U.S. Fish and Wildlife Service

Monitoring and Evaluation of the Leavenworth National Fish Hatchery Spring Chinook Salmon Program, 2022

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On the cover*: Barb Kelly sampling spring Chinook Salmon near Leavenworth National Fish Hatchery. U.S. Fish and Wildlife Service*

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Executive Summary- This report summarizes Leavenworth National Fish Hatchery's (LNFH) spring Chinook Salmon (*Oncorhynchus tshawytscha*) production program for 2022. Also, reported are complete brood year performance metrics (e.g., smolt to adult return, SAR) through brood year 2016. The goal of the program is to provide harvest opportunities with minimal impacts to natural-origin fish populations and their habitats. In 2022, LNFH released 1,325,770 juvenile spring Chinook Salmon into Icicle Creek, exceeding the production goal of 1,200,000. Juvenile release was conducted as planned and as described in the programs Biological Opinions. The 2022 adult return was 214% of the long-term average, with an estimated 11,002 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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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).

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 rkms from the Pacific Ocean, and upstream of seven Columbia River hydroelectric dams.

LNFH uses 44 outdoor rectangular raceways for current production ("H" and "I" in Figure 2). In 2022, four circular tanks on a water reuse system were commissioned. Since fish were in a single tank for 6 weeks prior to release, they are not discussed separately in this report. There are also 40 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 ("C" in Figure 2). Indoor nursery 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 Salmon have been produced annually (except brood 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 Salmon were phased out and spring Chinook Salmon became the primary species produced at LNFH.

From 1940-1943, spring Chinook Salmon were collected from upriver-bound stocks captured at Rock Island Dam. Additionally, some early imports of spring Chinook Salmon 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. To help support the transition to spring Chinook

Salmon production starting in 1970 when eggs were imported from lower Columbia River hatcheries, including Cowlitz Salmon Hatchery, Carson NFH and Little White Salmon NFH and comingled with progeny produced from volunteers to LNFH. These transferred eggs were largely of Carson stock, a hatchery stock initiated from comingled collections of Columbia River and Snake River runs. 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 Salmon production will be discussed in this report.

The stock used by LNFH is not included in the ESA-listed Upper Columbia River spring Chinook Salmon 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 Salmon 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 the quality of production at LNFH.
8. Effectively communicate with other salmon producers and managers in the Columbia River Basin.

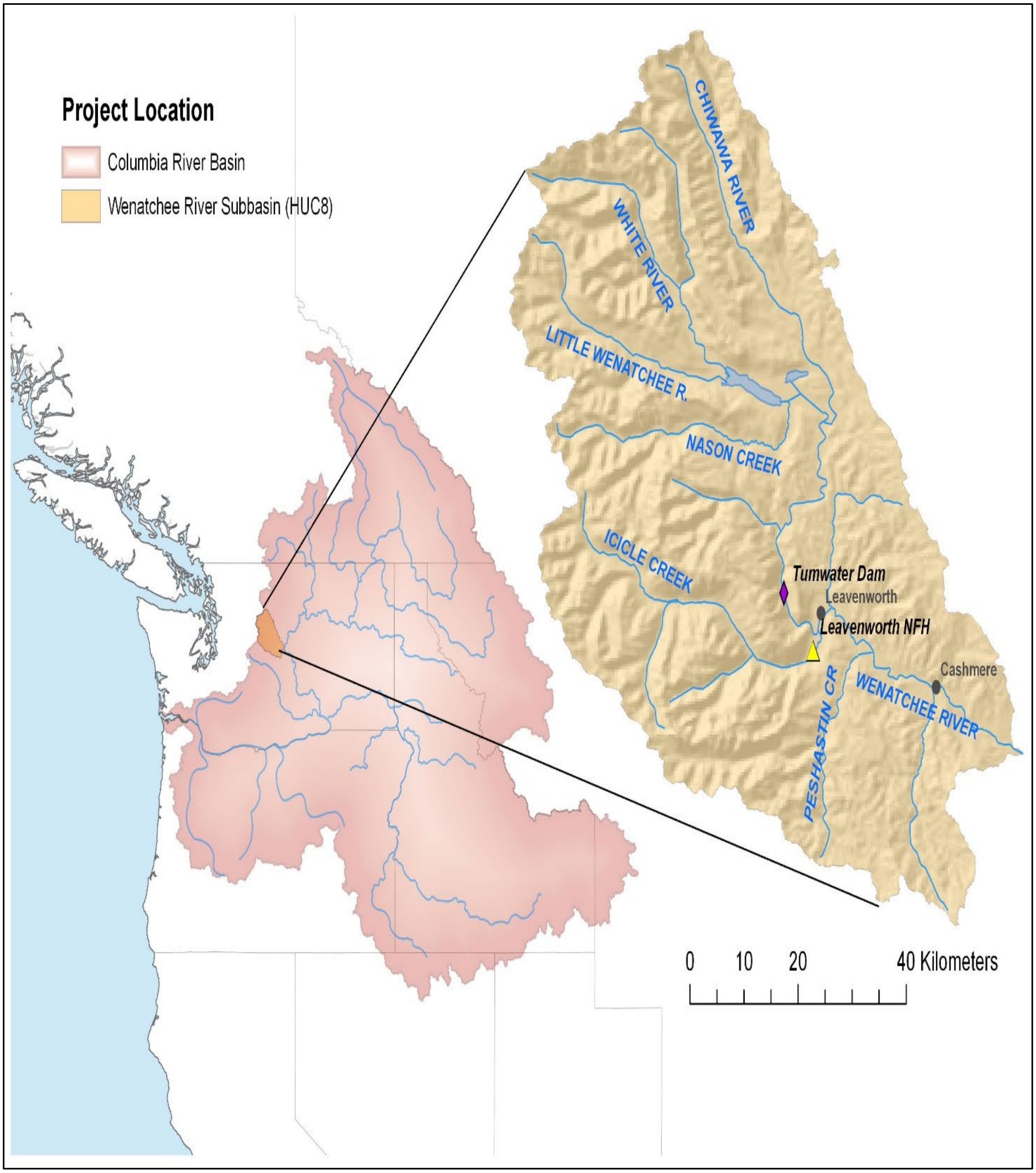

Figure 1. Leavenworth National Fish Hatchery location.

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

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 25,539 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 for current production levels 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 much 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 (Fraser 2017). 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. ºF	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 Salmon 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 the adult fish ladder 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).
11. Provide adult spring Chinook Salmon daily passage monitoring estimates above structure 5 into the historic channel of Icicle Creek during the brood stock collection period as directed by the Icicle Creek Adaptive Management Group.

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 hatchery and scientific purposes or as part of marine and freshwater fisheries monitoring, 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, the fish are marked and tagged with CWT’s, adipose fin clipping, and PIT tags by the US Fish and Wildlife Service’s Columbia River Fish and Wildlife Conservation Offices’ hatchery marking team. This team marks and tags for most 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. Fish are examined monthly to assist with the diagnosis 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). Medical treatments are performed under a current veterinarian-client-patient relationship and with direct oversight from a licensed veterinarian and Fish Health biologist(s).

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 Mitchell 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, respectively.

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 NOAA-Fisheries 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 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 2022

Life Stage	Attribute	Current Practices and Goals
Adults	*collection*	Hatchery ladder
	ladder operation	Pulsed
	brood target	1000 for LNFH*
	prophylaxis	Formalin treat adult holding pond
	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	< 58° F (14.4°C)
	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	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, 10x100's (covered) raceways and pRAS
	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, 10x100's (covered) raceways and pRAS
	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
	feeding frequency	1-2 times/day
	feed application	Hand
	cleaning frequency	Brushed 1-2 times/ week
	monitoring	Monthly fish health & biometrics
	rearing parameters	Temp <68^0F
		$d0^2$ <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 variation (CV)	<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

* LNFH may hold additional adult fish beyond the LNFH goal to assist with the Colville Tribes Chief Joseph Hatchery program. These fish are considered surplus to LNFH needs and are part of a 10-year agreement between the parties that ends in 2023.

Release Year 2022

Juvenile Rearing

Spring Chinook Salmon smolts released in 2022 were derived from 1,730,755 eggs collected from adults that returned to LNFH in 2020 (Table 3). This was 99.5% of the green egg goal of 1,740,000. The highest mortality (3.1%) occurred when 54,408 eggs were discarded due to Enzyme-Linked Immunosorbent Assay (ELISA) results or poor fertilization. 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. After culling, the green egg to eyed egg survival from the 2020 broodstock collection was 96.9% exceeding the performance goal of >90%. Juvenile rearing of this cohort began in March 2020, when 1,354,678 fry were placed into 122 starter tanks. This was 113% of the release number and 7.5% above target for the ponding performance goal of 1,260,000.

Beginning in 2017, LNFH implemented the use of chillers to delay emergence. This flexibility in hatch timing eliminates a reliance on the adult holding pond to rear smolts. This adjustment helps to aid the hatchery in improving discharge standards but the impact on meeting size targets and post-release survival is yet to be determined.

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 must be balanced against rearing space and water availability. For the release year 2022 rearing cycle, monthly Density Index (DI) was within the performance goal for all months, however,the Flow Index (FI) performance goal was exceeded from October to release (Table 3) as flow rates (gpm) were not sufficient to meet this rearing metric for disease risk mitigation.

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:

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

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 fish were 100% adipose clipped and CWTs were implanted into 203,093 (17%) fish in early June (Appendix C). The success of marking is maximized if the fish are within a critical size range (75-190 fish per pound, fpp) with limited variation in size (<6.0% CV, Cross et al. 2020). At the time of marking and tagging the fish were 162 fpp with a CV of 5.7% which met tagging size criteria. This size helped achieve a post mark CWT retention rate of >99.5% (target >98%) based on a sample of 952 fish 30 days post-tagging.

As part of the Fish Passage Centers' Smolt Monitoring Program, PIT tags were implanted into 21,929 fish in late October of 2021 (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, fish were 25 fpp, which was smaller than the performance goal of 22 fpp for the end of October. 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 2022

Year-Month	Life Stage	Production Inventory[a]	Fish per Pound	% Mort.	Temp (^{0}F) Ave [b]	Flow GPM[c]	Flow Index (lbs./in*GPM)[c]	Density Index (lbs./in*ft^3)[c]
2020-September	Egg	1,730,755	NA	NA	42.0	180	NA	NA
October	Eyed Egg	1,370,793	NA	NA	40.0	170	NA	NA
November	Eyed Egg	1,361,377	NA	0.70	40.0	170	NA	NA
December	Sac Fry	1,361,377	NA	0.00	40.0	170	NA	NA
21-Jan	Sac Fry	1,361,377	NA	0.00	40.0	170	NA	NA
February	Sac Fry	1,357,355	1167	0.30	40.0	170	NA	NA
March	Fry	1,354,678	486.6	0.20	47.7	2,940	0.54	0.14
April	Fry	1,353,342	203.3	0.10	46.2	4,950	0.54	0.15
May	Fingerling	1,352,941	162.2	0.03	42.5	7,200	0.46	0.15
June	Fingerling	1,352,265	80.8	0.05	48.0	14,280	0.37	0.08
July	Fingerling	1,350,786	42.8	0.11	59.2	15,550	0.57	0.11
August	Fingerling	1,345,505	33.0	0.39	59.0	19,624	0.52	0.15
September	Parr	1,328,651	26.8	1.25	52.1	18,680	0.59	0.17
October	Parr	1,328,136	25.1	0.04	43.9	18,654	0.62*	0.17
November	Parr	1,327,829	24.9	0.02	38.3	18,654	0.62*	0.16
December	Parr	1,327,745	25.0	0.01	34.5	18,704	0.62*	0.16
22-Jan	Parr	1,327,265	24.9	0.04	33.4	18,704	0.62*	0.16
February	Parr	1,326,835	24.9	0.03	35.2	18,704	0.64*	0.17
March	Parr	1,326,076	22.2	0.06	38.9	18,704	0.69*	0.18
April	Smolt	1,325,770	22.2	0.02	41.4	18,704	0.69*	0.18

[a]N is corrected or "back calculated" from time of marking.
[b]Includes monthly picking. Does not include predation.
[c]Calculated from values taken at the end of each month.
*Exceeds rearing parameter goals

Release

During the early afternoon through evening hours of April 11th -13th, 1,325,770 yearling spring Chinook smolts were force-released via a Heathro Fish Pump into Icicle Creek (Table 4). This was 111% 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 120mm with a CV of 7.6%.

Table 4. LNFH release dates, release numbers and tagging information for 2010–2022.

Release Year	Date Released	Total Released	# CWT	% CWT	% Adipose Clip	# PIT
2022	Apr. 11 - 13	1,325,770	203,093	15%	99	21,929
2021	Apr. 14 - 16	1,288,815	204,293	16	100	19,964
2020	Apr. 20 - 22	1,300,817	197,539	15	100	19,952
2019	Apr. 17 - 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

[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 measured at McNary Dam, because it is the first dedicated juvenile PIT tag monitoring facility they encounter during out-migration. McNary Dam is 205 rkms downstream from LNFH, roughly halfway to the Pacific Ocean. Multiple juvenile monitoring facilities downstream of McNary Dam enable mark-recapture methodologies to derive survival estimates at McNary Dam.

In 2022, LNFH smolts arrived and passed McNary Dam throughout early to mid-May on the ascending limb of the hydrograph (Figure 3). For the 2022 smolt release, the average travel time to McNary Dam was 34.2 days or 6.0 rkms (3.7 river miles) traveled per day (Table 5). This was the slowest travel time documented since 2010 and substantially slower than the 12-year average of 25 days which 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 or less than 19 days to cover the 177 river miles to McNary. This

BiOp requirement has only been achieved twice since 2010 and does not seem related to survival (r^2 = -0.17, $p<0.05$), however, the slower travel time could correspond to the smaller smolt release size of 22 fpp. The survival of this cohort to McNary Dam was estimated at 55% which meets the performance goal of >50% but is below the long-term average of 57%. The 2022 LNFH survival was compared to those from Chiwawa Rearing Ponds (CRP) in the upper Wenatchee, Chief Joseph Hatchery (CJH) on the mainstem Columbia River, and Winthrop NFH on the Methow River. The relative survivals between these four facilities has varied over the years and recently has become highly variable since 2021 (Figure 4). Recent changes to the operation of McNary Dam, has decreased PIT tag detections through the dedicated juvenile bypass facility. This operational change has made using McNary Dam for survival estimates problematic.

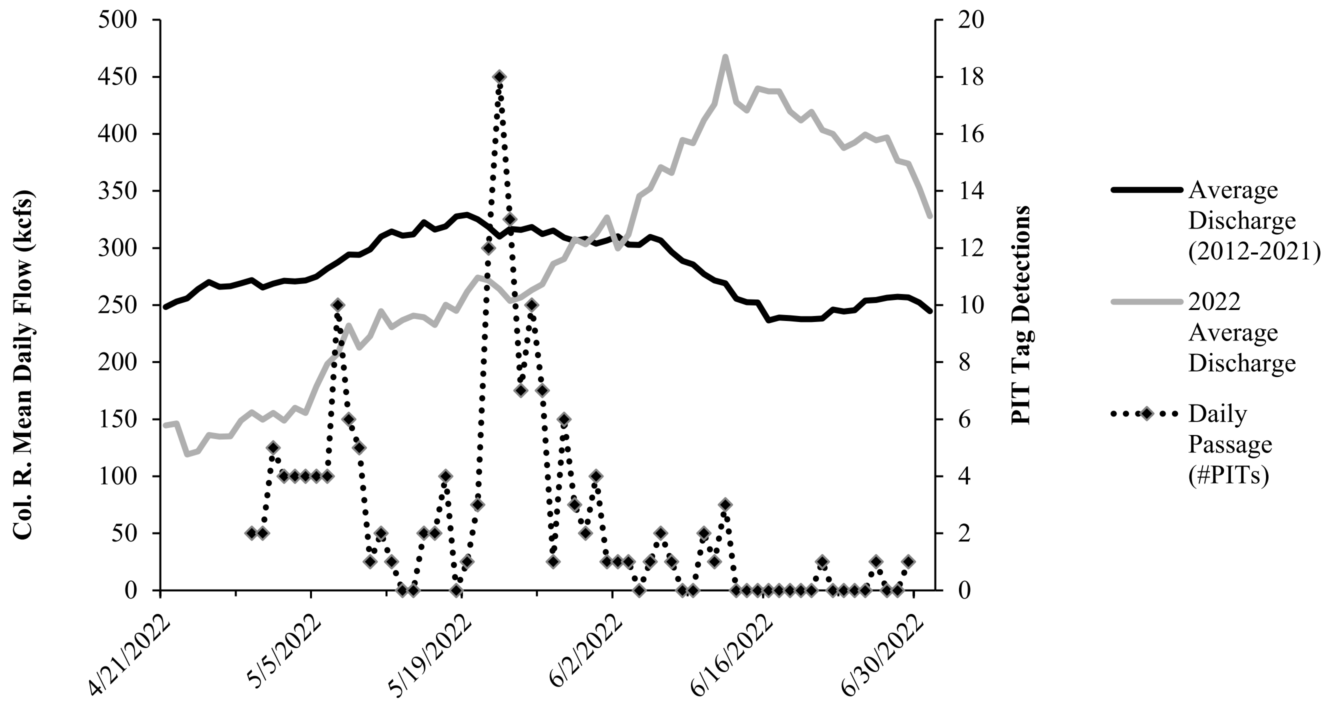

Figure 3. Daily passage of PIT tagged LNFH-origin spring Chinook Salmon smolts at McNary Dam in 2022.

Table 5. LNFH-origin spring Chinook Salmon smolt out-migration metrics to McNary Dam, 2010–2022.

Release Year	Release Day	McNary Dam Mean Travel Time (Days)	McNary Dam Median Travel Time (Days)	% Survival to McNary Dam (95% confidence limits)
2022	April 11, 12, and 13	34.2	39.0	55 (42-68)
2021	April 14, 15, and 16	30.1	32.0	51 (45-57)
2020	April 20, 21, and 22	23.0	17.0	61 (56-66)
2019	April 17, 18, and 19	25.2	23.0	52 (49-56)
2018	April 17 and 23	18.6	17.7	66 (62-70)
2017	April 18	28.2	23.1	54 (52-59)
2016[a]	April 21	17.4	17.3	49 (48-50)
2015	April 15	24.7	23.8	57 (54-60)
2014	April 23	21.5	22.0	57 (52-62)
2013	April 24	24.8	24.8	67 (54-81)
2012	April 24	28.7	28.8	59 (55-63)
2011	April 20	27.5	28.2	43 (39-47)
2010	April 26	25.3	22.2	66 (60-72)
Mean (10–21)		24.6	23.3	57 (52-62)
St. Dev. (10–21)		3.9	4.7	8 (6-9)

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

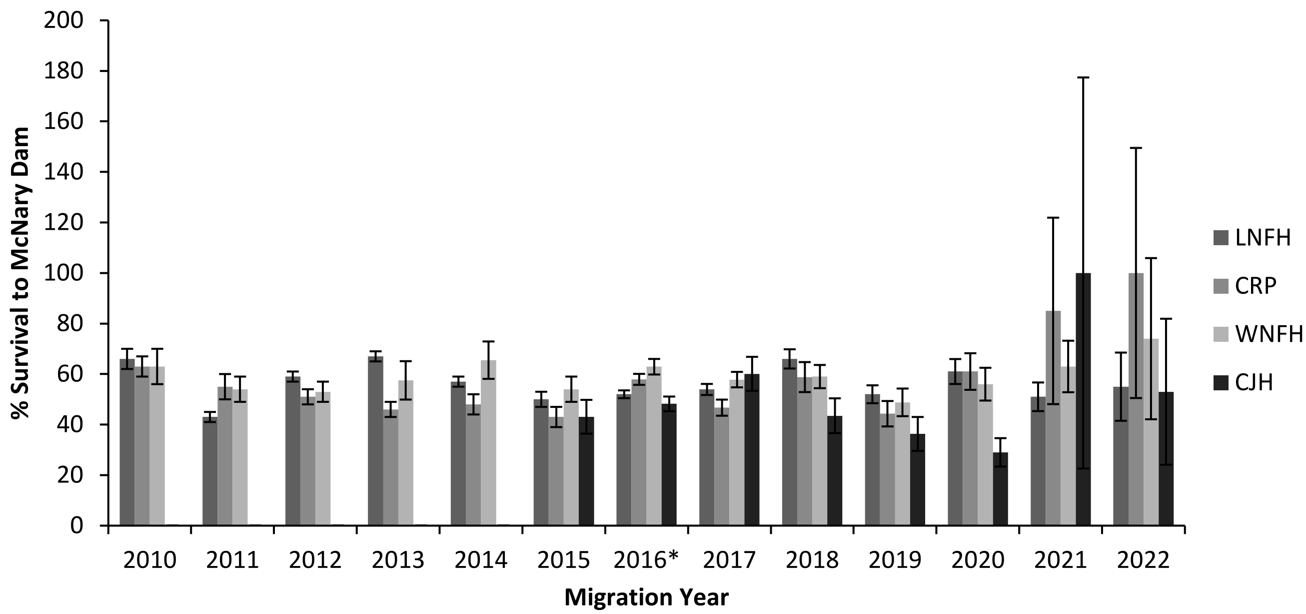

Figure 4. Upper Columbia River spring Chinook Salmon smolt survival (standard deviation) for LNFH, Chief Joseph Hatchery (CJH), Winthrop National Fish Hatchery (WNFH) and Chiwawa Rearing Ponds (CRP) to McNary Dam, 2010–2022. *380 PIT tags removed from LNFH survival estimates based on accidental early release.

Early Maturation

Spring Chinook Salmon most commonly mature in the ocean (after outmigration) at age 3 or older. Early maturation of spring Chinook Salmon is defined as the complete development of primary sexual characteristics (gonads) 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 2022 release year cohort there was one PIT tagged fish that was 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 2010–2022.

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 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. In 2022, of the 265 males that were sampled, 13 (4.9%) were showing signs of precocity (Figure 5). The highest percentage (25%) of maturing males were found in fish over 140 mm at time of sampling. 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, 2010–2022.

Release Year	Release Number	# PIT	PIT Ratio Non-Tag/Tag	Observed Minijacks	Expanded Minijacks[a]	Minijack Rate (%)	Release Precocity Rate from GSI (%)
2022	1,325,770	21,929	60	1	60	0.00	4.9
2021	1,288,815	19,964	65	2	129	0.01	3.6
2020	1,300,817	19,952	65	4	261	0.02	2.7
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*
Min	945,277	13,380	54	1	60	0.00%	2.7
Max	1,326,076	21,929	93	41	3,533	0.28%	22.0
Mean (10-21)	1,211,155	17,207	73	10	800	0.06%	10.3

*From Harstad et al. 2014.

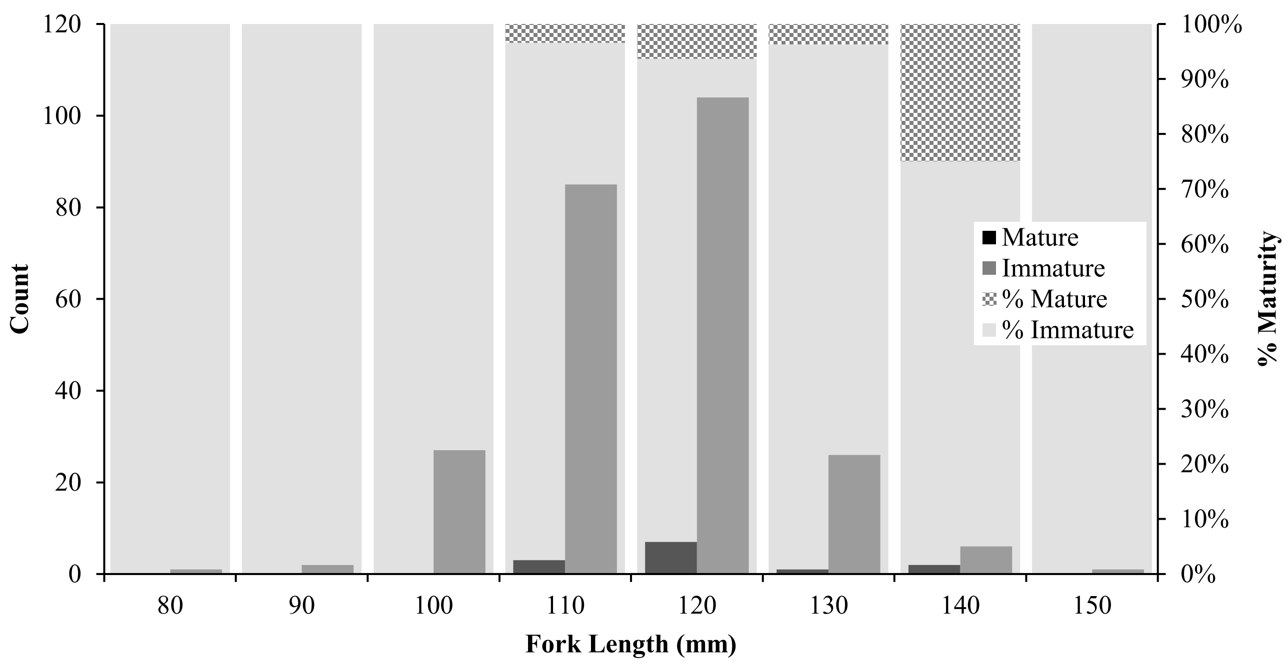

Figure 5. Precocity in sampled males by fork length, at LNFH, at release in 2022.

Adult Return 2022

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 2,588 (2,474-2,685), (Fraser, pers. comm.). All models indicated that the return would be sufficient to meet both broodstock and Icicle Creek harvest needs, yet weekly in-season forecasts were closely followed using PIT tag expansion, run timing and conversion rate estimates from Bonneville Dam. Run forecast models have been used for many years at LNFH. In general, pre-season estimates exhibit higher variability (± 55%), while in-season estimates tend to consistently under forecast with lower variability compared to the actual return (± 16%) to Icicle Creek (Table 7).

Table 7. A comparison of LNFH spring Chinook return forecast and accuracy to Icicle Creek, 2010–2022.

Return Year	Icicle Creek Adult Return	Pre-season Forecast	Pre-season Accuracy	In-season Forecast	In-season Accuracy
2022	11,002	2,588	0.24	9,906	0.90
2021	4,566	487	0.11	3,230	0.71
2020	2,262	635	0.28	1,787	0.79
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
Average (10-21)			1.00		0.73
StDev			0.55		0.16

Run Timing

Returning LNFH-origin spring Chinook were first detected at Bonneville Dam on March 21st with the 50% passage date occurring on May 3rd. The returning adults had a slightly earlier return timing when compared to the long-term (12 year) average (Table 8).

The detection efficiency of the PIT tag antenna arrays at Bonneville Dam are reported to be greater than 99% (Tenney et al. 2021) and assumed nearly complete interrogation census of returning tagged adults. Adults took an average of 52 days to travel from Bonneville Dam to the LNFH adult ladder in 2022 (Figure 6). The travel time between Bonneville and Icicle Creek, was two weeks slower than the average (31 days) for the previous 12 years. Returning adults were stalled between Rock Island Dam and the lower Icicle Creek array, with an average of 30 days between PIT tag detections. This was the longest recorded travel time between the two sites. The cause of the delay is unknown as temperature and flow were within a normal range.

Table 8. Passage dates for LNFH-origin spring Chinook Salmon at Bonneville Dam, 2010–2022.

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
2022	21-Mar	22-Apr	24-Apr	27-Apr	3-May	9-May	15-May	19-May	1-Jun
2021	19-Apr	22-Apr	25-Apr	28-Apr	1-May	8-May	13-May	14-May	16-May
2020	16-Apr	17-Apr	22-Apr	30-Apr	4-May	7-May	16-May	26-May	5-Jun
2019	2-May	2-May	2-May	3-May	8-May	25-May	27-May	30-May	30-May
2018	28-Apr	1-May	5-May	6-May	11-May	17-May	20-May	23-May	24-May
2017	27-Feb	27-Feb	1-May	4-May	15-May	21-May	23-May	27-May	27-May
2016	2-Apr	16-Apr	21-Apr	25-Apr	30-Apr	6-May	13-May	20-May	10-Jul
2015	9-Apr	12-Apr	16-Apr	20-Apr	27-Apr	2-May	16-May	25-May	27-Aug
2014	7-Apr	18-Apr	19-Apr	25-Apr	29-Apr	2-May	8-May	13-May	19-May
2013	5-Mar	18-Apr	23-Apr	28-Apr	2-May	7-May	19-May	22-May	5-Jun
2012	7-Apr	20-Apr	23-Apr	30-Apr	8-May	10-May	14-May	17-May	4-Jun
2011	20-Apr	26-Apr	28-Apr	1-May	8-May	15-May	27-May	31-May	27-Jul
2010	29-Mar	12-Apr	15-Apr	19-Apr	26-Apr	2-May	8-May	12-May	31-May
Mean (10-21)	6-Apr	16-Apr	24-Apr	28-Apr	4-May	10-May	17-May	21-May	13-Jun

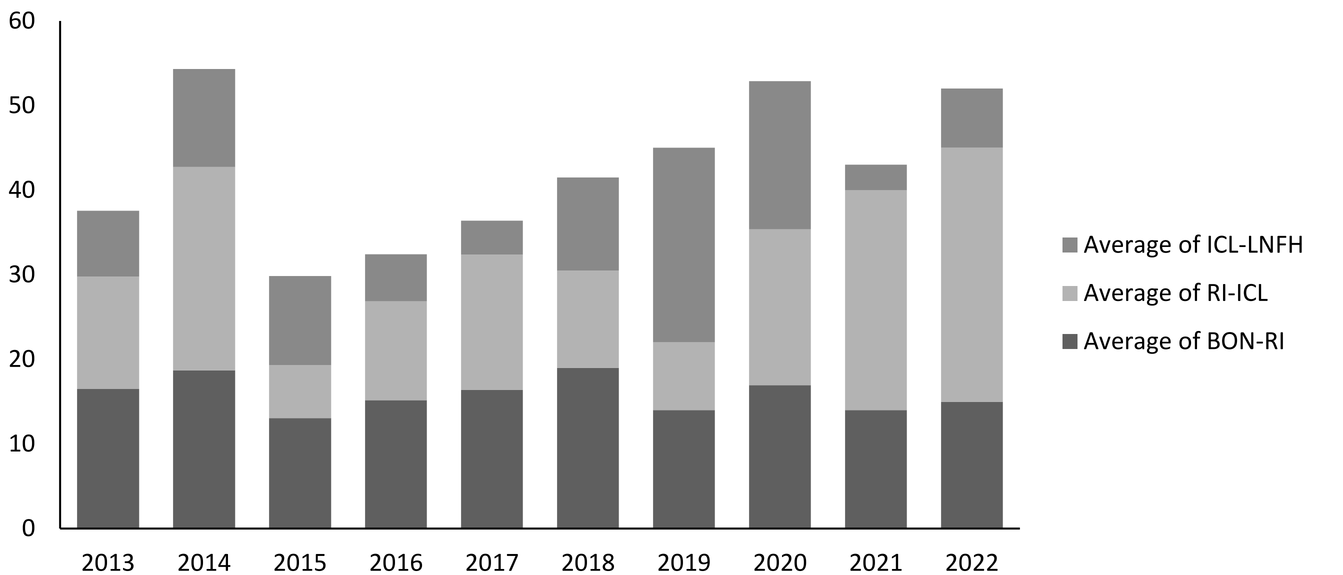

Figure 6. Travel time of adult LNFH-origin spring Chinook Salmon returns from Bonneville to Rock Island Dam (BON -RI), Rock Island Dam to the Lower Icicle array (RI-ICL) and the Lower Icicle array to LNFH (ICL-LNFH) from 2013–2022.

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 2022, the fish ladder was opened from May 10th through July 26th to assure adequate broodstock was collected to meet LNFH production goals. During this time, 7,521 spring Chinook adults ascended the fish ladder and entered the adult holding pond (Figure 7). This was 202% of the recent 12-year (2010-2021) average of 3,724 fish. The ladder was briefly closed for 11 nights to prevent over-crowding of fish in the adult holding pond and increase the potential of being harvested.

Figure 7. LNFH fish ladder operations and percent of Icicle Creek returning spring Chinook Salmon trapped in LNFH adult holding pond, 2010-2022.

Harvest

In 2022, an estimated 11,002 spring Chinook returned to Icicle Creek. In-basin estimates were generated from harvest estimates, spawning ground surveys, and LNFH adult holding pond counts.

Spring Chinook Salmon were subject to 62 days of a mark selective (i.e. adipose clip) sport fishery and a 78-day tribal fishery in Icicle Creek. It was estimated that a total of 3,192 Chinook Salmon were harvested from Icicle Creek in 2022. This was above the 2010-2021 average of 1,234 (Table 9).

Table 9. Abundance and fate of LNFH-origin adult spring Chinook Salmon returning to Icicle Creek from 2010–2022.

Return Year	Total Run to Icicle Cr.	Returned to LNFH	Sport Harvest	Tribal [a]	Remaining in River
	N	N (%)	N (%)	N (%)	N (%)
2022	11,002	7,521 (68.4)	999 (9.1)	2,193 (19.9)	289 (2.6)
2021	4,566	3,337 (73.1)	526 (11.5)	575 (12.6)	128 (2.8)
2020	2,262	1,908 (84.4)	121 (5.3)	170 (7.5)	63 (2.8)
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)
Min	976	799 (53.0)	13 (0.9)	144 (7.5)	2 (0.1)
Max	13,862	11,307 (84.7)	999 (13.7)	2,193 (29.4)	422 (7.0)
Mean (10–21)	5,108	3,724 (74.1)	453 (7.4)	781 (15.5)	183 (3.5)

[a] Estimated tribal harvest, 2010-2016

Wenatchee and Entiat River Strays

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

Beginning 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 are 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 2022, a preliminary estimate of 69 presumed 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 consider 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 2004).

All adipose clipped, non-CWT fish removed at Tumwater Dam are presumed to be LNFH-origin; however, some or potentially all of these fish likely originated 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) as these fish are 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 2022, one LNFH-origin tag (CWT) was recovered in the upper Wenatchee River (Table 10) and none on the spawning grounds in the Entiat River (Table 11). Until spawning escapement estimates become available for the Wenatchee River, it is too early to determine if the tag recoveries in 2022 meet 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 2010–2022.

Return Year	Upper WR SCS Escapement [a]	Upper WR SCS Carcass Recoveries [a]	Percent Carcasses Sampled [b]	LNFH-origin CWT Recoveries [c]	LNFH-origin Estimated Recoveries [d]	LNFH-origin Expanded Recoveries [e]	Proportion of LNFH-origin spawners (pHOS) in Upper WR SCS Escapement
2022	TBD	TBD	TBD	1	TBD	TBD	TBD
2021	1,678	505	30.1	1	3	20	1.2
2020	738	358	48.5	0	0	0	0.0
2019	886	410	46.3	1	2	12	1.4
2018	882	324	36.7	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
Min	649	230	9.7	0	0	0	0.0
Max	2,990	792	48.5	2	9	20	1.4
Mean (10-21)	1,472	419	32.3	0	2	6	0.4

[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 2010-2022.
[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 2010–2022.

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]
2022	186	54	29.0	0	0	0	0.0
2021	154	54	35.0	1	3	19	12.4
2020	130	25	19.0	0	0	0	0.0
2019	75	25	33.3	0	0	0	0.0
2018	92	28	30.4	1	3	15	16.2
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
Min	75	19	11.6	0	0	0	0.0
Max	505	173	35.0	2	6	50	16.2
Mean (10-21)	244	65	25.3	0	1	7	3.2

[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 7,521 adults that returned to the LNFH holding pond, 590 adults were transferred off station for Chief Joe Hatchery broodstock prior to sampling and 635 (8.4%) were sampled to determine population characteristics. All fish were scanned for the presence of a PIT tag and CWT and inspected for the presence of an adipose fin. Snouts from a third of the surplus fish and all spawned fish with CWT's were collected. Age and hatchery origin were verified using tag information and reported to RMIS. All CWT recoveries were expanded by their cohort-specific tagging rates to best estimate age structure of the returning adults. Scales samples were collected on presumed natural-origin fish with intact adipose fins to determine rearing origin. In 2022, three natural-origin fish were identified in the adult holding ponds at LNFH.

Age composition for LNFH-origin returns was based on 597 samples collected (589 CWT recoveries and 8 ages from scale samples). The 2022 return was dominated by age-4 adults, based on random sampling (Table 12). The male-female ratio of the return was 1.0, with equal number of males and females returning (Table 13). Fork lengths for returning adult spring Chinook were within the standard deviation for age-3 and age-4 adults. Age-5 males were larger than the 12-year mean, while age-5 females were smaller (Table 14).

Table 12. LNFH-origin spring Chinook Salmon age compositions by sex and return year, 2010–2022.

	% Male Age			% Female Age			% Combined Age		
Return Year	**3**	**4**	**5**	**3**	**4**	**5**	**3**	**4**	**5**
2022	13.2	35.5	0.2	0.3	48.6	0.3	13.6	84.1	0.5
2021	8.3	32.2	0.2	0.2	57.9	1.2	8.5	90.1	1.4
2020	5.6	36.1	1.2		55.9	1.2	5.6	92.0	2.4
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	4.0	34.3	6.3		48.7	5.8	4.0	83.1	12.1
2015	9.0	35.8	2.1	0.1	50.0	2.9	9.1	85.8	5.0
2014	15.5	31.8	0.7	0.1	48.2	1.9	15.6	80.0	2.6
2013	18.2	19.0	9.4	0.2	35.9	13.5	18.4	54.9	22.9
2012	1.4	31.7	4.4	0.1	56.0	6.3	1.5	87.7	10.7
2011	34.8	14.3	11.6	0.1	23.2	15.1	34.9	37.5	26.7
2010	0.9	36.9	0.7		60.7	0.7	0.9	97.7	1.4
Min	0.9	14.3	0.2	0.1	23.2	0.3	0.9	37.5	0.5
Max	34.8	36.9	11.6	0.6	60.7	15.1	34.9	97.7	26.7
Mean (10-21)	12.4	30.2	3.6	0.3	48.1	4.8	12.6	78.4	8.4

Table 13. Sex composition of sampled spring Chinook Salmon returning to LNFH, 2010–2022.

Return Year	**% of Return Sampled**	**# Males**	**# Females**	**Male/Female Ratio**
2022	8.4	318	317	1.00
2021	13.5	195	255	0.76
2020	28.1	229	307	0.75
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
Min	8.4	174	202	0.56
Max	100.0	863	779	1.60
Mean (10-21)	30.5	365	429	0.87

Table 14. LNFH spring Chinook Salmon mean fork length (cm) by age, sex, and return year, 2010–2022.

Return Year	Males			Females		
	age-3	age-4	age-5	age-3	age-4	age-5
2022	49.3	77.3	78.0	71.5[a]	72.9	86.5
2021	49.1	75.5	96.0	45.0[a]	73.9	81.4
2020	51.7	73.8	88.8		70.5	84.2
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
Mean (10–21)	51.1	77.4	92.5	63.9	73.3	85.3
St. Dev. (10-21)	1.5	1.6	2.1	8.5	1.3	1.4

[a] *n=1*

Broodstock

Of 7,521 spring Chinook Salmon that returned to the hatchery, 908 were spawned (451 females), 229 fish died while being held in the adult holding pond (DIP), 5,516 were provided to area tribes for ceremonial and subsistence purposes,14 were green, bad, or spent, and 590 (surplus adults) were transferred for use as hatchery production by area tribes (Table 15).

To minimize pre-spawn mortality, daily formalin treatments were administered for one hour a day at 167 ppm to the adult holding ponds to control fungus and parasites.

In 2022, LNFH spawned 908 of the 1,292 fish held for broodstock resulting in a 70% broodstock utilization rate, which did not meet the utilization goal of 88% (Table 2). Many of the returning adults did not enter the hatchery until early July. Due to this late return, fish were beyond food quality and were held until spawning, leading to the unusually low broodstock utilization rate. Additionally, the targeted male: female spawning ratio of 1:1 was met, with a backup male used in the event the primary male was infertile.

Portions of the returning adults were tested for regulated viral 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 broodstock used in 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. Of the sampled adults one non-LNFH hatchery-origin spring Chinook Salmon identified by CWT entered the adult holding pond in 2022 (Table 16). Based on sampling ratios this equates to 3 fish originating from the Wenatchee River sub-basin Nason Creek Acclimation Facility.

Table 15. Fate of spring Chinook Salmon that entered the adult holding ponds at LNFH, 2010–2022.

Return Year	Total Returns to LNFH	DIP	Excess Adults	Adults Spawned	Excess Broodstock	Green/ Spent/ Bad	Transfers	Returned to River
2022	7,521	229	5,516	908	261	14	590	3
2021	3,352	61	1,918	981	15	25	352	0
2020	1,919	22	648	1,005	11	17	216	0
2019	1,189	456	186	534	0	1	0	0
2018	825	45	23	724	26	30	0	0
2017	1,189	31	274	802	33	47	0	2
2016	3,350	52	1,527	1,002	97	117	640	0
2015	6,571	124	4,838	955	6	14	640	0
2014	4,770	122	2,801	1,101	41	106	640	0
2013	2,461	227	666	767	0	53	422	163
2012	4085	42	2,931	1,036	0	72	0	4
2011	4,970	112	3,932	926	0	0	0	0
2010	11,366	104	10,250	729	0	214	0	69
Min	825	22	0	546	0	0	0	0
Max	11,366	456	10,250	1,101	261	214	640	163
Mean (10-21)	3,837	116	2,490	881	19	58	243	20

Table 16. Fate of non-LNFH-origin fish that entered the LNFH adult holding ponds in 2021.

CWT Code	# Observed	Age	% Tagged	Deposition	Origin	Expanded #
637586	1	4	98	Broodstock	Nason Creek Acc Facility	3
Natural-Origin	3			Surplus		

Virology and ELISA Results

For salmonids, the Pacific Region Fish Health Program categorizes BKD risk from ELISA optical density values into five levels, ranging from “Below Low” to “High +” risk (Figure 8). In 2022, 95% of the females were in the “Below 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 “High +” risk groups were culled. On average (2010–2021), 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%.

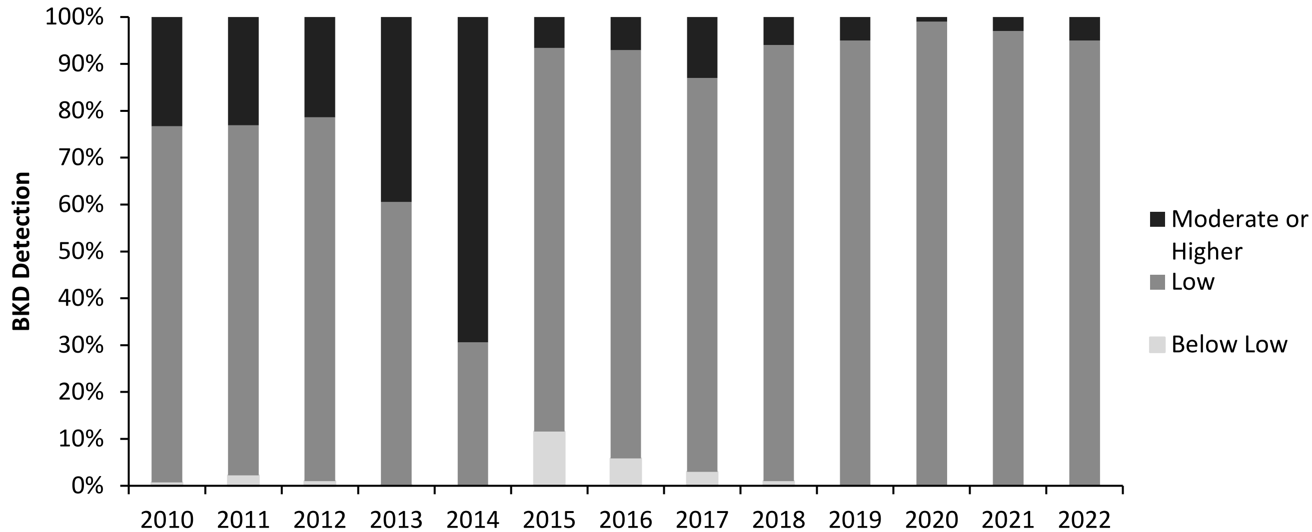

Figure 8. Summary of BKD detection from female spring Chinook Salmon at LNFH, 2010-2022,

Egg Survival

In 2022, the average fecundity was 3,900 eggs with a total egg take of 1,759,058 eggs (Table 17) which was 101% of the green egg take goal of 1,740,000. The ELISA culling rate of 5% (85,800 eggs) is below the average excluding the anomalous years (2010–2014). The post-cull eyed egg inventory of 1,317,600 was 99% of the production goal of 1,330,000. In March, after chiller facilitated incubation, 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 2010–2022.

Return Year	Fecundity	Green Eggs	Bad Eggs	Culled [a]	Eyed Eggs	% Eyed Survival
2022	3,900	1,759,058	95,864	345,594	1,317,600	94.4
2021	3,638	1,854,218	52,754	478,864	1,322,600	96.8
2020	3,534	1,730,755	45,748	8,698	1,676,309	96.9
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
Min	3,426	1,422,827	31,250	8,660	1,172,894	91.7
Max	4,109	2,391,794	123,802	1,044,168	1,676,309	99.8
Mean (10-21)	3,780	1,768,624	67,605	377,601	1,330,526	96.3

[a] Includes ELISA culling of Moderate, High, and Very High ranks

Brood Year 2016

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 by a variety of collecting agencies. Given these delays, the brood year analysis herein uses brood year 2016 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.

2016 Adult Return Summary

The 2016 brood year was produced from an average run size with the hatchery capturing and holding 3,350 returning adults. Of these LNFH spawned 500 females, yielding a green egg take of 1,914,435 and an average fecundity of 3,822 eggs per female. The ELISA testing for Bacterial Kidney Disease (BKD) resulted in only 7% of the spawned females had a moderate or higher risk of vertical transmission from mother to progeny, allowing the hatchery to retain only those eggs with a low risk of BKD.

Brood year 2016 ultimately released 1,252,307 smolts into Icicle Creek. The released smolts exhibited a faster than average travel time of 19 days and a higher than average (66%) survival to McNary Dam (2010–2021 average travel time = 25 days, survival = 57%).

Brood year 2016 Performance

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 Salmon return data by age from a variety of data sources, including hatchery returns, harvest creels, and spawning ground surveys.

Spring Chinook Salmon from brood year 2016, returned as adults from 2019-2021 and had a SAR of 0.21% 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 or off-site factors caused annual SAR variation we compared LNFH SARs to spring Chinook Salmon programs at 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 and Chiwawa Rearing Pond from 2003–2015 suggesting that external hatchery conditions (e.g., marine rearing environment) are the primary drivers of SAR and influenced all three programs similarly (Figure 9).

Brood year 2016 returned as 23% age-3 fish, 75% age-4 fish, and 1% 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 2016 was 49% females and 51% males (age-3+) (Figure 11).

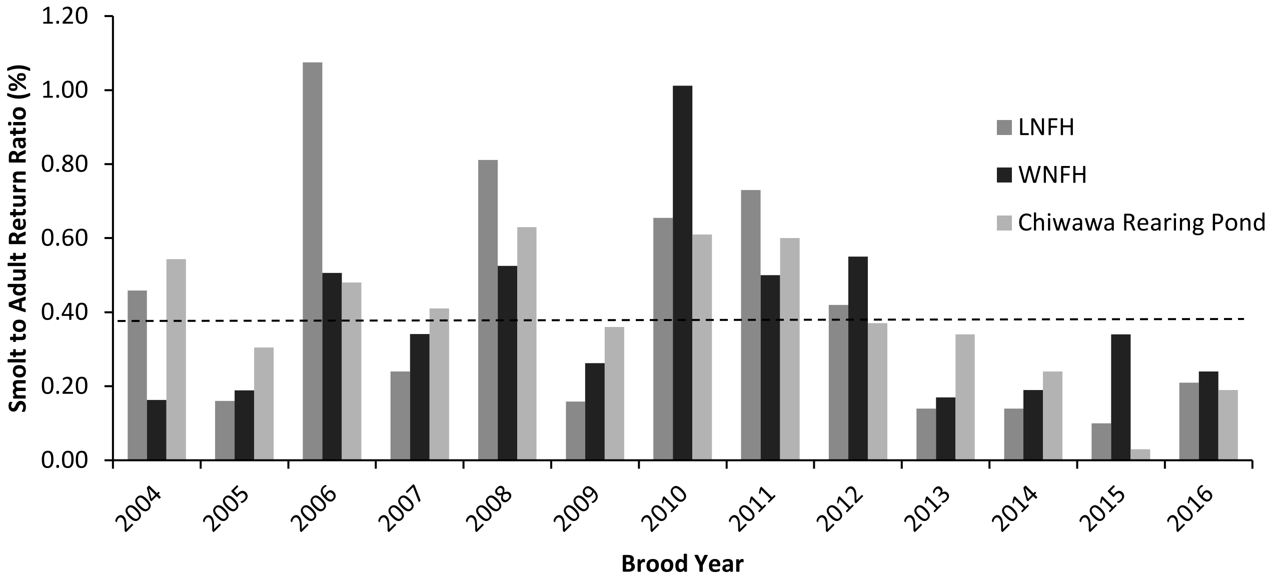

Figure 9. Smolt to Adult Return (SAR) Leavenworth National Fish Hatchery (LNFH), for Chiwawa Rearing Pond (CRP), and Winthrop National Fish Hatchery (WNFH) for brood years 2004–2016, with dashed line indicating LNFH 2004–2015 mean.

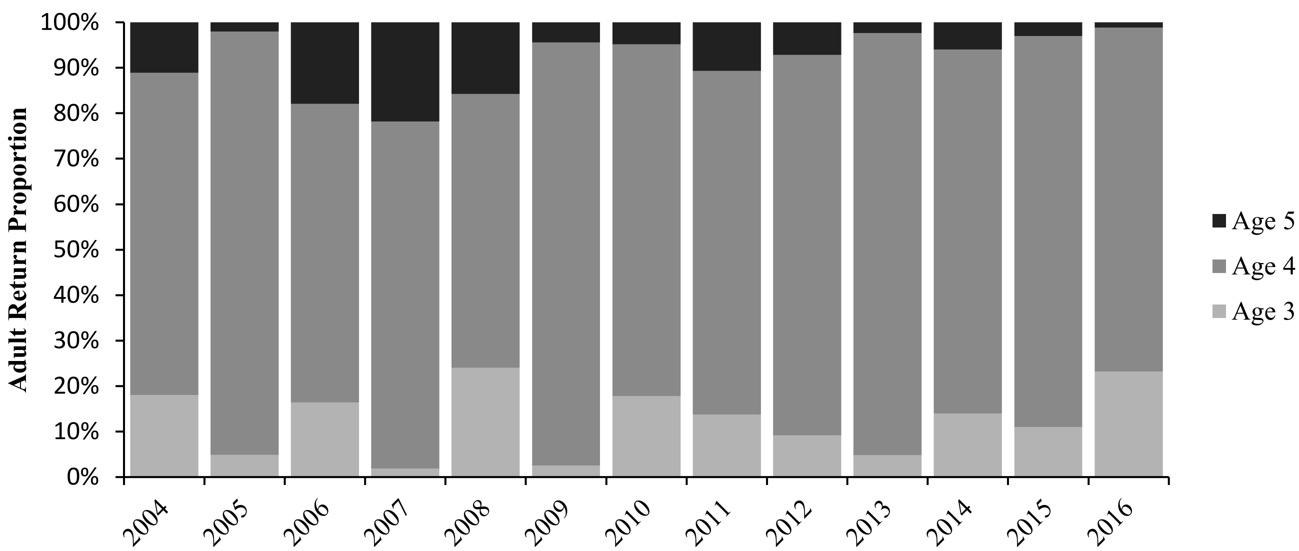

Figure 10. Leavenworth NFH spring Chinook proportion of ages produced, by brood year, 2004 ‒2016.

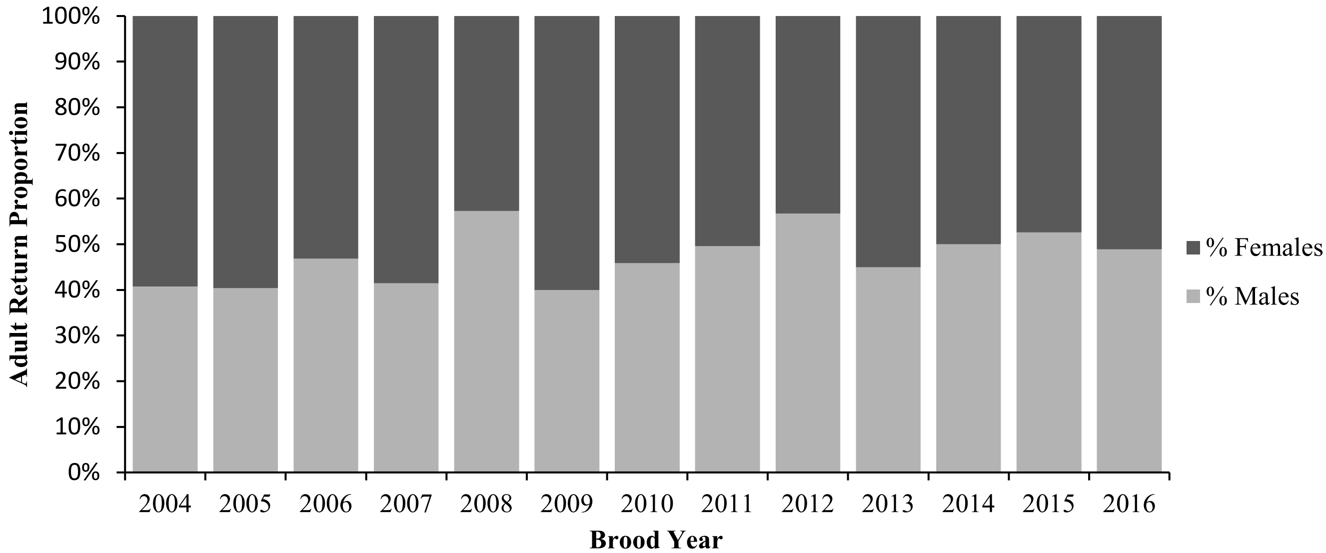

Figure 11. Leavenworth NFH spring Chinook sex composition produced by brood year, 2004–2016.

Harvest Contribution

Brood year 2016 produced an estimated 2,614 adults that returned to freshwater. Of these, 344 (14%) were harvested. Locally, the sport fishery in Icicle Creek accounted for 122 (5%) of the return and tribal fishers in Icicle Creek harvested another 222 (9%) adults. Of those that returned to LNFH, 1,091 (42%) were used for production and 875 (34%) were surplus fish donated to local tribes (Table 18).

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

Brood Year	Total Return	Columbia River Harvest	Sport Fishery (Wenatchee River)	Sport Fishery (Icicle Creek)	Tribal Fishery (Icicle Creek)	Hatchery Production	Excess Hatchery Returns	Other
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
2016	2,614	0 (0.0)		122 (4.7)	222 (8.5)		1,091 (41.7)	875 (33.5)
2015	1,090	40 (3.7)		11 (1.0)	147 (13.5)	427 (39.2)	143 (13.1)	322 (29.5)
2014	1,264	57 (4.5)		7 (0.6)	190 (15.0)	809 (64.0)	75 (5.9)	126 (10.0)
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)	1,070 (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)
Mean (04-15)	6,502	1,063(12.7)	198 (3.0)	428 (7.0)	855(13.9)		840 (21.5)	2,719 (32.0)
St. Dev	5,258	1345 (9.7)	300 (4.4)	356 (6.7)	654 (4.2)		330 (17.5)	3,404 (18.5)

Summary

- The 2022 LNFH release of 1,325,770 spring Chinook exceeded the production goal of 1,200,000 by 10.4%.
- 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 55%, which was below the 12-year mean.
- Of the 11,002 spring Chinook that returned to Icicle Creek, 3,192 (29%) were harvested, 7,560(68%) were trapped in the adult holding ponds and 289 (3%) remained in Icicle Creek.
- Of the 7,560 trapped at LNFH, 6,106 (84%) were excessed or transferred to Tribal Nations and 1,154 (16%) were kept for brood.
- The proportion of LNFH-origin spawners in the upper Wenatchee River and Entiat subbasins has remained very low with one LNFH-origin CWT recovered both the upper Wenatchee River in 2022.
- In 2022, 451 females were used for broodstock with an average fecundity of 3,900.
- LNFH had a green egg take of 1,759,058. This exceeded the performance goal of 1,740,000.
- LNFH culled 345,594 eggs and began rearing brood year 2022 with 1,317,600 eyed eggs.
- The 2016 brood year had a SAR of 0.21%.

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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-listed spring 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 2022 Coded Wire Tag Codes.

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

Table C1. Release year 2022 coded wire tag codes

Tag Code	N Released
056275	101,518
056276	101,575

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

August 2023