AGE			% COMBINED AGE			
Return Year	2	3	4	5	3	4	5	2	3	4	5
2019		28.0	27.4	3.3	0.6	37.4	3.3		28.6	64.7	6.7
2018		8.1	34.7	1.1	0.6	54.7	0.8		8.6	89.5	1.9
2017		15.1	28.7	2.6		49.1	4.5		15.1	77.8	7.1
2016	0.8	4.0	34.3	6.3		48.7	5.8	0.8	4.0	83.1	12.1
2015	0.1	9.0	35.8	2.1	0.1	50.0	2.9	0.1	9.1	85.8	5.0
2014	1.8	15.5	31.8	0.7	0.1	48.2	1.9	1.8	15.6	80.0	2.6
2013	3.8	18.2	19.0	9.4	0.2	35.9	13.5	3.8	18.4	54.9	22.9
2012	0.1	1.4	31.7	4.4	0.1	56.0	6.3	0.1	1.5	87.7	10.7
2011	0.9	34.8	14.3	11.6	0.1	23.2	15.1	0.9	34.9	37.5	26.7
2010		0.9	36.9	0.7		60.7	0.7		0.9	97.7	1.4
2009		24.3	25.2	5.6	0.1	37.9	6.9		24.4	63.2	12.4
2008		3.3	31.4	8.7		47.5	9.1		3.3	78.9	17.8
Min	0.1	0.9	14.3	0.7	0.1	23.2	0.7	0.1	0.9	37.5	1.4
Max	3.8	34.8	36.9	12.4	0.6	60.7	15.1	3.8	34.9	97.7	26.7
Mean (08-18)	1.3	12.9	28.3	5.5	0.2	46.1	6.5	1.3	13.0	74.4	12.0

Table 13. Sex composition of sampled spring Chinook Salmon returning to LNFH, 2008–2019.

Return Year	% of Return Sampled	# Males	# Females	Male/Female Ratio
2019	32.0	174	202	0.86
2018	100.0	338	461	0.73
2017	40.0	213	249	0.86
2016	12.0	174	214	0.81
2015	16.7	510	583	0.87
2014	23.6	498	536	0.93
2013	28.6	309	290	1.07
2012	33.3	471	779	0.60
2011	28.2	863	538	1.60
2010	10.1	409	733	0.56
2009	31.7	563	461	1.22
2008	97.8	1,380	1,779	0.78
Min	10.1	174	202	0.56
Max	100.0	1,380	1,779	1.60
Mean (08-18)	37.8	499	576	0.91

Table 14. LNFH spring Chinook Salmon mean fork length (cm) by age, sex, and return year, 2008–2019.

	Males			Females		
Return Year	age-3	age-4	age-5	age-3	age-4	age-5
2019	50.9	76.1	90.8	52.0	72.3	84.5
2018	47.7	77.4	95.0		71.5	85.0
2017	51.7	79.2	95.2		74.2	87.1
2016	52.5	76.2	92.9		72.6	83.3
2015	52.4	75.9	90.0	72.0[a]	73.6	85.0
2014	50.6	79.2	88.7	56.0	74.0	83.6
2013	51.8	76.3	91.4	70.0	72.3	84.1
2012	50.5	75.3	93.3	61.0	71.9	84.9
2011	51.0	77.1	93.3	74.5[a]	74.0	86.7
2010	49.8	79.3	94.1		74.7	86.3
2009	53.1	79.2	93.2	62.0	75.4	87.4
2008	53.9	78.7	95.5		75.3	87.5
Mean (08–18)	51.5	77.8	93.0	62.3	73.7	85.6
St. Dev. (08-18)	1.7	1.6	2.1	5.8	1.4	1.5

[a] *n=1*

Broodstock

Of 1,189 spring Chinook Salmon that returned to the hatchery, 546 were spawned (399 females), 456 fish died while being held in the adult holding pond (DIP), 186 were excess, and 1 was green, bad, or spent adult females (Table 15).

To minimize pre-spawn mortality of adults, daily formalin treatments were administered for one hour at 167 ppm to the adult holding ponds to control fungus and parasites. However, in mid-August male broodstock started to show increased mortality. Upon inspection, hatchery staff noticed that there was a water blockage on the male side of the adult holding pond. The stress caused by a lack of flow caused a common bacteria *Flavobacterium columnare* (Columnaris) to infect the gills of the males. Adults were treated with Potassium permanganate for the outbreak, and seemed to reduce overall levels of Columnaris, but mortality continued until the last day of spawning.

In 2019, LNFH spawned 546 of the 1,002 fish held for broodstock resulting in a 54% broodstock utilization rate, which was below the utilization goal of 88% (Table 2). The targeted male : female spawning ratio was 1:1, with a backup male used in the event the primary male was infertile. This goal was not met for a second consecutive year, due to the increased mortality of the male broodstock. To help achieve the production goal for the 2021 release group, milt was transferred from Little White Salmon NFH (LWSNFH) and Chief Joseph Hatchery (CJH). This was the first time since 1985 that gametes have been transferred to LNFH. Milt from Little White Salmon NFH and Chief Joseph Hatchery were refrigerated for 24 hours. Prior to use motility was examined by the Pacific Region Fish

Health team for assessments of viability. If available, males from LNFH were used as the primary male contribution and transfer gametes were used as the backup. Milt from Little White Salmon and Chief Joseph Hatchery was only used as the primary male contribution for 27 and 34 females, respectively (Appendix D). It should be noted that while Little White Salmon NFH spring Chinook are derived directly from lower Columbia River stocks, Chief Joseph Hatchery stock was recently established directly from LNFH and for all reasonable purposes considered LNFH stock. Therefore, the 2019 out of basin inclusion (LWSNFH) into the LNFH stock is estimated at approximately 7% (male only contribution to 27 of 399 crosses, assuming only primary males contributed).

Portions of the returning adults were tested for pathogens, including: Viral Hemorrhagic Septiciemia Virus (VHSV), Infectious Pancreatic Necrosis Virus (IPNV), and Infectious Hematopoietic Necrosis Virus (IHNV). The Washington Animal Disease Diagnostic Laboratory (WADDL) supplied pathogen profiles for the broodstock used for production. Sampling protocols included testing all females for the presence and relative abundance of *R. Salmoninarum* the causative agent of bacterial kidney disease (BKD). Additionally, bacteriology and virology testing were performed on kidney/spleen samples from 60 fish and virology testing was conducted on ovarian fluid from 60 females.

Table 15. Fate of spring Chinook Salmon that entered the adult holding ponds at LNFH, 2008–2019.

Return Year	Total Returns to LNFH	DIPS	Adults Excessed	Adults Spawned	Green/ Spent/ Bad	Transfers	Returned to River	Non-LNFH origin CWT's Collected	Natural Origin
2019	1,189	456	186	534	1	0	0	3	0
2018	799	45	23	724	7	0	0	3	0
2017	1,156	31	274	802	47	0	2	0	0
2016	3,241	52	1,527	1,002	20	640	0	8	1
2015	6,557	124	4,838	955	8	640	0	6	1
2014	4,375	122	2,801	1,101	65	640	0	10	0
2013	2,094	227	666	767	0	422	163	32	0
2012	3,749	42	2,931	1,036	0	0	4	29	0
2011	4,970	112	3,932	926	0	0	0	95	0
2010	11,307	104	10,250	729	214	0	69	9	0
2009	3,232	109	2,178	714	52	0	0	19	1
2008	3,229	64	2,189	968	5	0	0	10	0
Min	799	31	23	534	0	0	0	0	0
Max	11,307	456	10,250	1,101	214	640	163	95	1
Mean (08-18)	3,868	89	2,693	890	35	195	20	19	0

Included within the broodstock were three hatchery-origin out-of-basin spring Chinook identified by CWT (Table 16). All out-of-basin recoveries were age-4 fish two of which were utilized as LNFH broodstock. The fate of all out-of-basin recoveries fell within the guidelines of the NMFS BiOp Terms and Conditions 2a (Appendix A). Additionally, four intact adipose unknown origin fish were also included in broodstock. Further scale analysis on these fish revealed all were of hatchery origin.

Table 16. Fate of non-LNFH-origin fish that entered the LNFH adult holding ponds in 2019

CWT Code	# Observed	Age	% Tagged	Deposition	Origin	Expanded #	Conservation Program
055714	1	4	99	Pre-Spawn Mortality	Winthrop NFH	1	Safety-Net
091050	1	4	100	Spawned	Umatilla Hatchery	1	None
636942	1	4	96	Spawned	Chiwawa Hatchery	1	ESA
Wild Origin	0						

Virology and ELISA Results

For salmonids, the Pacific Region Fish Health Program categorizes BKD risk from ELISA optical density values into six levels, ranging from "Very Low" to "Very High" risk (Figure 8). In 2019, 98.0% of the females were in the "Very Low" and "Low" risk levels. At the time of spawning, the eggs from each female were held in separate trays. When the ELISA results were complete, "Moderate", "High" and "Very High" risk groups were culled. On average (2008–2018) approximately 18% of the tested spring Chinook females rank moderate or higher. However, the long term average was greatly increased due a high proportion of moderate risk detections from 2010-2014. During these years, adults were held on second or third pass surface water from the juveniles. Excluding the anomalous years (2010-2014) the average rate of moderate or higher risk detections is 6%.

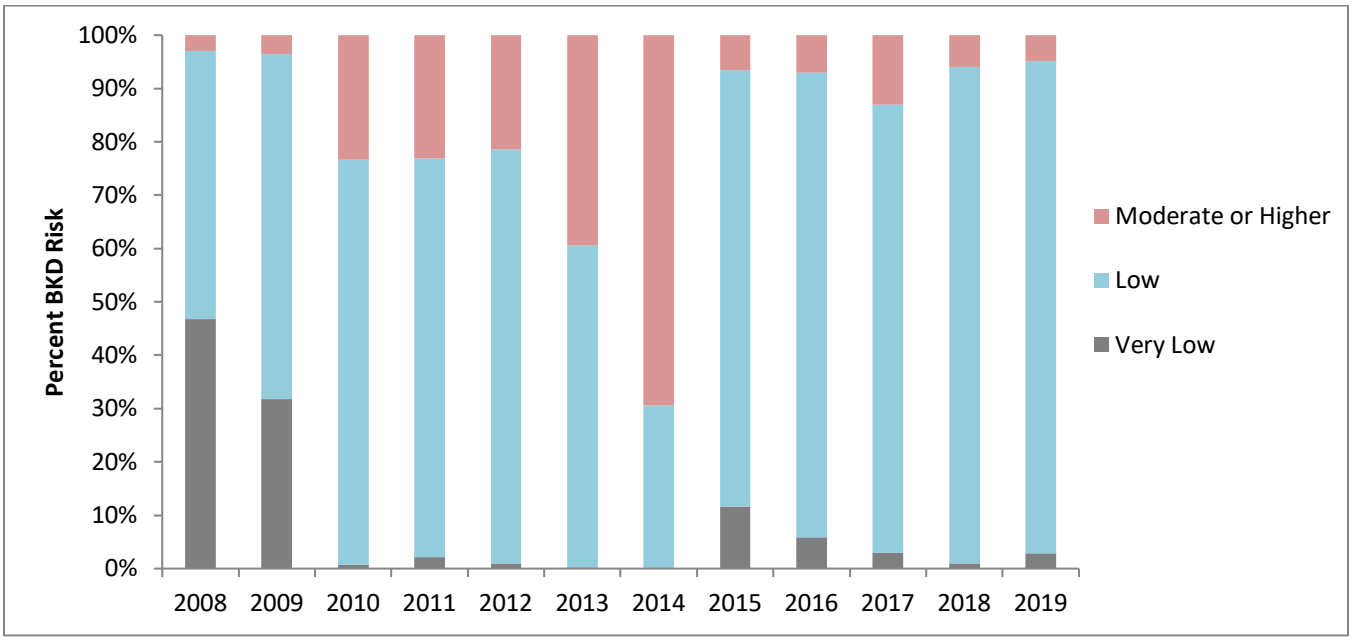

Figure 8. Summary of BKD detection from female spring Chinook Salmon at LNFH, 2008-2019

Egg Survival

In 2019, the average fecundity was 3,571 eggs with a total egg take of 1,422,827 eggs (Table 17) which was 82% of the green egg take goal of 1,740,000. The ELISA culling rate of 1.3% (8,660 eggs) was the lowest since 2010 and allowed LNFH to move closer to production needs even with a low average fecundity. The post-cull eyed egg inventory of 1,306,560 was 98% of the production goal of 1,330,000. Unfortunately, egg inventory did not exceed production needs such that LNFH was able to provide excess eggs to multiple tribes for production or educational purposes. In March, emergent fry were placed in indoor starter tanks to begin the rearing cycle.

Table 17. Eyed egg survival for LNFH spring Chinook Salmon for return years 2008–2019.

Return Year	Fecundity	Green Eggs	Bad Eggs	Culled[a]	Eyed Eggs	% Eyed Survival
2019	3,571	1,422,827	119,394	8,660	1,306,560	91.7
2018	3,426	1,516,574	121,667	31,310	1,394,907	94.0
2017	3,635	1,563,121	55,832	232,602	1,326,892	99.8
2016	3,822	1,914,435	31,250	547,544	1,335,641	98.4
2015	4,104	1,953,690	41,400	600,636	1,301,654	97.4
2014	3,960	2,391,794	39,988	1,044,168	1,307,638	98.3
2013	3,909	1,557,224	123,802	260,528	1,172,894	92.0
2012	3,656	1,857,748	58,748	504,000	1,295,000	96.8
2011	3,993	1,809,216	74,257	428,609	1,306,350	95.9
2010	4,109	1,651,881	46,416	385,597	1,219,868	97.2
2009	4,252	1,620,733	25,635	326,349	1,268,749	98.4
2008[b,c]	3,980	1,949,442	20,910	652,857	1,275,675	98.9
Min	3,426	1,422,827	20,910	8,660	1,172,894	91.7
Max	4,252	2,391,794	123,802	1,044,168	1,711,130	99.8
Mean (08-18)	3,858	1,827,434	57,288	430,080	1,345,720	97.1

[a] Includes ELISA culling of Moderate, High, and Very High ranks
[b] Retained Moderate Risk eggs to meet production goals
[c] Beginning in return year 2008, the release number goal was reduced to from 1,625,000 to 1,200,000.

Brood Year 2013

Analysis of brood year performance is delayed by several factors that stem from the fact that it takes a minimum of five years for a brood year cohort to return as adults. Additionally, it may take several more years for all CWT recoveries to be reported. Given these delays, the brood year analysis herein uses brood year 2013 as the most recent cohort for which reasonably complete data is available. All brood year data is subject to change as more CWT recoveries are reported.

2013 Adult Return Recap

The 2013 brood year was produced from an average run size with the hatchery capturing and holding 2,094 returning adults. Of these LNFH spawned 408 females, yielding a green egg take of 1,557,224 and an average fecundity of 3,909 eggs per female. The green egg take was below the estimated 1,740,000 needed to meet the release goal of 1,200,000.

Many of the Adult Return/Broodstock metrics for the 2013 brood year fell in the "average" category. Broodstock utilization, 50% spawn date, and size were all on par for this program. With no major mortality events, brood year 2013 ultimately released 1,139,567 smolts into Icicle Creek on April 17, 2015. The released smolts performed on average exhibiting a slightly slower than average travel time of 25 days and a 57% survival to McNary Dam (2008 – 2018 average travel time = 24 days, survival = 57%).

Brood year 2013 Performance

Population Cohort- A Smolt-to-Adult Return (SAR) is the primary metric for evaluating hatchery program performance for a brood year. SAR is the number of adults that are produced from a single release of juveniles. The HE program calculates SAR by compiling LNFH-origin spring Chinook return data by age from a variety of data sources, including hatchery returns, harvest creels, and spawning ground surveys.

Spring Chinook from brood bear 2013, returned as adults from 2016-2018 and had an SAR of 0.14% which is below the performance goal of >0.40%. Annual variation in LNFH's SAR may be explained by LNFH specific factors such as on-site rearing factors or off-site factors such as ocean or river conditions. To assess whether on-site of off-site factors caused annual SAR variation we compared LNFH SARs to the WNFH in the Methow River subbasin and Chiwawa Rearing Pond in the upper Wenatchee River subbasin (Figure 9). Intra-hatchery variables could be any of the rearing parameters that occur on-site. Similar to LNFH, annual variation in SARs occurred at WNFH, Chiwawa Rearing Pond from 2002–2013 suggesting that external hatchery conditions (eg. Marine rearing environment) are the primary

drivers of SAR and influenced all four programs similarly. For example, in 2009 the SARs were low for all three programs followed by large increases for all three programs in 2010 (Figure 9).

Brood year 2013 returned as 18% age-3 fish, 77% age-4 fish, and 5% age-5 fish (Figure 10). These data are derived from CWT's recovered at the LNFH, and assumes that the application of and/or presence of CWT's does not influence age of return, and that CWT's are recovered randomly. The gender composition for brood year 2011 was 55.0% females and 45.0% males (age-3+) (Figure 11).

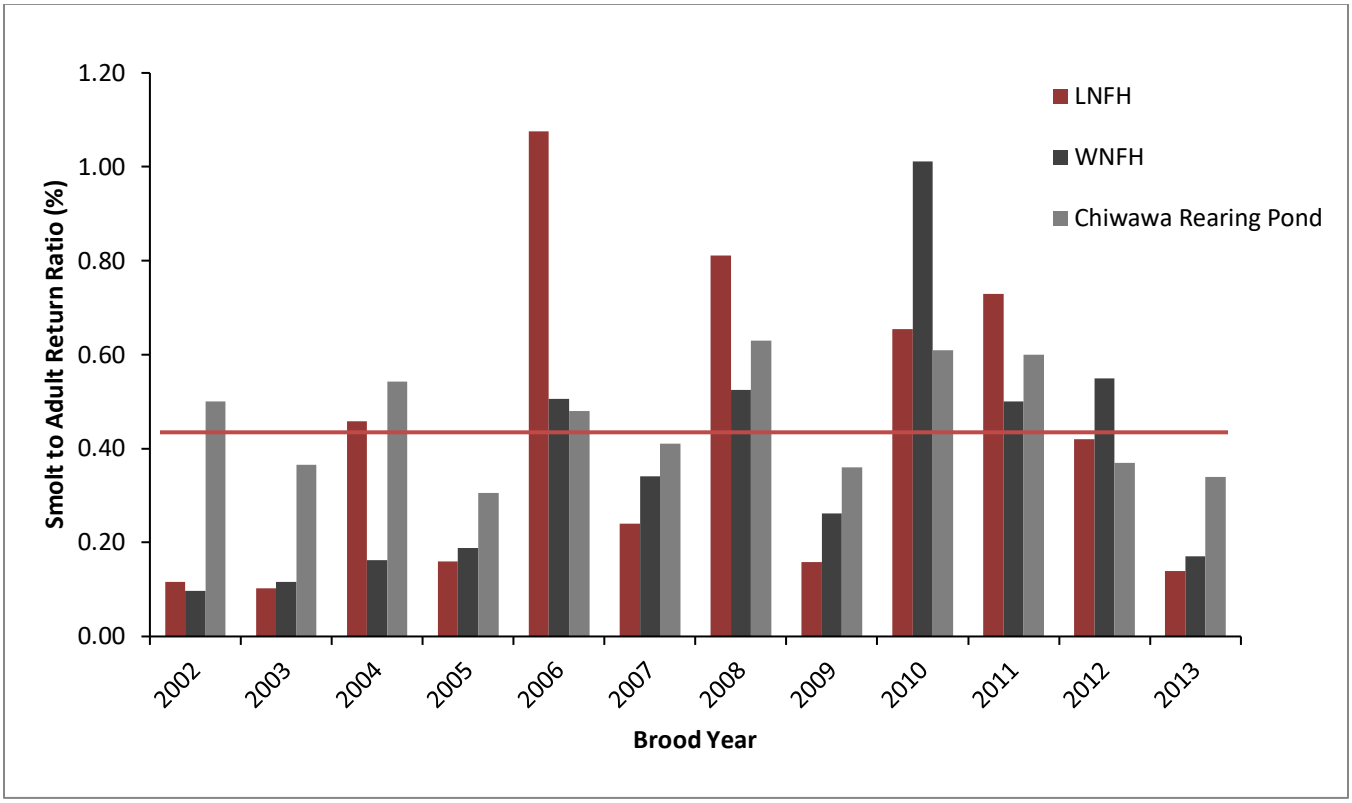

Figure 9. Smolt to Adult Return (SAR) Leavenworth National Fish Hatchery (LNFH), for Chiwawa Rearing Pond (CRP), and Winthrop National Fish Hatchery (WNFH) for brood years 2002–2013, with red line indicating LNFH 2002–2012 mean.

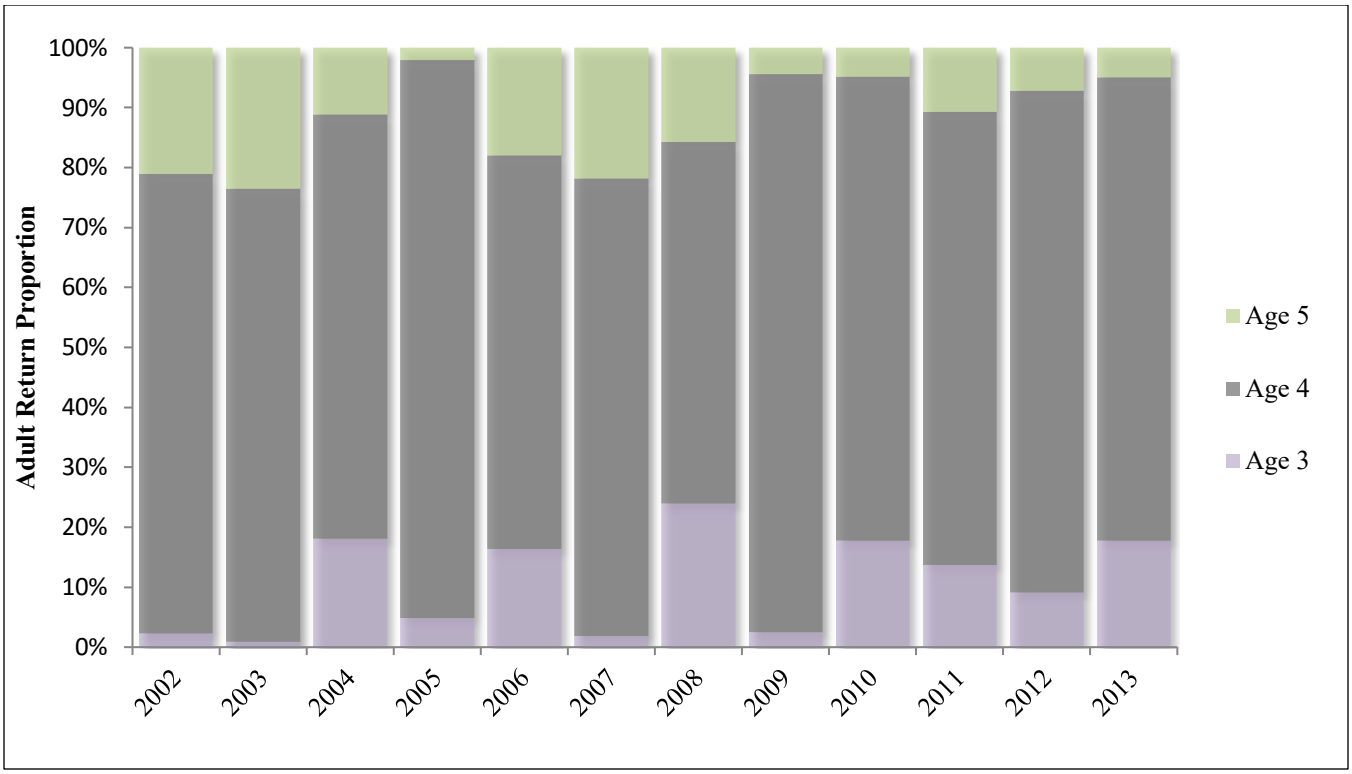

Figure 10. Leavenworth NFH spring Chinook proportion of ages produced, by brood year, 2002-2013.

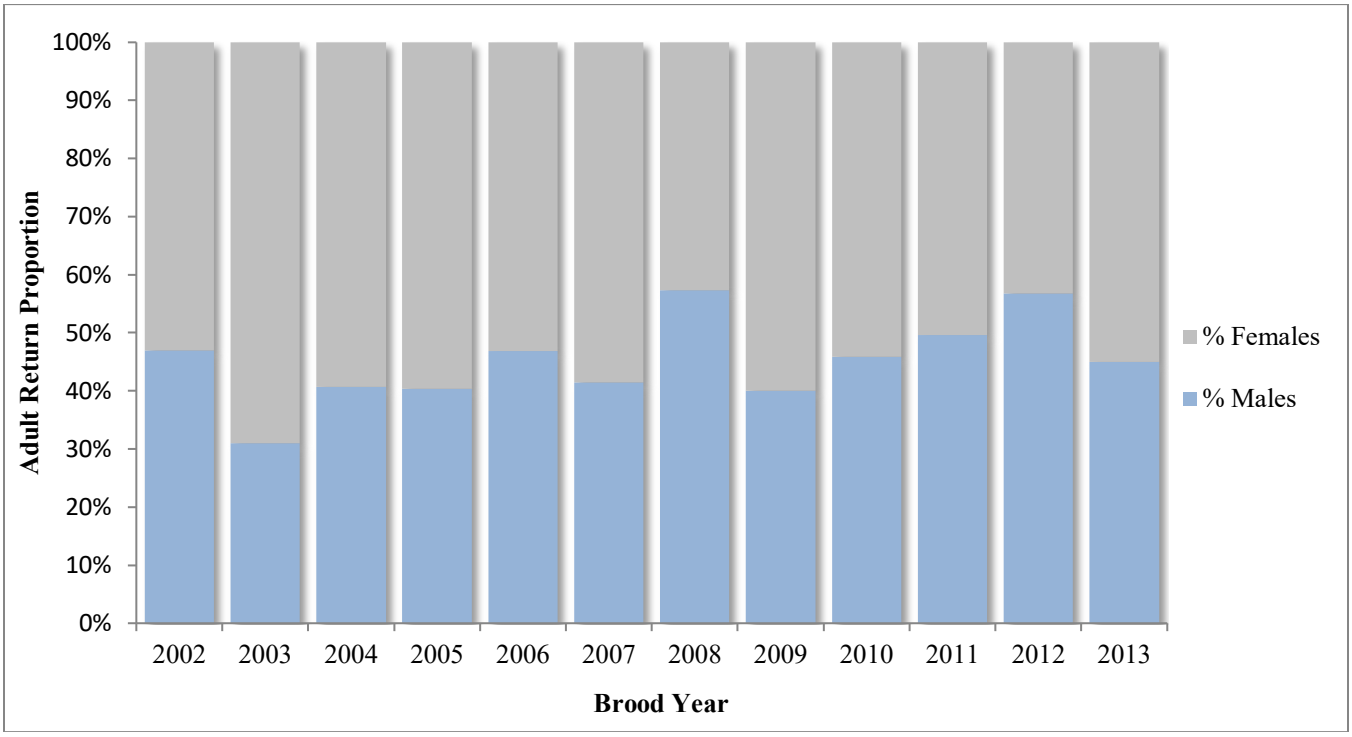

Figure 11. Leavenworth NFH spring Chinook sex composition produced by brood year, 2002-2013.

Harvest Contribution

Brood year 2013 produced an estimated 1,547 adults that returned to freshwater. Of these 694 (45%) were either harvested or excessed for consumption, 679 (44%) were utilized for broodstock and 174 (11%) were found in "other" areas including spawning ground recoveries. Locally, the sport fishery in the Wenatchee River and Icicle Creek accounted for 44 (3%) of the return and tribal fishers in Icicle Creek harvested another 177 (11%) adults (Table 18). Brood year 2013 returning adults contributed to a variety of Columbia Basin Tribes through either harvest or hatchery excessing efforts (30%). This is lower than the average for brood years 2002-2012 (52%) and is due to prioritizing the collection of broodstock for LNFH.

Table 18. LNFH-origin adult return and fate by brood year.

Brood Year	Total Return	Columbia River Harvest N (%)	Sport Fishery (Wenatchee River) N (%)	Sport Fishery (Icicle Creek) N (%)	Tribal Fishery (Icicle Creek) N (%)	Hachery Production N (%)	Excess Hatchery Returns N (%)	Other N (%)
2013	1,547	198 (12.8)		44 (2.8)	177 (11.4)	679 (43.9)	275 (17.8)	174 (11.2)
2012	6,076	187 (3.1)		294 (4.8)	1,381 (22.7)	977 (16.1)	404 (6.6)	143 (2.4)
2011	9,565	747 (7.8)	34 (0.4)	469 (4.9)	1,094 (11.4)	1,112 (11.6)	5,650 (59.1)	459 (4.8)
2010	6,708	930 (13.9)	544 (8.1)	157 (2.3)	825 (12.3)	1070 (16.0)	3,143 (46.9)	39 (0.6)
2009	2,841	108 (3.8)	15 (0.5)	566 (19.9)	424 (14.9)	465 (16.4)	855 (30.1)	408 (14.4)
2008	10,725	1,943 (18.1)		704 (6.6)	2,222 (20.7)	1,407 (13.1)	4,095 (38.2)	354 (3.3)
2007	4,932	568 (11.5)		1,012 (20.5)	532 (10.8)	465 (9.4)	1,902 (38.6)	454 (9.2)
2006	20,562	4,219 (20.5)		1,031 (5.0)	1,721 (8.4)	1,134 (5.5)	12,029 (58.5)	430 (2.1)
2005	4,282	647 (15.1)		465 (10.9)	621 (14.5)	493 (11.5)	1,815 (42.4)	242 (5.6)
2004	8,438	3,115 (36.9)		376 (4.5)	921 (10.9)	1,044 (12.4)	2,248 (26.6)	734 (8.7)
2003	2,840	453 (15.9)		132 (4.6)	582 (20.5)	725 (25.5)	842 (29.6)	106 (3.7)
Mean (03-12)	7,697	1,292 (14.7)	198 (3.0)	521 (8.4)	1,032 (14.7)	889 (13.8)	3,298 (37.7)	337 (5.5)
St. Dev	5,258	1375 (9.7)	300 (4.4)	316 (6.6)	583 (5.0)	331 (5.3)	3,465 (15.7)	208 (4.2)

Summary

- The targeted rearing density and flow indices of < 0.20 and < 0.60, respectively, were met for release year 2019, with the exception of February while fry were held in the nursery.
- The 2019 LNFH release of 1,248,910 spring Chinook exceeded the production goal of 1,200,000.
- Fish were released at 22 fish per pound (fpp) which was 23% below the size goal of 17 fpp.
- Juvenile survival to McNary dam was 52%, which was below the 11-year mean.
- Of the 1,404 spring Chinook that returned to Icicle Creek, 213 (15.2%) were harvested, 1,189 (84.7%) were trapped in the adult holding ponds and 2 (0.1%) remained in Icicle Creek.
- The proportion of LNFH-origin spawners in the upper Wenatchee River and Entiat subbasins has remained very low with 1 LNFH-origin CWT recovered in the upper Wenatchee River in 2019.
- Age composition of spring Chinook returning to LNFH in 2019 was 29% age-3 fish (n = 402), 64% age-4 (n = 908), and 7% (n = 94) age-5. Based on CWT recoveries no age-6 fish were detected.
- In 2019, 399 females were used for broodstock with an average fecundity of 3,571.
- LNFH had a green egg take of 1,422,827. This was below the performance goal of 1,740,000.
- LNFH culled 8,660 eggs and began rearing brood year 2019 with 1,306,560 eyed-eggs (88% of eyed-egg goal).
- The 2013 brood year had a SAR of 0.14%.

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Appendix A: National Marine Fisheries Service Biological Opinion Term and Conditions for Leavenworth National Fish Hatchery

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Action Agencies have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) would likely lapse.

1a. NMFS is using LNFH contribution to pHOS as a surrogate for gene flow, with a limit of 3.2% annually on the LNFH contribution to pHOS for the Upper Wenatchee and Entiat Basins. The LNFH will continue their marking strategy for the spring Chinook salmon hatchery program to help identity LNFH spring Chinook salmon, request removal of them at Tumwater Dam, and validate that the surrogate for gene flow—i.e., pHOS—is no higher than the rates evaluated in this opinion (up to 3.2%) annually for the Upper Wenatchee and Entiat Basins. Monitoring and escapement estimates shall be reported to NMFS SFD annually (see 3b).

2a. The disposition by USFWS of all natural-origin and hatchery-origin spring Chinook salmon and steelhead that enter the LNFH fish collection ladder and water delivery system will be addressed as follows:

All ESA-listed natural-origin spring Chinook salmon (up to 3 adults) (i.e., identified by presence of adipose fin and verified with scale pattern as appropriate) and steelhead (up to 10 adults) shall be monitored, documented, and returned to Icicle Creek during broodstock collection activities, of which no more than three spring Chinook salmon would die annually. In addition, up to 50 juvenile steelhead (with no mortality) may be encountered during broodstock collection.

ii. Annually, up to 120 ESA-listed adult hatchery-origin spring Chinook salmon (identified retrospectively through agency/program specific CWT code; safety-net program) may be encountered[104] during broodstock collection with no more than 120 annual mortalities through use as broodstock, for tribal consumption, or other disposal.

iii. Annually, up to 50 ESA-listed adult hatchery-origin spring Chinook salmon (i.e., identified by presence of adipose fin and CWT; conservation program) may be encountered during broodstock collection and shall be returned to Icicle Creek or transferred to the appropriate hatchery operator (e.g., WDFW) for use as broodstock with no more than 50 annual mortalities.

iv. Annually, up to 1,000 naturally spawned spring Chinook salmon juveniles would be encountered through the water delivery system, of which no more than 50 would result in mortalities.

v. Annually, 10 adult ESA-listed spring Chinook salmon, 10 adult ESA-listed steelhead, and 500 juvenile ESA-listed steelhead may be encountered through the water delivery system and shall be returned to Icicle Creek, of which no more than five juvenile steelhead would die. Icicle Creek also contains a resident rainbow trout population. Since juvenile steelhead are indistinguishable from juvenile rainbow trout during the first few years of their life, this take is likely to include fish from both life history strategies.

2b. Ensure that the gates at Structure 2 are open from March 1 through May 31 to allow for unimpeded steelhead adult migration with the following exception. In March, Structure 2 will only be operated if adult steelhead have not been detected recently (within the last 30 calendar days) in Icicle Creek. Structure 2 may be operated in May for the purpose of installing the DIDSON™ fish counter for monitoring the 50-fish trigger and to block upstream passage of LNFH-origin spring Chinook salmon after reaching the 50-fish trigger, as long as the flow in the historical channel remains above 300 cfs at all times. Structure 2 will not be operated in August. If Structure 5 is closed during LNFH-origin spring Chinook salmon broodstock collection (i.e., due to reaching 50-fish trigger), traps would be checked twice daily and ESA-listedspring Chinook salmon and steelhead would be released upstream or downstream of Structure 5 (depending on marking for spring Chinook salmon and spawning status for steelhead).

2c. From August 1 through September 30, release up to 50 cfs of supplemental flow from the Snow/Nada Lake Basin Supplementation Water Supply Reservoirs, to ensure access to LNFH's surface water withdrawal and improve instream flow conditions to the extent possible during the irrigation season in cooperation with IPID as described in this opinion.

2d. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the IPID's withdrawal from Snow Creek and diversion at Structure 1 (up to 42 cfs).

2e. If USFWS and USBR become aware that the amount of supplementation reaching Icicle Creek from Snow Creek in August and September is less than the amount of water diverted at Structure 1, USFWS and USBR shall notify NMFS within 3 business days. USFWS and USBR shall also confer with IPID and seek permission to include the volume of IPID's withdrawal from Snow Creek in August and September in the annual report to NMFS.

2f. The circumstances under which the LNFH would need to deviate from a 100 cfs collective minimum flow goal in the Icicle Creek historical channel are described and analyzed in Section 2.4.2.6.2, Table 30. Under these circumstances, the LNFH would operate (including operating Structure 2 for purposes of aquifer recharge) in a manner intended to maintain daily average instream flow goals of 40 cfs in October, 60 cfs in

November - February, and 80 cfs in March in the Icicle Creek historical channel.

2g. By May 2023, USBR and USFWS shall have a water delivery system in place and operating that complies with NMFS current screening and fish passage criteria for anadromous fish passage facilities (NMFS 2011c). All holding areas and intake structures incidentally take listed species. Because water withdrawals at the LNFH facility do not currently meet or exceed NMFS current water intake screening criteria, to minimize injury or death of listed species, the USFWS shall evaluate such withdrawals and effects by regularly surveying the sand settling basin and capturing and releasing listed species as follows:

i. Protocol for detecting listed species:

a. Visual observation through snorkeling (to determine if fish are present and capture and release is required) as long as the entire sand settling basin can be viewed. If any *O. mykiss* or spring Chinook salmon are present or if the fish identification is inconclusive, the sand settling basin is drawn down.

b. If the entire sand settling basin cannot be viewed, or if the snorkeler determines that visual detection through snorkeling is not effective, the sand settling basin is drawn down.

c. Any time the sand settling basin is drawn down, all fish in the basin shall be promptly captured and released unharmed into Icicle Creek near the LNFH spillway pool (RM 2.8). If a steelhead is in pre-spawn condition, it shall be released upstream of Structure 1.

d. If less than 2 staff is available to snorkel during the timeframe described below, USFWS will confer with NMFS to assess the benefits and risks associated with performing this protocol understaffed (e.g., risks to the listed species, efficiency of snorkeling, human safety concerns).

ii. Frequency of monitoring for detection:

a. On a weekly basis, as defined by every 7 calendar days to the extent feasible[107] and no less frequently than every calendar week, starting on April 1 through October (particularly during the UCR steelhead smolt migration in spring and again during the first onset of cold weather during the fall).

b. Starting on April 1 through October, if, after three weeks, no *O. mykiss* or spring Chinook salmon are encountered (other than during the spring steelhead smolt migration in fall as described above), survey the sand settling basin for the presence of listed species every 31 calendar days. If more than five steelhead were detected during one survey effort, then the monitoring interval would change back to weekly.

c. During the November through mid-April period, after the onset of cold weather, survey the sand settling basin and remove listed species every 31 calendar days. If more than five *O. mykiss* were detected during one survey effort, then the monitoring interval would change back to weekly.

d. If surveying the sand settling basin is ineffective (e.g., high sediment loads, typically lasting 3 to 4 days) and/or removing fish from the basin is not possible (e.g., presence of ice covering basin pool, potentially up to a month), confer with NMFS to determine the best method of detection, immediately survey basin and remove ESA-listed species as soon as possible, and return to regular survey schedule as stated above.

iii. If no ESA-listed fish is present in the sand settling basin (e.g., if the sand settling

basin has no water) and no fish could enter the water delivery system (e.g., if the hatchery is not withdrawing water from Structure 1), no monitoring of the sand settling basin is necessary. Include results of spring Chinook salmon or *O. mykiss* detection from the above actions and monitoring in annual reports submitted to NMFS (see 3b).

2h. The USFWS will monitor and report monthly average instream flows in Icicle Creek, using current monitoring systems at Structures 1 and 2 and the USGS and Ecology stream gauging systems on Icicle Creek until real-time instream flow monitoring becomes available; when real-time instream flow monitoring becomes available, USFWS will use real-time instream flow monitoring to monitor and report monthly average instream flows in Icicle Creek. USFWS will also monitor for daily flows and will notify NMFS within 3 business days if daily average flow in the Icicle Creek historical channel drops below 40 cfs in October, 60 cfs from November – February, 80 cfs in March, or 100 cfs from April through July. USFWS will not operate Structure 2 without real-time instream flow monitoring. By November 30, 2017, the USFWS will install real-time instream flow monitoring stations with the intent of measuring flows upstream of the intake at RM 4.5 (Structure 1) and with the intent of measuring flows in the Icicle Creek historical channel between RM 3.8 and 2.8 (Structure 2) in order to monitor instream flows in Icicle Creek. USFWS will notify NMFS by October 31, 2017, if real-time instream flow monitoring cannot be installed by November 30, 2017. Instream flow reporting can be combined with other hatchery reporting requirements and submitted to NMFS by March 1st (see 3b).

2i. Disturbing natural-origin spawning salmon and steelhead during hatchery maintenance activities of diversions and instream structures shall be avoided, as shall disturbing salmon and steelhead redds.

2j. The USBR shall replace the valve at Snow Lake to allow accommodating for multiple water users by the end of calendar year 2019, or USBR will notify NMFS, by October 31, 2019, if the valve cannot be installed by the end of 2019.

2k. The USFWS shall monitor the time it takes LNFH juveniles to migrate out of the system, using methods adequate to identify LNFH juveniles, such as PIT tag detections or observations in screw traps. The USFWS shall annually report to NMFS the hatchery fish post-release out-of-basin migration timing (in mean and median travel time) to McNary Dam and travel rate of juvenile hatchery-origin fish. The USFWS shall notify NMFS if the running 3-year average of travel rate (using mean travel time) is at or below 9.4 RM/day, including instances where it is apparent, from numbers observed in years prior to the third year, that the average of 9.4 RM/day would not be achieved after 3 years.

3a. NMFS' SFD must be notified, in advance, of any change in hatchery program operation and implementation that would potentially result in increased take of ESA-listed species or a change in the manner of that taking.

3b. NMFS' SFD must be notified as soon as possible, but no later than two days, after any authorized level of take is exceeded. A written report shall be provided to SFD detailing why the authorized take level was exceeded or is likely to be exceeded. NMFS prefers communication via phone and electronic submission of reporting documents. The current point of contact for document submission is Craig Busack (*craig.busack@noaa.gov*), but this may change during the life of the permits. All reports,

as well as all other notifications required in the permits, can also be submitted to NMFS at:

Craig Busack
Anadromous Production and Inland Fisheries
NMFS – Sustainable Fisheries Division
National Marine Fisheries Service, West Coast Region
1201 NE Lloyd Blvd, Suite 1100
Portland, Oregon 97232
Phone: (503) 230-5412
Fax: (503) 872-2737

3c. Apply measures to ensure that, before their release into Icicle Creek, LNFH-origin spring Chinook salmon juveniles are ready to actively migrate to the ocean. To meet this condition, fish shall be released at a uniform size and demonstrate signs of smoltification that ensure that the fish will migrate seaward without delay.

i. Variance from this release requirement is only approved, per best management practice, in the event of an emergency, such as flooding, water loss to raceways, or vandalism, which necessitates early release to prevent catastrophic mortality.

ii. Any emergency releases must be reported as soon as reasonably possible to SFD.

3d. Post-release survival of LNFH-spring Chinook salmon smolts shall be monitored and evaluated to determine the speed of emigration and level of residualism.

3e. To the extent possible without imposing increased risk to ESA-listed species, USFWS shall enumerate and identify marks and tags on all anadromous species encountered at adult collection and water intake sites. This information shall be included in the broodstock protocol or LNFH monitoring report submitted to NMFS annually.

3f. If water temperature in the adult holding ponds or sand settling chamber exceeds 21 °C (69.8 °F), fish collection shall cease pending further consultation with NMFS to determine if continued collection poses substantial risk to ESA-listed species that may be incidentally encountered.

3g. The USFWS shall update and provide SFD, by March 1st of each year, the projected hatchery releases by age class and location for the upcoming year (see 3b).

3h. The USFWS shall provide annual report(s) that summarize numbers, fish weights, dates, tag/mark information, locations of artificially propagated fish releases, and monitoring and evaluation activities that occur within the hatchery environment, and adult return numbers (specifying the program of origin) to the UCR basin. Ensure collection and reporting of the coefficient of variation around the average (target) release size for LNFH spring Chinook salmon immediately prior to their liberation from the rearing ponds to serve as an indicator of population size uniformity and smoltification status. Reports must include any preliminary analyses of scientific research data, identification of any problems that arise during conduct of the authorized activities, a statement as to whether or not the activities had any unforeseen effects, and steps that have been and will be taken to coordinate the research or monitoring with that of other researchers. Unless otherwise noted in the specific terms and conditions, the reports will be submitted by March 1st, of

the year following release to NMFS (i.e., brood year 2016, release year 2017, report due March 2018, see 3b).

3i. Provide plans in advance of any future projects and/or changes in collection locations for NMFS concurrence through the UCR annual broodstock protocol memorandum.

3j. Adult return information shall include available annual estimates of pHOS for LNFH spring Chinook salmon in the Wenatchee and Entiat basins, including the number, location, and timing of recoveries. Adult return information and results from monitoring and evaluation activities outside the hatchery environment shall be included in the annual report or a separate report. If a separate report on monitoring and evaluation activities conducted outside the hatchery environment is prepared, it will be submitted by March 1st, of the year following the monitoring and evaluation activities (i.e., surveys conducted on 2014, report due March 2015, see 3b).

4a. EPA will notify NMFS' SFD if the terms of the NPDES permit (including monitoring requirements) pertaining to phosphorus will change from what is currently proposed prior to issuance of the final permit.

4b. EPA will include terms in its final NPDES permit that require LNFH to also notify NMFS' SFD for non-compliance with the daily maximum and monthly average phosphorus limits using the same method as reporting to the EPA.

4c. Until monitoring is implemented for phosphorus in the effluent, USFWS and USBR will use feed only up to the levels of the feeding regimen for the spring Chinook salmon program described in Table 18 of USFWS (2011c).

4d. If monitoring is implemented before the issuance of a final NPDES permit, USFWS and USBR will notify NMFS' SFD if LNFH operation exceeds the amount of phosphorus in the effluent described in the draft NPDES permit until final permit issuance. Upon final permit issuance, USFWS and USBR will notify NMFS' SFD if LNFH operation exceeds the amount of phosphorus in the effluent described in the final NPDES permit, per conditions indicated in the final NPDES permit.

Appendix B: U.S. Fish and Wildlife Service Biological Opinion Terms and Conditions for Leavenworth National Fish Hatchery

V. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the LNFH must comply with the following terms and conditions (T&Cs), which implement the reasonable and prudent measures described above, and are designed to minimize impacts to bull trout. These terms and conditions are mandatory.

To implement RPM 1:

T&C 1. In years where the >50 Chinook salmon trigger is met (and structure 5 is closed during the BSC period, which will also require structure 2 to be closed to manage flows), structures 2 and 5 shall be re-opened by June 24. This action will minimize the period of impairment of upstream passage of migratory bull trout and provide for a total of 6 of 7 predicted weeks of passage opportunities for migratory bull trout.

To implement RPM 2:

T&C 2. The analysis in the Biological Opinion assumed up to 64 bull trout would be exposed to adverse effects as a result of aquifer recharge in August. To validate this assumption and ensure that the extent of effects of the Project is within the scope of what was analyzed, the LNFH shall conduct surveys as follows:

- Conduct 3 daytime snorkel surveys (as broadly spaced in time as possible) between rm 2.8-3.8 at least 2 weeks prior to the August aquifer recharge.
- If the mean number of bull trout observed is <64, then the effects are within those analyzed and August aquifer recharge may proceed.
- If the mean number of bull trout observed is >64, then the effects are not within those analyzed and reinitiation of consultation is required prior to the August aquifer recharge. Alternately, if the mean number of bull trout observed is >64, and aquifer recharge is delayed until September, then reinitiation of consultation is not required.

T&C 3. The analysis in the Biological Opinion assumed lethal effects to bull trout would not likely be caused by the August aquifer recharge. To validate this assumption and ensure that the effects of the Project are within the scope of what was analyzed, the LNFH shall conduct temperature monitoring as follows:

- Temperature monitoring shall be conducted at least two weeks prior to the August aquifer recharge, and should incorporate the techniques of Isaak and Horan (2011) and Dunham et al. (2005). Measure the 7-day average daily maximum (7-DADMax) temperature in the historical channel with structure 2 open. If the 7-DADMax is less than 19 °C, the temperature criterion for proceeding with aquifer recharge is met and August aquifer recharge may proceed.
- If the 7-DADMax is greater than 19 °C in the historical channel with structure 2 open, defer aquifer recharge for one week, and continue temperature monitoring. If the 7-DADMax remains above 19 °C after one week, reinitiate consultation. Alternately, if aquifer recharge is delayed until September, then reinitiation of consultation.
- Monitor water temperatures during August aquifer recharge, if it occurs.

If the 7-DADMax is greater than 19 °C during August aquifer recharge, cease operations immediately and re-open structure 2.

• If on-going temperature monitoring efforts can achieve this same objective of determining water temperatures in the historical channel in August, then the additional temperature monitoring prescribed above need not occur.

To implement RPM 3:

T&C 4. Monitor, capture, and release all bull trout in the sand settling basin as follows (based on the expected likelihood of bull trout presence recorded in the LNFH 2006-2010 capture log):

• In July through October, weekly monitoring for bull trout presence in the sand settling basin shall occur. Monitoring may consist of visual observation (to determine if fish are present and capture and release is required) as long as the entire sand settling basin can be viewed. If any bull trout are detected, they shall be promptly captured and released.

• In January through June and November through December, the interval for monitoring, capturing, and releasing all bull trout shall be monthly. If any bull trout are detected in this period, then the interval shall be changed to weekly and reinitiation of consultation shall occur.

• Any bull trout captured in the sand settling basin shall be released downstream of rm 4.5.

T&C 5. Schedule the annual maintenance at the intake (ladder, water conveyance channel, and building sump) to avoid the upstream migration period of bull trout. The BA specifies that once or twice a year, maintenance could occur between November 1 and June 1 for 2-3 days.

To implement RPM 4:

T&C 6. During BSC, when water temperatures are <15 °C in the Chinook salmon holding ponds, the interval for monitoring, capturing, and releasing all bull trout shall be weekly. During BSC, when water temperatures are >15 °C in the Chinook salmon holding ponds, the interval of monitoring, capturing, and releasing all bull trout shall be twice weekly. This T&C is designed to minimize physiological stress and allow for the bull trout to return to normal behavior patterns (e.g., the ability to feed, breed, etc.), with consideration of environmental (e.g., temperature, water quality, overcrowding, etc.) stressors.

T&C 7. Between May and August, release all bull trout captured in the Chinook holding ponds above rm 5.7. Based on past records, very few bull trout ascend the hatchery ladder and enter the Chinook salmon holding ponds. If the affected individuals are of Icicle Creek local population origin, then this T&C facilitates their upstream migration. If these affected individuals are not of Icicle Creek local population origin, then they will likely either (1) not spawn and move downstream under their own volition, or (2) they may spawn in upper Icicle Creek (which would be consistent with the expected infrequent demographic and genetic contributions from bull trout from other local populations).

T&Cs common to all RPMs:

T&C 8. Continue the adaptive management group process, during the BSC period, to develop and implement strategies to minimize upstream passage impairment at structure 2 and 5 and other adverse effects to bull trout caused by the Project. These strategies shall be consistent with the conservation needs of the bull trout and the conservation role of critical habitat for the bull trout.

T&C 9. Keep written records of all adjustments to structures 2 and 5. Include key information such as staff gauge readings at structure 2, dates of operational

changes and maintenance, estimated degree of opening at structure 2, and other data. These data may better inform our understanding of the relationship between operational changes and effects of the Project on bull trout.

T&C 10. Record all incidents of bull trout being observed, captured, handled, and released at LNFH facilities and structures. These data will enhance our understanding of bull trout distribution and abundance in the Project area and better inform the assessment of LNFH effects to bull trout.

Appendix C: Release Year 2019 Coded Wire Tag Codes.

Number released accounts for shed tag rate from 30-day retention trial.

Table C1. Release year 2019 coded wire tag codes

Tag Code	N Released
056022	101934
056023	101901

Appendix D: Out-of-Basin gamete transfers

Table 19 Male gamete transfers from out-of-basin stock, 2019

LNFH		Little White Salmon		Chief Joseph Hatchery*	
Primary	Total Males Used	Primary	Total Males Used	Primary	Total Males Used
135	142	27	151	34	22

*Chief Joseph Hatchery segregated spring Chinook program originated with fish that returned to LNFH.

U. S. Fish and Wildlife Service
Mid-Columbia Fish and Wildlife Conservation Office
7501 Icicle Road
Leavenworth, WA

April, 2020