U.S. Fish and Wildlife Service

Leavenworth National Fish Hatchery Annual Report, 2017

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***On the cover**: Adult spring Chinook Salmon sampling at the Leavenworth National Fish Hatchery. USFWS.*

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LEAVENWORTH NATIONAL FISH HATCHERY ANNUAL REPORT, 2017.

Executive Summary- Leavenworth National Fish Hatchery (LNFH) was constructed as partial mitigation for anadromous fish loses associated with the construction and operation of Grand Coulee Dam. The hatchery is located on Icicle Creek in central Washington State and produces an unlisted stock of spring Chinook Salmon (*Oncorhynchus tshawytscha*) as a segregated-harvest program. In release year 2017, LNFH force-released 1,131,913 juvenile spring Chinook Salmon into Icicle Creek, which was 6% under the production goal of 1,200,000. At the time of release juveniles were 20 fish per pound (fpp) or 15% under the release size goal of 17fpp. In return year 2017, it was estimated 1,417 spring Chinook Salmon returned to Icicle Creek, of which 1,156 were captured at LNFH adult holding ponds. An estimated 41 fish were harvested in the Icicle Creek sport fishery and an estimated 144 fish were harvested in the Icicle Creek Tribal Fishery and 76 fish remained in Icicle Creek. Of the 1,156 fish that were captured in the adult holding ponds, 274 were excessed to regional Native American tribes and 802 were used as broodstock. Testing of the female broodstock showed 93% were in the “very low” and “low” risk levels for transmitting BKD from mother to progeny. After culling, LNFH began rearing brood year 2017 with 1,326,892 eyed eggs.

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Location

Leavenworth National Fish Hatchery (LNFH) is located adjacent to Icicle Creek near the town of Leavenworth in central Washington State (47°33'32.12" N, 120°40'29.12" W, Figure 1). Icicle Creek is a tributary to the Wenatchee River, which flows into 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. There are also 53 historic Foster-Lucas style ponds that are no longer used for production of spring Chinook Salmon (Figure 2, Table 1). Indoor facilities include: 540 Heath type incubation trays in 36 stacks and 122 starter tanks.

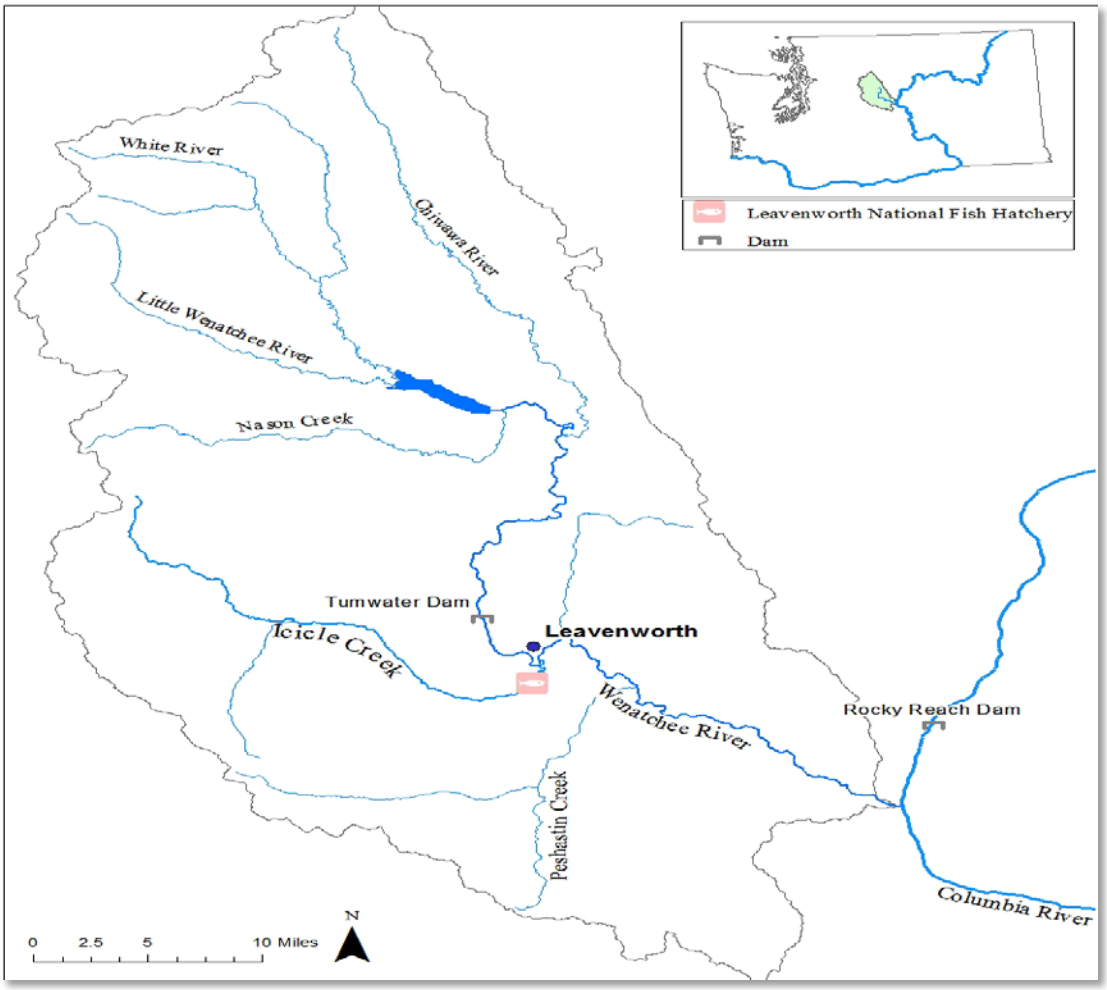
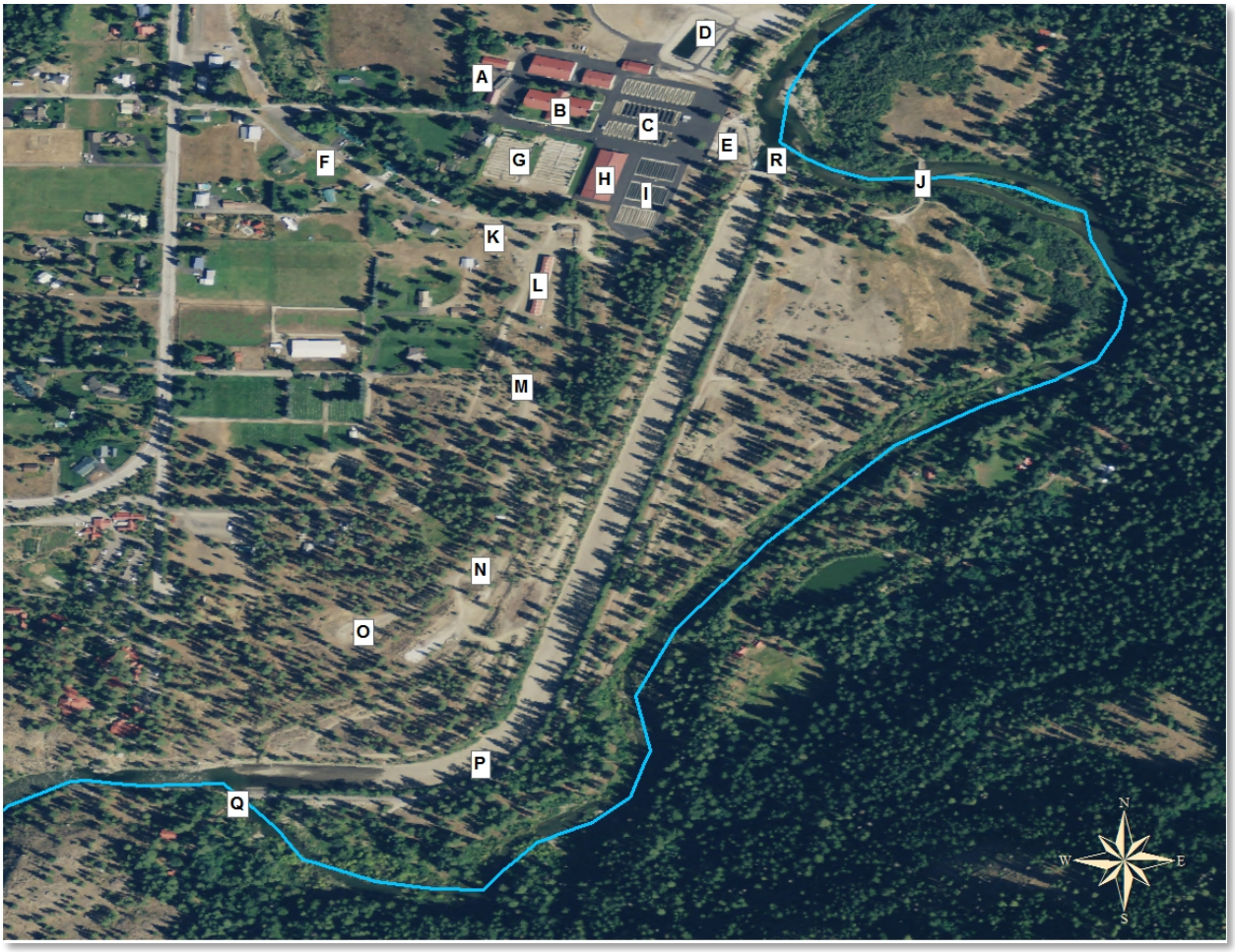


Figure 1. Map of the Wenatchee River watershed.



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

Table 1. Outdoor facilities currently used for production at LNFH.

Description	N	Size (ft)	Covered?	Predation Risk?	Shape	Use
rearing pond	45	8x80	No	Yes	rectangular	juvenile rearing
rearing pond	14	10x100	Yes	No	rectangular	juvenile rearing
adult holding pond	2	15x150	No	Yes	rectangular	adult collection/juvenile rearing

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 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 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. Some early imports of spring Chinook to LNFH 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. Fish and/or eggs have 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 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. Maximize survival at all life stages using disease control and disease prevention techniques. Prevent introduction, spread, or amplification of fish pathogens.
6. Conduct environmental monitoring to ensure that hatchery operations comply with water quality standards and to assist in managing fish health.
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.

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 2). 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. The remaining well 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 (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 2. Summary of water sources at LNFH.

Source	Depth (casing)	Annual Temp. ^{o}F	Average gpm	Min gpm	Max gpm	Storage Capacity ac-ft	Average Release Volume ac-ft
Icicle	Surface	42.3 - 53.9^{0}F	18,484*				
Snow/Nada	Surface	42.3 - 53.9^{0}F	22,442*			12,450	6,500
Well No. 1	80 (40-80')	42.3 - 53.9^{0}F	300	175	400		
Well No. 2A	203 (70-90')	47.0 - 49.4^{0}F	225	175	300		
Well No. 3A	120 (63-98')	44.0 - 49.8^{0}F	288	200	325		
Well No. 4A	333(64-94')	43.1 - 48.3^{0}F	300	200	400		
Well No. 5	300(250-300')	<52.0^{0}F	675	350	900		
Well No. 6	195(102-170')	50.5 - 52.5^{0}F	700	350	850		
Well No. 7	192(102-110')	43.3 - 46.7^{0}F	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 in guiding 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 operation 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. Forecast adult returns and track in-season fish abundance to 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 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 number of fish tagged 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 Columbia River Fish and Wildlife Conservation Offices' hatchery marking team. 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.

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. The hatchery is funded by the U.S. Bureau of Reclamation and operated by the U.S. Fish and Wildlife Service (USFWS). 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 2008-2017 *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, steelhead, and Bull Trout (*Salvelinus confluentus*), 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 term "take" is defined by the ESA as: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any threatened or endangered species. The Terms and Conditions outlined by each BiOp 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 3). 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 (Table 3). 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 (Table 3).

Brood Year- Brood Year Performance Goals apply to adult fish, assessing survival and contribution to harvest (Table 3). Assessment of Brood Year Performance Goals cannot be accurately completed until all of the adults have returned and all of the various marking 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 3. LNFH production practices goals by life stage in 2017

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	one antibiotic injection to brood females. 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	< 58° F (14.4°C)
	adult pre-spawn survival	88%
Eggs	green egg target	1,740,000 eggs
	prophylaxis	disinfect, water harden
	incubation units	Heath trays
	water source	Well
	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, 3500 eggs/tray

Table 3 continued. LNFH production practices goals by life stage in 2017

Fry	rearing unit	starter tanks
	water source	well, river water as emergency backup
	water quality monitoring	temperature and flow rates, dissolved gases when needed
	feed type	Bio Oregon Starter feeds
	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
	feed	Bio Oregon Feeds; Vita, Bio Pro 2, Bio Clarks Fry
	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% Adclip, 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	BioVita
	feeding frequency	variable: daily to 3x/week
	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$\leq$ hour
		density index $\leq$ 0.20
		flow index $\leq$ 0.60
	condition factor	1
	size	17 fish per pound
	early male maturation	< 20%
	release type	forced pumped
	release time	3^{rd} week of April
	release goal	1,200,000
Survival Targets	green egg to eyed egg survival	$\geq$90% / 1,330,000 eggs
	eyed egg to fry survival	$\geq$95% / 1,260,000 fry
	green egg to smolt survival	81%
	fry to smolt survival	$\geq$95%
	outmigration survival	>50%
	smolt to adult survival	>0.40%
	hatchery return rate	>2.0

Release Year 2017

Environmental Conditions

In the primary rearing year of 2016, Icicle Creek flows peaked early and then were reduced during late spring through late summer, resulting in a mean daily peak flow of 3,415 cfs which occurred on April 22nd, 2016. This was substantially earlier than the average annual peak flow that typically occurs in early June (Figure 3). The cool water supplementation from Snow Creek helped reduce maximum Icicle Creek temperatures by an average of 1.0°C in 2016 (Fraser, 2016).

The Pacific Northwest experienced below average air temperatures from December 2016 through March of 2017. The average air temperature at LNFH for the month of January was -2.8°C and nine consecutive days had an average low of -11°C. These low temperatures caused a thick layer of ice to form on all raceways for 10 weeks.

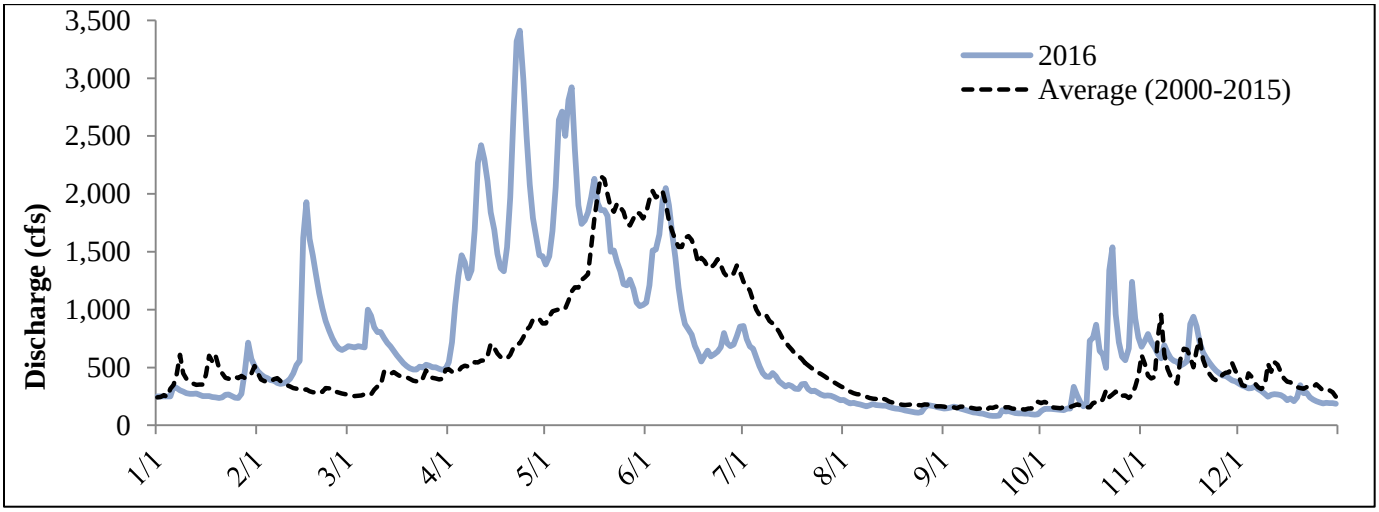


Figure 3. Mean daily flow (ft^3/s) of Icicle Creek, WA (U.S. Geological Survey gauge #12458000) for a 16 year period (2000–2015) and the primary rearing year 2016.

Juvenile Rearing

Spring Chinook Salmon smolts released in 2017 were derived from 1,953,690 eggs collected from adults that returned to LNFH in 2015. This was 112% above the green egg goal of 1,740,000. After culling, the green egg to eyed egg survival from the 2015 broodstock collection was 99% meeting the performance goal of >90%. Juvenile rearing of this cohort began in December 2015, when 1,270,275 fry were placed into 122 starter tanks. This was 105% of the release number and within 1% of the fry ponding performance goal of 1,260,000. The highest mortality (31%) occurred when a total of 600,636 eggs were culled. Of the culled eggs 128,931 (7%) eggs were culled due to Enzyme-Linked Immunosorbent Assay (ELISA) results, 131,328 (7%) were due to bad fertilization, a fungal infection of *Saprolegnia parasitica* (*Saprolegnia*), or water hardening prior to spawning, and 340,377 (17%) eggs

were surplus production. 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 (Tables 4, 17, and 18).

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 2017 rearing cycle, the mean monthly Density Index (DI) and Flow Index (FI) was 0.11 and 0.42, respectively which met the performance goals (DI <0.2 &FI<0.6) for these categories (Table 4).

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 February 2016, 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 206,576 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 covariance in size (<6.0% CV). At the time of marking and tagging the fish were 120 fpp with a CV of 6.0% which met tagging size criteria. This size helped achieve a post mark CWT retention rate of >99.9% (target >98%) based on a sample of 1,049 fish 30 days post-tagging. To reduce densities, the fish were split into 30-8x80 and 14-10x100 raceways after tagging.

As part of the Fish Passage Centers' Smolt Monitoring Program, PIT tags were implanted into 20,158 fish in late October (Table 5). 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 26 fpp, which was 18%

smaller than the performance goal of 22 fpp for the end of October. Opportunistic shed tag recoveries and mortalities were removed from the dataset during rearing, however total tag loss due to sheds and predation is difficult to definitively ascertain.

Due to limited rearing space at LNFH, fish from 15 of the 8x80 raceways were moved into two adult holding ponds to complete their rearing in January of 2017.

Two elevated mortality incidences occurred during the rearing of release year 2017. The first high mortality incident (3%) occurred in August, 2016 when a raceway was culled due to epizootic levels of the parasite *Ichthyophthirius multifiliis* (Ich) and a secondary bacterial infection of columnaris, despite aggressive formalin treatment. Ich is a common parasite at LNFH and is naturally occurring in Icicle Creek. The infestation was likely caused by the presence of adult spring Chinook above the LNFH water intake combined with unfavorable conditions in Icicle Creek.

Losses due to BKD and Bacterial Cold Water Disease were later seen from January to April, 2017. During an unusually long and exceptionally cold winter, a 6 inch layer of ice covered all outside rearing units. Following the thaw, three raceways began to experience persistent epizootic mortality. Attempts to reduce the pathogen load and stocking density with a series of small culls were unsuccessful at reducing the disease severity. Two of the three raceways continued to climb beyond epizootic levels and were culled prior to release as part of standard fish health policy.

Table 4. Juvenile rearing performance for release year 2017.

Month-Year	Life Stage	Production Inventory	Fish per Pound	% Mort.[b]	Cumulative Survival %	Temp (^{o}F) Ave [c]	Flow GPM[d]	Flow Index[d]	Density Index[d]
August-2015	Egg	1,819,486[a]	NA	NA	NA	48.5	135	NA	NA
September	Egg	1,953,690[a]	NA	NA	NA	48.5	195	NA	NA
October	Egg (cull)	1,311,654[a]	NA	32.86	NA	48.5	155	NA	NA
November	Sac Fry	1,299,792[a]	NA	0.99	99.01	48.5	155	NA	NA
December	Fry	1,270,275[a]	820	0.75	98.26	48.5	3,050	0.32	0.09
January-2016	Fry	1,268,589[a]	404	0.13	98.12	48.6	3,050	0.51	0.14
February	Fry	1,263,619[a]	243	0.39	97.73	48.0	5,460	0.40	0.07
March	Fingerling	1,263,233[a]	188	0.03	97.70	43.0	5,810	0.44	0.07
April	Fingerling	1,262,970[a]	120	0.02	97.68	43.7	8,550	0.40	0.09
May	Fingerling	1,262,058[a]	90	0.07	97.61	44.8	17,232	0.24	0.06
June	Fingerling	1,261,560	64	0.04	97.57	51.5	17,232	0.31	0.08
July	Fingerling	1,261,019	43	0.04	97.52	57.8	17,232	0.40	0.10
August	Fingerling	1,214,731	31	3.81	93.71	59.1	17,184	0.48	0.13

Table 4 continued. Juvenile rearing performance for release year 2017.

September	Fingerling	1,213,828	28	0.07	93.64	51.8	17,184	0.51	0.13
October	Fingerling	1,212,733	26	0.09	93.55	45.9	18,810	0.49	0.14
November	Yearling	1,211,043	24	0.14	93.41	41.6	18,810	0.51	0.15
December	Yearling	1,209,548	24	0.12	93.29	33.3	18,810	0.52	0.15
January	Yearling	1,206,526	24	0.25	93.03	32.5	18,810	0.52	0.15
February	Yearling	1,203,786	23	0.23	92.81	32.3	18,810	0.52	0.15
March	Yearling	1,193,036	22	0.90	91.91	37.2	20,500	0.50	0.15
April-2017	Smolt	1,131,913	20	4.96	86.95	40.0	20,500	0.54	0.16

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.

Release

During the daylight hours of April 14th and April17th, 1,131,913 yearling spring Chinook smolts were force-released via a Heathro Fish Pump into Icicle Creek (Table 5). This was 94% of the targeted release number of 1,200,000. Upon release fish were 20.4 fpp which was 15% below the release size goal of 17fpp, the mean fork length was 120mm with a CV of 9.9%.

Table 5. LNFH release dates, release numbers and tagging information for 2005–2017.

Release Year	Date Released	Total Released	# CWT	% CWT	% Adipose Clip	# PIT
2017	Apr 18	1,131,913	206,598	18%	100	20,158
2016[a]	Apr 21	994,167	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
2007	Apr 18	1,177,568	547,049	46%	100	14,969
2006	Apr 17	1,005,505	470,174	47%	100	14,700
2005	Apr 15	1,476,046	782,602	53%	100	14,825

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

Smolt Outmigration

Survival and travel time data are 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 is 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 2017 LNFH smolts arrived and passed McNary Dam in multiple peaks throughout early to mid-May on the descending limb of the hydrograph (Figure 4). For the 2017 smolt release, the average travel time to McNary Dam was 28 days or 7.3 river miles traveled per day (Table 6). This was three days slower than the 12 year average of 25 days and did not meet LNFH 2017 NMFS BiOp Term and Condition 2k (Appendix A). The survival of this cohort to McNary Dam was estimated at 54% which meets the performance goal of >50% but is lower than the long term average of 56%. The 2017 LNFH survival was lower compared to the spring Chinook programs at Winthrop NFH on the Methow River but higher than Chiwawa Rearing Ponds (CRP)in the upper Wenatchee River. The comparative survivals between these three facilities have been highly variable over the years suggesting a comparable hatchery effect (Figure 5).

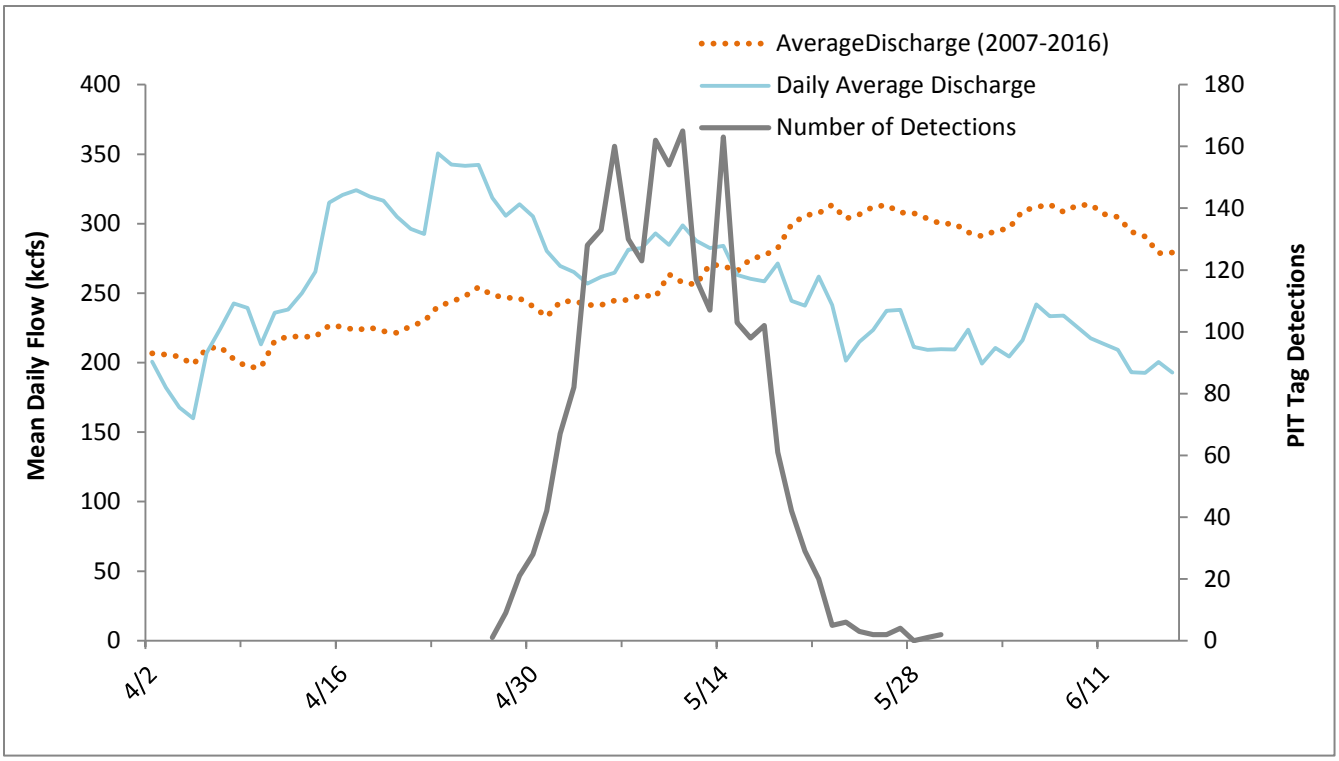


Figure 4. Daily passage of LNFH PIT tagged spring Chinook Salmon smolts at McNary Dam compared to spill in 2017.

Table 6. LNFH-origin spring Chinook Salmon smolt out-migration metrics, 2005–2017.

Release Year	Release Day	McNary Dam Mean Travel Time (Days)	Survival to McNary Dam	Confidence Limits (95%)	
2017	Apr. 18	28.2	0.54	0.52	0.59
2016[a]	Apr. 21	17.4	0.49	0.48	0.5
2015	Apr. 15	24.7	0.57	0.54	0.6
2014	Apr. 23	21.5	0.57	0.52	0.62
2013	Apr. 24	24.8	0.67	0.54	0.81
2012	Apr. 24	28.7	0.59	0.55	0.63
2011	Apr. 20	27.5	0.43	0.39	0.47
2010	Apr. 26	25.3	0.66	0.6	0.72
2009	Apr. 28	25.7	0.48	0.44	0.52
2008	Apr. 28	21.1	0.58	0.53	0.62
2007	Apr. 18	30.8	0.59	0.57	0.62
2006	Apr. 17	22.9	0.56	0.53	0.59
2005	Apr. 15	31.8	0.53	0.5	0.55
Average (05–16)		25.18	0.56	0.52	0.60
St. Dev. (05–16)		4.15	0.07	0.06	0.09

[a] 380 PIT tags removed from Travel Time and Survival estimates

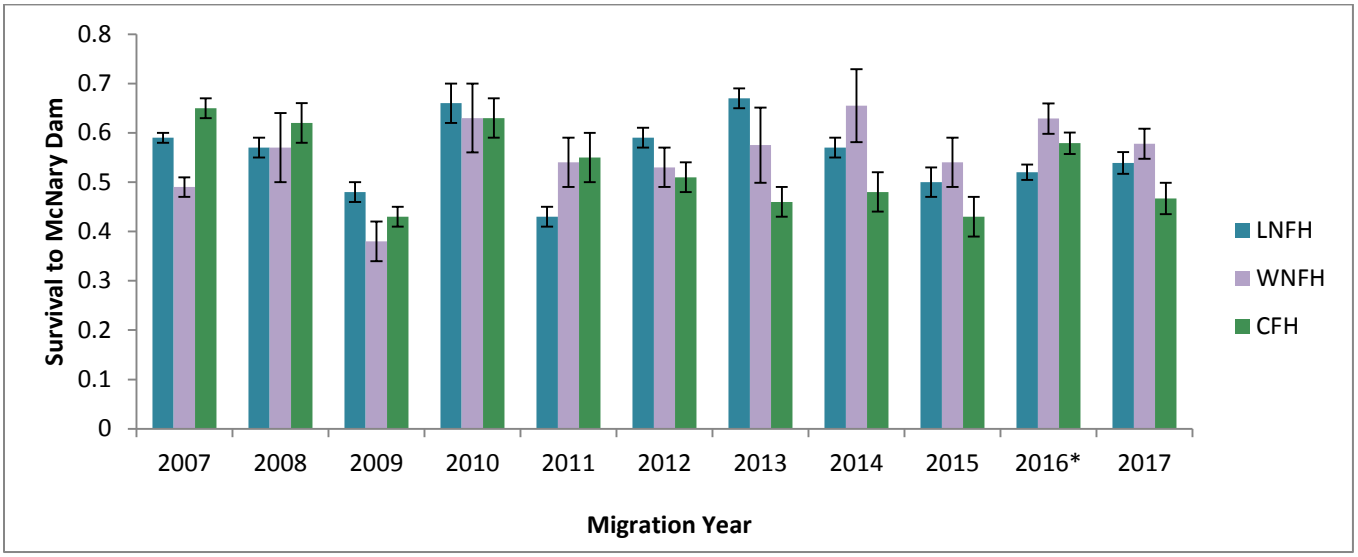


Figure 5. Upper Columbia River spring Chinook Salmon smolt survival (standard deviation) comparing LNFH with Winthrop National Fish Hatchery (WNFH) and Chiwawa Rearing Ponds (CRP), 2007–2017. *380 PIT tags removed from LNFH survival estimates based on accidental early release.

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) 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 a 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 (Clark and Blackburn 1994; Silverstein et al. 1998; Beckman et al. 1999, 2000; Shearer and Swanson 2000; Larsen et al. 2004). 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 2017 release year cohort there were two PIT tagged fish that were detected at dams and displayed upstream migration through dams (Table 7). Using this method, the rate of early maturation for LNFH-origin fish is <1% for release years 2005–2017, and it should be noted that this method of determining early maturation is plagued by very low sample sizes, and does not account for non-migrating minijacks.

To accurately address LNFH 2017 NMFS BiOp Term and Condition 3d (Appendix A), the HE program implemented pre-release male early-maturation sampling using a Gonadosomatic Index (GSI) as described by Larsen, 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. Juveniles were sampled 30 days post-release to allow more time for gonad development and easier separation of maturation levels. Of the 317 males that were sampled, 30(9.5%) were showing signs of precocity and this only occurred in larger juveniles (>130mm of fork length; Figure 6) and is similar to the same pattern observed in 2016.

Table 7. Rate of early maturation (minijacks and precocity by GSI) of LNFH-origin fish by release year, 2005–2017.

Release Year	Release Number	# PIT	PIT Ratio	Observed Minijacks	Expanded Minijacks[a]	Minijack Rate (%)	Release Precocity Rate by GSI (%)
2017	1,131,913	20,158	60	2	120	0.011	0.095
2016	945,277	19,957	53	2	106	0.011	0.086
2015	1,139,567	14,994	76	4	306	0.027	na
2014	1,239,025	13,380	93	13	1206	0.097	na
2013	1,289,293	14,951	87	13	1127	0.087	na
2012	1,186,622	14,901	80	9	718	0.061	na
2011	1,189,400	14,875	83	9	751	0.063	0.214*
2010	1,284,653	14,948	86	41	3533	0.275	0.220*
2009	1,685,038	14,931	113	21	2370	0.141	0.162*
2008	1,539,668	15,968	96	36	3471	0.225	0.288*
2007	1,177,568	14,969	79	15	1180	0.100	0.331*
2006	1,005,505	14,700	68	2	137	0.014	0.142*
2005	1,476,046	14,825	100	1	100	0.007	0.094*
Min	945,277	13,380	53	1	100	0.007	0.086
Max	1,685,038	19,957	113	41	3,533	0.275	0.331
Mean (05-16)	1,263,139	15,283	85	14	1,250	0.092	0.192

*From Harstad et al. 2014.

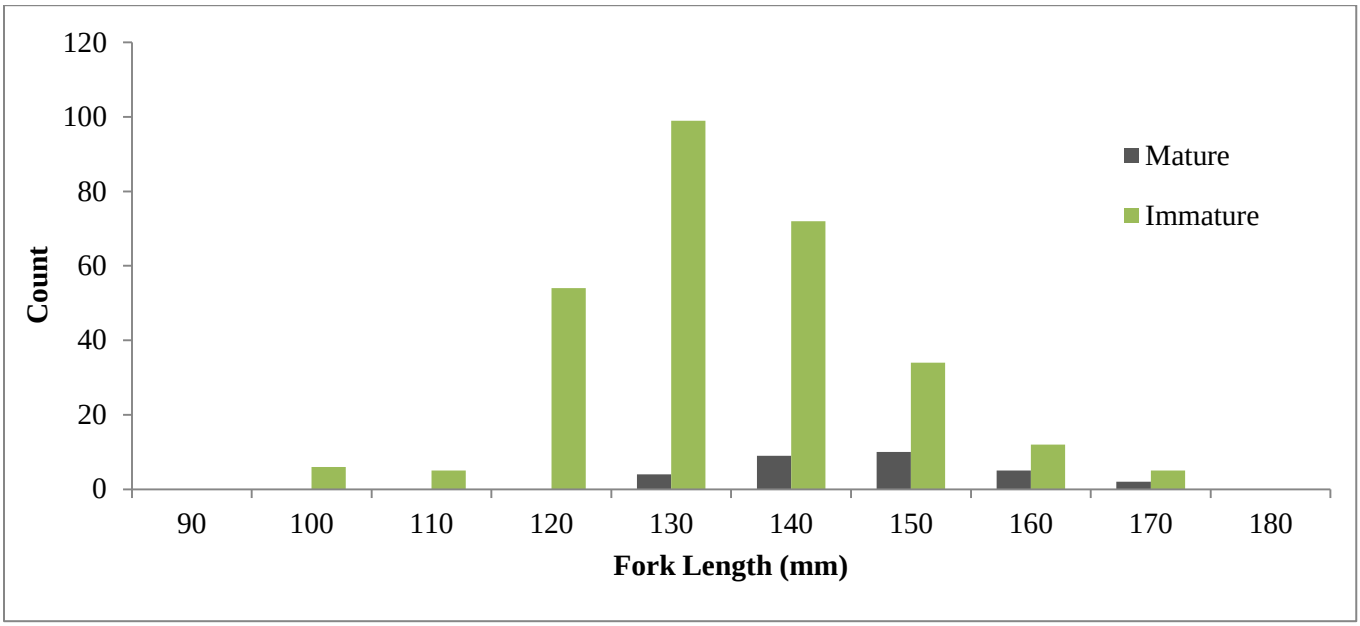


Figure 6. Precocity in sampled males by fork length, binned to the tenth mm, at LNFH, 30 days post-release, 2017.

Adult Return 2017

Run Forecast

Predictive models used to forecast the return of LNFH-origin spring Chinook Salmon to Icicle Creek suggested that the 2017 return may be one of the lowest ever recorded (Fraser et al. 2017). The pre-season forecast was for a return of 2,416 (1,332 -4,760). As some models indicated that the return may not be sufficient to meet both brood stock and Icicle Creek harvest needs weekly inseason forecasts were closely followed utilizing PIT tag expansion, run timing and conversion rate estimates from Bonneville Dam. The inseason estimate was 756 adults which was insufficient to meet brood stock needs or harvest opportunity. Based on this information harvest managers representing both state and Tribal fisheries elected to keep the Icicle fishery closed which traditionally opens in mid-May. In late-June sufficient brood stock was collected in the adult holding pond to allow harvest fisheries in Icicle Creek. Run forecast models have been utilized for a number of years at LNFH. In general pre-season estimates exhibit higher variability while inseason estimates tend to consistently under forecast the actual return to Icicle Creek (Table 8).

Table 8. A comparison of LNFH spring Chinook return forecast and accuracy to Icicle Creek, 2006 – 2017.

Return Year	Icicle Creek Return	In-season Forecast	Pre-season Forecast	Pre-season Accuracy	In-season Accuracy
2017	1,417	756	2,416	1.71	0.53
2016	5,277	4,130	6,872	1.30	0.78
2015	8,149	4,599	7,307	0.90	0.56
2014	6,005	5,802	5,975	1.00	0.97
2013	3,309	2,197	4,844	1.46	0.66
2012	7,074	5,387	7,668	1.08	0.76
2011	6,990	6,130	6,003	0.86	0.88
2010	13,862	11,283	9,592	0.69	0.81
2009	4,977	3,969	4,980	1.00	0.80
2008	4,692	3,687	5,897	1.26	0.79
2007	2,622	953	3,191	1.22	0.36
2006	3,147	1,905	3,836	1.22	0.61
Average				1.14	0.71
StDev				0.28	0.17

Run Timing

Returning LNFH-origin spring Chinook were first detected at the Bonneville Dam PIT tag antenna arrays on May 1st with the 50% passage date occurring on May 17th. The returning adults were delayed by two weeks compared to the long-term (12 year) average and slow to ascend Bonneville Dam reaching

the 90% passage date on July 1st (Table 9). The delay could potentially be associated to increased flows due to spring runoff of the above average snowpack in the Snake River Basin.

The detection efficiency of the PIT tag antenna arrays at Bonneville Dam are reported to be greater than 90% (Burke et al 2006). The 100% passage estimate over Bonneville Dam was July 5th. Adults took an average of 16 days to travel from Bonneville Dam to Rock Island Dam in 2017 (Figure 7). The average travel time of LNFH-origin adults from Rock Island Dam to the Lower Icicle Creek instream PIT tag antenna array was 16 days in 2017. The travel time between Bonneville and Rock Island was equal to the five year average but between Rock Island and lower Icicle Creek, travel time was slightly slower than the average (14 days) for the previous five years.

In 2017, an estimated 1,417 spring Chinook returned to Icicle Creek. In-basin estimates were generated from WDFW creel surveys, tribal harvest estimates, spawning ground surveys, and LNFH adult holding pond counts. The 2017 adult return was 24% of the average return for the previous 12 years (Table 10).

Table 9. Passage dates for LNFH-origin spring Chinook Salmon at Bonneville Dam, 2005–2017.

	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
2017	1-May	1-May	5-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
2007	12-Apr	13-Apr	15-Apr	19-Apr	26-Apr	9-May	21-Jun	29-Jun	19-Jul
2006	21-Feb	26-Apr	30-Apr	4-May	8-May	11-May	15-May	20-May	2-Jul
2005	11-Apr	20-Apr	22-Apr	25-Apr	28-Apr	4-May	11-May	16-May	19-Jul
Mean (05-16)	30-Mar	18-Apr	21-Apr	27-Apr	3-May	18-May	16-Jun	26-Jun	24-Jul

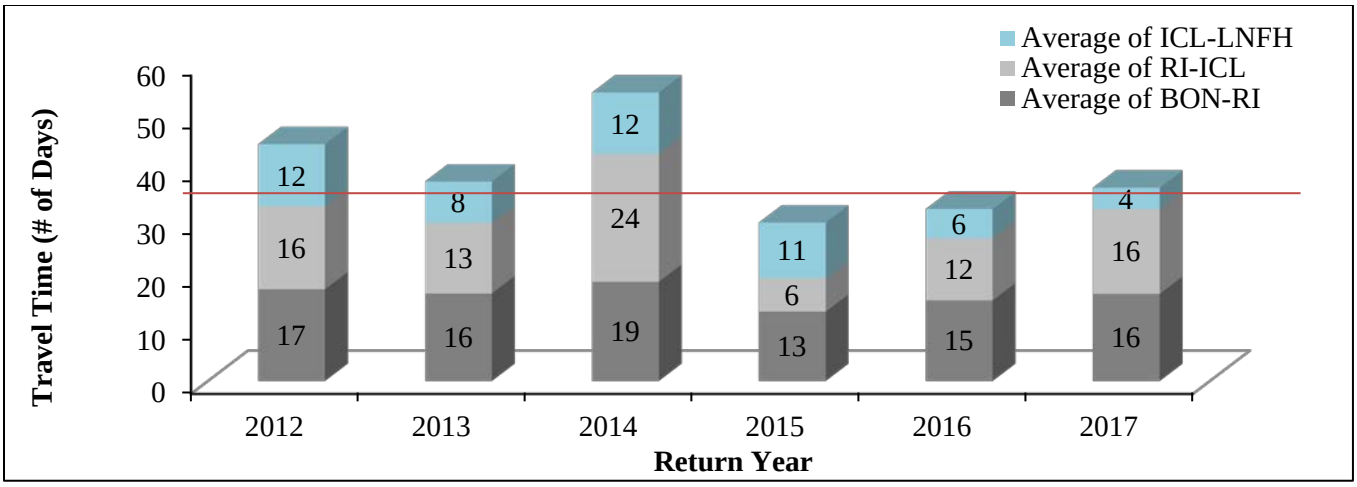


Figure 7. Travel time of adult LNFH-origin spring Chinook Salmon returns from Bonneville to Rock Island Dam (BON -RI), Rock Island Dam to the Lower Icicle array (RI-ICL) and the Lower Icicle Array to LNFH (ICL-LNFH). The average number of days is given for each reach in the data bars, with red line indicating mean travel time between BON to LNFH from 2012–2016.

Fish Ladder Operation

The fish ladder was opened continuously from May 18th through June 20th to assure enough broodstock was collected to meet LNFH production goals. Once broodstock needs were met the ladder was open and closed intermittently to capture portions of the run, minimize strays, and to maximize catch opportunity by sport and tribal harvest fisheries (Figure 8). During this time, 1,156 spring Chinook adults ascended the fish ladder and entered the adult holding pond (Table 10). This was 28% of the 12 year average of 4,082 fish. The fish ladder was closed for the season on July 12th.

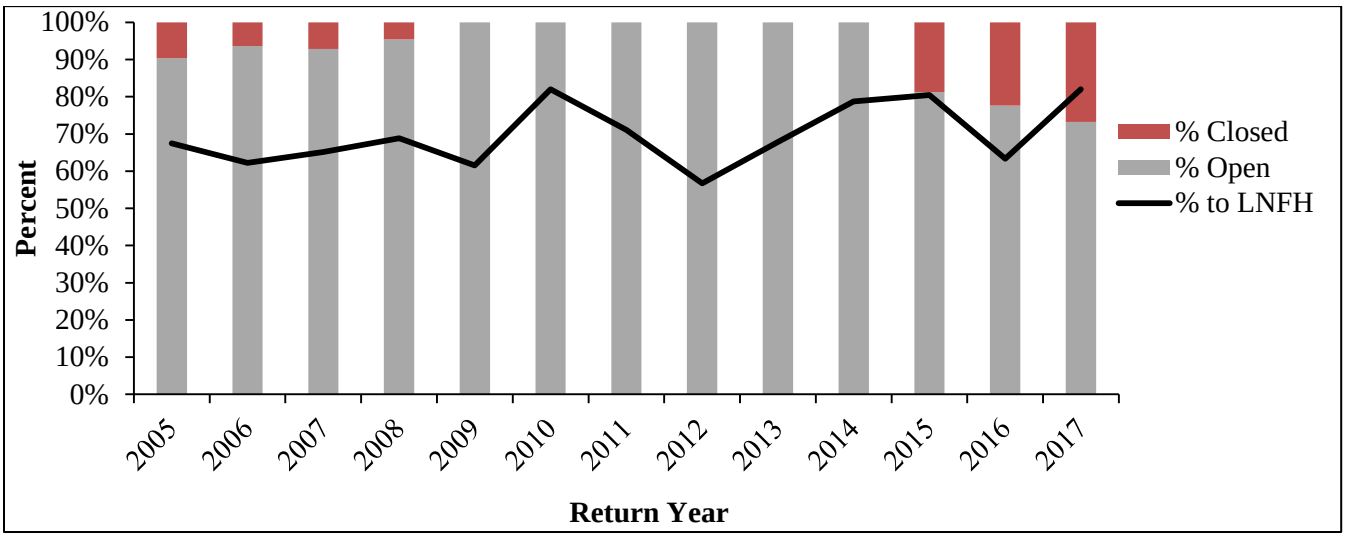


Figure 8. LNFH fish ladder operations and percent of the Icicle Creek returning spring Chinook Salmon trapped in LNFH adult holding pond, 2005-2017.

Harvest

In 2017, harvest for spring Chinook Salmon in Icicle Creek was delayed until LNFH acquired adequate numbers to meet broodstock goals.

Spring Chinook Salmon were subject to 38 days of a mark selective (i.e. adipose clip) sport fishery in Icicle Creek. WDFW creel census of Icicle Creek estimated the sport fishery harvested 41 LNFH-origin spring Chinook in 2017 which is 8% of the 2005-2016 average of 502 (Table 10, T. Maitland pers. comm.).

Additionally, Icicle Creek spring Chinook were subjected to a 38 day tribal harvest. It was estimated the tribal fishery harvested 144 fish from Icicle Creek in 2017 which was 14% of the 2005-2016 average of 1,021(Table 11).

Table 10. Sport fishery harvest and creel estimates targeting Leavenworth NFH spring Chinook in Icicle Creek and/or Wenatchee River, 2005 – 2017.

Year	Season	# Anglers	Hours Fished	Fish Caught	Run Size	% Sport Harvest	CPUE	Hours/Fish
2017	June 24- July 31	197	800	41	1,417	2.9%	0.051	19.5
2016	May 16 - July 31	1,377	7,939	303	5,120	5.9%	0.038	26.2
2015	May 20 - July 31	990	5,064	433	6,990	6.2%	0.086	11.7
2014	May 23 - July 31	1,587	7,299	390	4,765	8.2%	0.053	18.7
2013	May 18 - July 31	1,979	9,644	323	2,403	13.4%	0.034	29.9
2012	May 19 - July 31	4,922	21,492	971	4,720	20.6%	0.045	22.1
2011	May 21 - July 31	5,229	25,934	873	5,844	14.9%	0.034	29.7
2010	May 13 - July 31	5,231	23,549	993	12,303	8.1%	0.042	23.7
2009	May 22 - July 31	1,530	8,235	640	4,790	13.4%	0.078	12.9
2008	May 28 - July 31	1,147	7,144	347	4,995	6.9%	0.049	20.6
2007	May 22 - July 31	1,058	7,754	115	2,622	4.4%	0.015	67.4
2006	May 26 - July 31	2,402	13,553	529	3,147	16.8%	0.039	25.6
2005	May 28 - July 31	1,108	8,131	103	3,793	2.7%	0.013	78.9
	Min	990	5,064	103	2,403	2.7%	0.013	11.7
	Max	5,231	25,934	993	12,303	20.6%	0.086	78.9
	Mean (05 – 16)	2,380	12,145	502	5,124	10.1%	0.044	30.6

Table 11. Abundance and fate of LNFH-origin adult spring Chinook Salmon returning to Icicle Creek from 2005–2017.

Return Year	Total Run to Icicle Cr.	Returned to LNFH	Sport Harvest	Tribal [a]	Remaining in River
2017	1,417	1,156	41	144	76
2016	5,277	3,241	303	1,550	130
2015	8,149	6,557	433	908	251
2014	6,005	4,375	390	818	422
2013	3,309	2,094	323	678	214
2012	7,074	3,749	971	2,036	318
2011	6,990	4,970	873	805	342
2010	13,862	11,307	993	1,314	248
2009	4,977	3,232	640	910	195
2008	4,692	3,229	347	833	283
2007	2,622	1,708	115	751	48
2006	3,147	1,957	529	588	73
2005	3,793	2,560	103	1,063	67
Min	2,622	1,708	103	588	48
Max	13,862	11,307	993	2,036	422
Mean (05–16)	5,825	4,082	502	1,021	216

[a] Estimated tribal harvest, 2009-present

Tumwater Dam Stray Removal

Within the Wenatchee River basin, nearly all natural spawning of spring Chinook occurs in the upper basin, upstream of Tumwater Dam (Figure 1). While the structure is not used for power production, the WDFW use it as an interception point for spring Chinook attempting to enter the upper basin spawning grounds.

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 2017, a preliminary estimate of 36 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 basin 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 (pHOS) in the upper Wentachee River Basin has averaged 0.5% since 2005. In

2017, no LNFH-origin coded wire tags were identified on the spawning grounds in the upper Wenatchee River meeting LNFH 2017 NMFS BiOp Term and Condition 1a (Table 12, Appendix A).

Although adipose clipped, non-CWT fish removed at Tumwater Dam are presumed to be LNFH-origin, it is possible these fish could have originated from the upper Wenatchee River spring Chinook acclimation programs (CWT shed tag loss) or low CWT tag rate harvest mitigation programs in the Snake River basin (ie. Dworshak NFH) which 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 is needed.

Table 12. Escapement abundance of spring Chinook Salmon to the upper Wenatchee River, sampling rates, and LNFH-origin fish data and expansions 2004–2016.

Return Year	Upper Wenatchee SCS Escapement[a]	Upper Wenatchee SCS Carcass Recoveries[a]	Percent Carcasses Sampled[b]	LNFH-origin CWT Recoveries[c]	LNFH-origin Estimated Recoveries[d]	LNFH-origin Expanded Recoveries[e,f]	Proportion of LNFH-origin spawners (pHOS) in Upper Wenatchee SCS Escapement[g]
2017	TBD	TBD	TBD	0	0	0	0.0%
2016	879	337	38.3%	0	0	0	0.0%
2015	1,293	380	29.4%	*1*	4	20	1.5%
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%
2007	2,007	517	25.8%	0	0	0	0.0%
2006	940	484	51.5%	2	4	6	0.6%
2005	1,472	828	56.3%	2	4	4	0.3%
Min	848	290	9.7%	0	0	0	0.0%
Max	2,990	828	56.3%	5	14	42	2.0%
Mean (05–16)	1,799	517	31.6%	1	4	9	0.5%

[a] From CCPUD M&E report (Hillman et al 2017)
[b] Upper Wenatchee SCS Carcass Recoveries/Upper Wenatchee SCS Escapement
[c] From RMIS
[d] LNFH-origin CWT Recoveries/Percent Carcasses Sampled
[e] LNFH-origin Estimated Recoveries/CWT rate (CWT rate not shown)
[f] 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 2009-2017.
[g] LNFH-origin Expanded Recoveries/ Upper Wenatchee SCS Escapement

Hatchery Returns

Of the 1,156 adults that returned to the LNFH holding pond 495 (43%) 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 population biometrics. If a CWT was detected, the snout was collected and age 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 2017 five fish with intact adipose fins were accidentally killed and scale examination revealed that two were hatchery and three were of unknown origin due to regenerated scales. Age composition for LNFH-origin returns was based on 206 CWT recoveries and 311 ages from scale samples. The age analysis resulted in 15.1% age-3 fish (n=78), 77.8% age-4 (n=403), and 7.1% (n=37) age-5 (Table 13). The age-3 and age-4 components of this run were above average for the past 12 years, and the age-5 returns were below average. Age-3 females were not observed in 2017. The male-female ratio of returns was 0.9, with fewer males having returned than females (Table 14). No out–of –basin CWT recoveries were detected in 2017.

Fork lengths for returning adult male spring Chinook were within the standard deviation for all age classes with mean fork lengths of 51.7 cm for age-3, 79.2 cm for age-4 and 95.2 cm for age-5. Age-4 females were within the standard deviation with a mean fork length of 74.2 cm, while age-5 females returned slightly larger than average with a mean fork length of 87.1 cm (Table 15).

Table 13. LNFH-origin spring Chinook Salmon age compositions by sex and return year, 2005–2017.

	% MALE AGE				% FEMALE AGE			% COMBINED AGE			
Return Year	2	3	4	5	3	4	5	2	3	4	5
2017	0.0	15.1	28.7	2.6	0.0	49.1	4.5	0.0	15.1	77.8	7.1
2016	0.8	4.0	34.3	6.3	0.0	48.7	5.8	0.8	4.0	83.1	12.1
2015	0.1	9.0	35.8	2.1	0.1	50	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	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	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	0.0	0.9	36.9	0.7	0.0	60.7	0.7	0.0	0.9	97.7	1.4
2009	0.0	24.3	25.2	5.6	0.1	37.9	6.9	0.0	24.4	63.2	12.4
2008	0.0	3.3	31.4	8.7	0.0	47.5	9.1	0.0	3.3	78.9	17.8
2007	0.0	19.9	16.2	12.4	0.2	40.8	10.5	0.0	20.1	57.1	22.9
2006	0.0	0.7	31.9	8.4	0.0	51.2	7.7	0.0	0.7	83.2	16.1
2005	0.0	2.5	34.8	2.7	0.0	57.1	3.0	0.0	2.5	91.9	5.6
Min	0.0	0.7	14.3	0.7	0.0	23.2	0.7	0.0	0.7	37.5	1.4
Max	3.8	34.8	36.9	12.4	0.2	60.7	15.1	3.8	34.9	97.7	26.7
Mean (05–16)	0.6	11.2	28.6	6.1	0.1	46.4	7.0	0.6	11.3	75.1	13.0

Table 14. Sex composition of sampled spring Chinook Salmon returning to LNFH, 2006–2017.

Return Year	% of Return Sampled	# Males	# Females	Male/Female Ratio
2017	42.6	230	265	0.9
2016	12.0	174	214	0.8
2015	16.7	510	583	0.9
2014	23.6	498	536	0.9
2013	28.6	309	290	1.1
2012	33.3	471	779	0.6
2011	28.2	863	538	1.6
2010	10.1	409	733	0.6
2009	31.7	563	461	1.2
2008	97.8	1,380	1,779	0.8
2007	31.9	259	286	0.9
2006	28.7	227	334	0.7
Min	10.1	174	214	0.6
Max	97.8	1,380	1,779	1.6
Mean (06–16)	31.2	515	594	0.9

Table 15. LNFH spring Chinook Salmon mean fork length (cm) by age, sex, and return year, 2003–2017.

	Males			Females		
Return Year	age-3	age-4	age-5	age-3	age-4	age-5
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
2007	52.8	79.6	93.6		75.1	85.9
2006	47.3	78.8	92.2		72.7	84.5
2005	52.9	78.7	92.8		74.7	84.3
2004	51.5	76.0	94.9		72.5	87.3
2003	52.8	78.0	97.0		75.9	89.5
Mean (05–16)	51.6	77.9	93.1	62.3	73.9	85.7
St. Dev. (05–16)	1.7	1.5	2.1	5.8	1.3	1.8

[a] *n=1*

Broodstock

Of 1,156 spring Chinook Salmon that returned to the hatchery, regional tribes received 274 surplus fish, 802 were spawned, 31 fish died while being held in the adult holding pond (DIP), 47 were green, bad, or spent, and 2 presumably natural origin fish were returned to the river (Table 16).

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

In 2017, LNFH spawned 802 of the 871 fish held for broodstock resulting in 92% broodstock utilization, which met the utilization target (Table 3). Fish were determined to be "held for broodstock" if they remained in the adult holding ponds after the last excessing event. There were 466 females and 408 adult males available at the time of spawning. Of fish available for spawning 36 females and 11 males were not used because they were either green (not ready), spent (no milt remaining), or poor condition. The targeted male:female spawning ratio was 1:1, with a backup male used in the event the primary male was infertile. The 2017 adult return had an insufficient return of males, so a 1:1 spawning ratio was not met.

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). Pathogen profiles for the broodstock used for production were supplied by Olympia Fish Health Center, USFWS. Sampling protocols included testing all females for the presence and relative abundance of *R. Salmoninarum*. 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 16. Fate of spring Chinook Salmon that entered the adult holding ponds at LNFH, 2005–2017.

Return Year	Total Returns to LNFH	DIPS	Adults Excessed	Adults Spawned	Green/ Spent/ Bad	Transfers	Unknown Fate/ Returned to River	Non-LNFH origin CWT's	Natural Origin
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	6,565	124	4,838	955	8	640	0	6	1
2014	4,729	122	2,801	1,101	65	640	0	10	0
2013	2,082	227	666	767	0	422	163	32	0
2012	4,009	42	2,931	1,036	0	0	4	29	0
2011	4,970	112	3,932	926	0	0	0	95	0
2010	11,297	104	10,250	729	214	0	69	9	0
2009	3,053	109	2,178	714	52	0	0	19	1
2008	3,226	64	2,189	968	5	0	0	10	0
2007	1,708	41	712	955	0	0	0	4	1
2006	1,757	99	677	981	0	0	0	3	0
2005	2,491	8	1,807	676	0	0	0	0	2
Min	1,708	8	666	676	0	0	0	0	0
Max	11,297	227	10,250	1,101	214	640	163	95	2
Mean (05–16)	3,929	88	2,726	907	28	180	18	18	0

Virology and ELISA Results

For salmonids, the Pacific Region Fish Health Program categorizes BKD risk from ELISA optical density (OD) values into six levels, ranging from “No Detection” to “Very High” risk (Table 17). In 2016, over 93% 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 (2005–2016) 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.

Table 17. Summary of BKD detection from female spring Chinook Salmon at LNFH, 2005–2017.

Year	No Detection (%)	Very Low (%)	Low (%)	Moderate (%)	High (%)	Very High (%)	N
2017	0	4	84	9	1	2	430
2016	1	6	87	4	1	3	500
2015	0	12	82	3	2	2	476
2014	0	0	31	43	19	7	572
2013	0	0	60	36	3	1	408
2012	0	1	78	20	1	1	520
2011	0	2	75	19	2	2	463
2010	0	1	76	22	1	1	402
2009	0	32	65	2	0	1	380
2008	0	47	50	1	0	2	473
2007	0	26	69	2	1	2	523
2006	0	15	75	7	1	3	547
2005	0	78	17	1	1	2	337
2004	15	74	4	0	1	5	494
Min	0	0	17	1	0	1	337
Max	1	78	87	43	19	7	572
Mean (05-16)	0	18	64	13	3	2	467

Egg Survival

In 2017, 96.0% of the green eggs survived to eye-up, meeting the stage survival target of >90% (Table 17). The percentage does not include the 336,672 culled eggs, of which 205,678 eggs were as a result of ELISA testing (results of moderate or higher risk), 27,902 eggs due to bad fertilization or water hardening prior to spawning, and the remaining 103,092 eggs were culled to production goals. The 12.0% ELISA culling rate met the 15% performance goal for this category. In December, the emergent fry were placed in the indoor starter tanks to begin the rearing cycle. The average fecundity between the

two takes was 3,986 eggs (Table 18). The green egg take of 1,719,396 was slightly below the performance goal of 1,740,000 (Table 3).

Table 18. Eyed egg survival for LNFH spring Chinook Salmon for return years 2006–2017.

Return Year	Fecundity	Green Eggs	Bad Eggs	Culling			Eyed Eggs Kept	% Green to Eyed Survival
				ELISA[a]	Bad Female	Production		
2017	3,986	1,719,396	55,832	205,678	27,902	103,092	1,326,892	96.0
2016	3,822	1,921,935	31,250	133,770	NA	413,774	1,343,141	97.7
2015	4,104	1,953,690	41,400	128,931	131,328	340,377	1,311,654	96.9
2014	3,960	2,259,815	39,988	977,144[b,d]	NA	0	1,282,671	100.0
2013	3,909	1,557,224	123,802	179,814	62,544	18,170	1,172,894	90.5
2012	3,656	1,883,040	58,748	405,816	NA	102,169	1,316,307	95.7
2011	3,993	1,809,216	74,257	406,500	NA	22,109	1,306,350	94.6
2010	4,109	1,651,881	46,416	386,246	8,218	0	1,219,868	97.0
2009	4,252	1,620,634	25,635	85,040	17,008	224,202	1,268,749	98.0
2008[c]	3,980	1,967,195	20,910	47,760	NA	605,097	1,293,428	98.4
2007	3,546	1,750,550	36,755	89,019	NA	288,435	1,336,341[d]	97.3
2006	3,100	1,726,920	68,090	179,744	NA	19,644	1,459,442[d]	95.5
Min	3,100	1,557,224	20,910	47,760	8,218	0	1,172,894	90.5
Max	4,252	2,259,815	123,802	977,144	131,328	605,097	1,459,442	100.0
Mean (06-16)	3,857	1,827,464	51,568	274,526	54,775	184,907	1,300,986	96.5

NA Records do not state the number of bad females
[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 1,200,000.
[d] Reported data different than LNFH production records

Brood Year 2011

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 CWT recoveries to be reported. Given these delays, the Brood Year analysis herein uses Brood Year 2011 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.

2011 Adult Return Recap

The 2011 Brood Year was produced from a slightly above average run size in 2011 with the hatchery capturing and holding 4,970 returning adults. Of these LNFH spawned 463 females, yielding a green egg take of 1,809,216 and an average fecundity of 3,993 eggs per female. The green egg take was above the estimated 1,740,000 needed to meet the release goal of 1,200,000.

Many of the Adult Return/Broodstock metrics for the 2011 Brood Year fell in the "average" category. Broodstock Utilization, 50% spawn date, and size were all on par for this program. The 2011 adult return had the highest proportion of age-3 returns of all brood years at 35%. The high proportion of age-3 returns skewed the sex ratio towards one of the highest male proportions on record with a male to female ratio of 1.6/1. With no major mortality events, Brood Year 2011 ultimately released 1,289,293 smolts into Icicle Creek on April 24, 2013. The released smolts performed above average exhibiting a faster than average travel time of 24.8 days and a 67% survival to McNary Dam which is the largest in 13 years of record (2005 – 2017 average travel time = 25.2 days, survival = 56%). Early maturation as determined by the occurrence of minijacks was about average at 0.09.

Brood Year 2011 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 Year 2011, returned as adults from 2014-2016 and had an SAR of 0.73% meeting the performance goal of >0.40% and is above the 10 year average of 0.44% (Figure 9). Annual variation in LNFH's SAR may be explained by LNFH specific factors such as on-site rearing metrics or off-site metrics common among hatchery programs in the region such as ocean or river conditions. To assess whether on-site of off-site metrics caused annual SAR variation we compared LNFH SARs to the Chiwawa Rearing Pond (CRP) in the upper Wenatchee River basin and WNFH in the Methow River Basin (Figure 10). Intra-hatchery variables could be any of the rearing parameters that occur on-site.

Similar to LNFH, annual variation in SARs occurred at CRP and WNFH from 2002–2011 suggesting that external hatchery conditions influenced all three programs similarly. For example, in 2005 the SARs were low for all three programs followed by large increases for all three programs in 2006 (Figure 10).

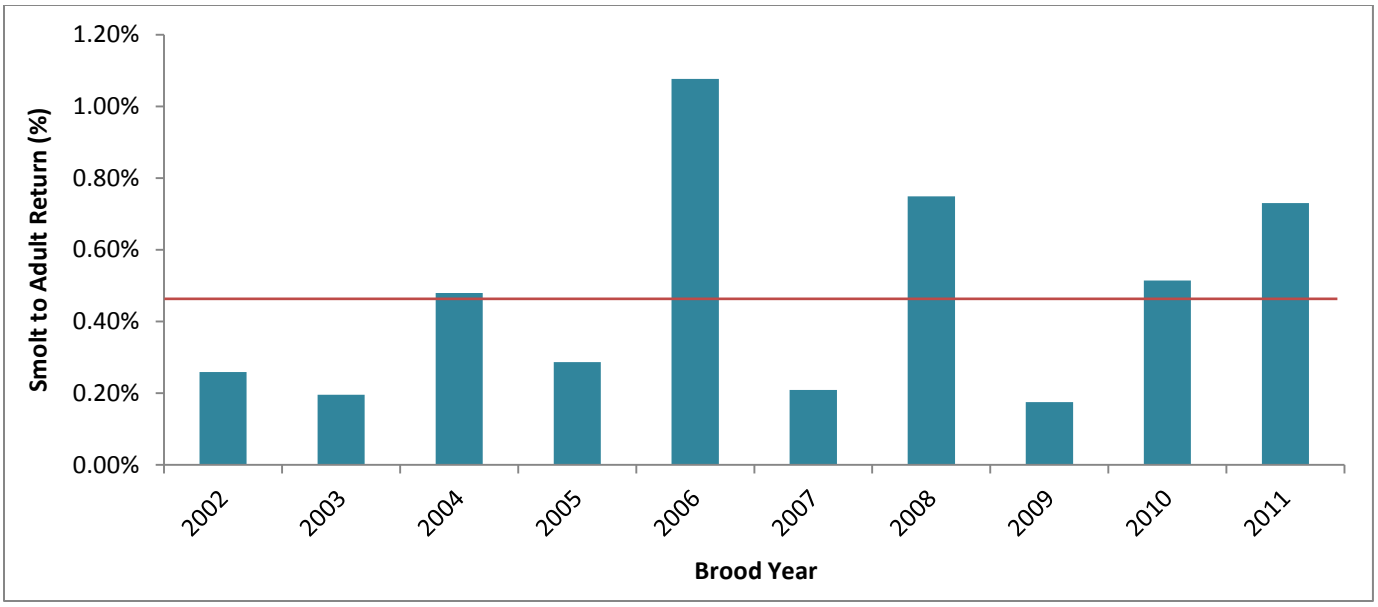


Figure 9. LNFH SAR's, 1999-2011, with red line indicating 1999–2010 mean.

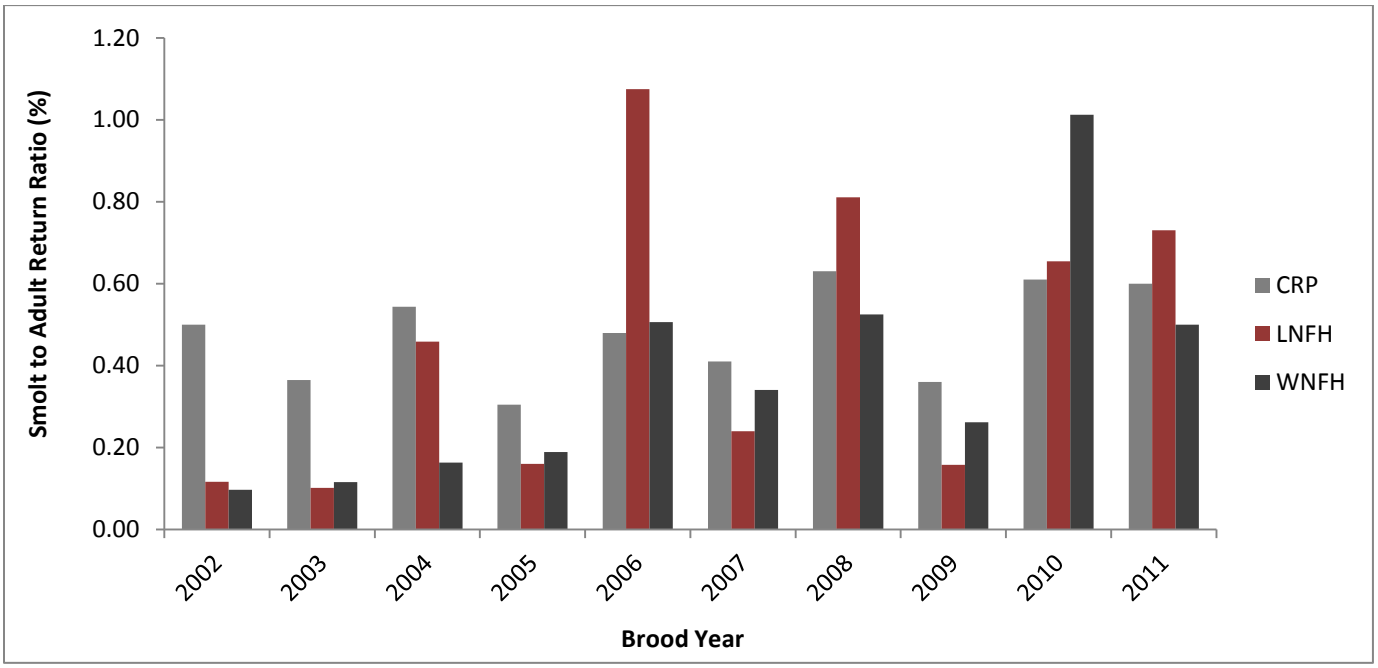


Figure 10. Smolt to Adult Return (SAR) for Chiwawa Rearing Pond (CRP), Leavenworth National Fish Hatchery (LNFH), and Winthrop National Fish Hatchery (WNFH) for brood years 2002–2011.

Brood year 2011 return age classes were 14% age-3 fish, 76% age-4 fish, and 11% age-5 fish (Figure 11). 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 50.2% females and 49.8% males (age-3+) (Figure 12).

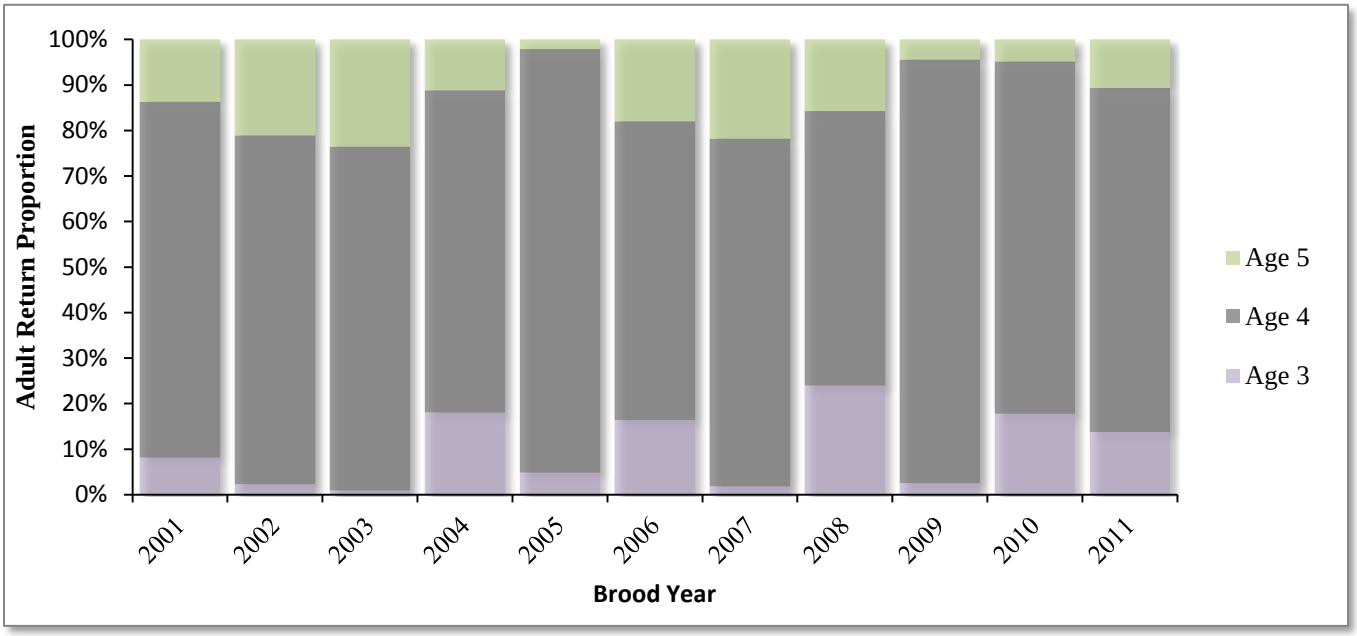


Figure 11. Leavenworth NFH spring Chinook proportion of ages produced, by brood year. Note: Percentages may not equal 100% due to rounding and outliers (i.e. age-2 and age-6)

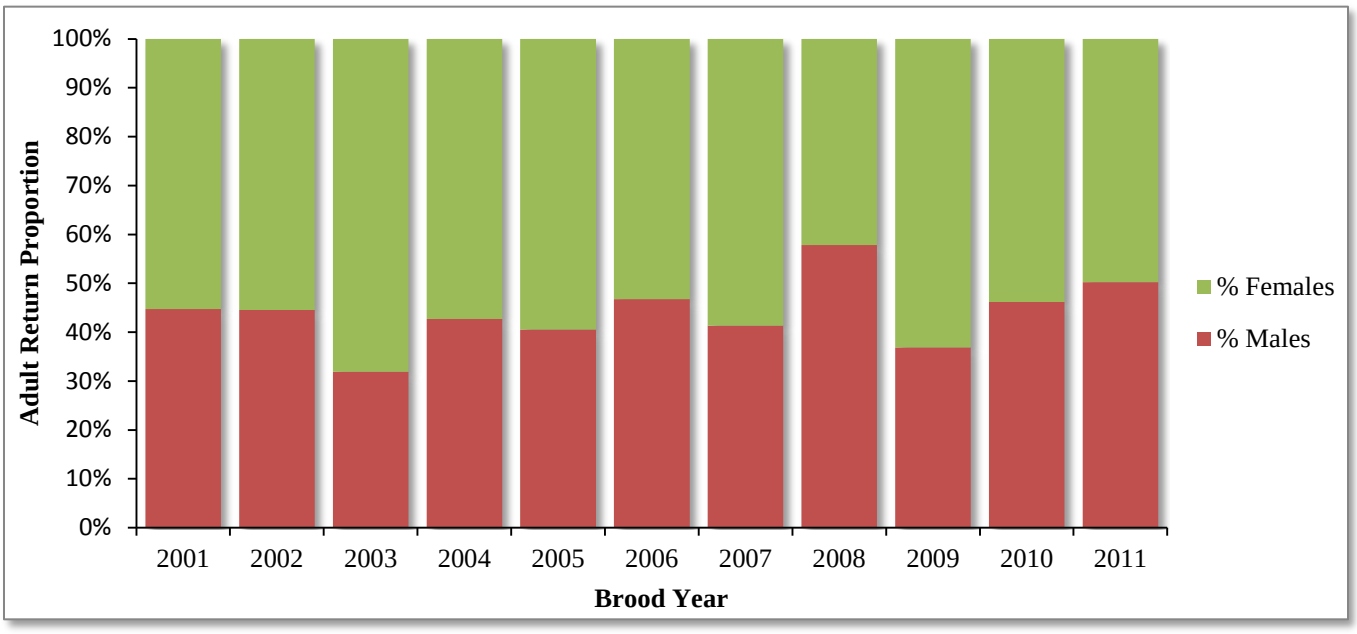


Figure 12. Leavenworth NFH spring Chinook sex composition produced by brood year.

Harvest Contribution- Brood year 2011 produced an estimated 9,403 returning adults. Of these 7,993 (85%) were either harvested or excessed for consumption, 1,112 (12%) were utilized for brood stock and 298 (3%) were found in "other" areas to include spawning ground recoveries. Locally, the sport

fishery in the Wenatchee River and Icicle Creek accounted for 5% (1,563) of the return and tribal fishers in Icicle Creek harvested another 1,094 (12%) adults (Table 19). The largest portion of Brood Year 2011 returning adults contributed to a variety of Columbia Basin Tribes either through harvest or hatchery excessing efforts (80%). This is higher than the average for brood years 2003-2010 (66%).

Table 19. 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)		Hachery Production		Excess Hatchery Returns		Other	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%
2003	2,840	453	15.9			132	4.6	582	20.5	725	25.5	803	28.3	145	5.1
2004	8,438	3,115	36.9			376	4.5	921	10.9	1,044	12.4	2,140	25.4	842	10.0
2005	4,282	647	15.1			465	10.9	621	14.5	493	11.5	1,592	37.2	464	10.8
2006	20,562	4,219	20.5			1,031	5.0	1,721	8.4	1,134	5.5	11,596	56.4	862	4.2
2007	4,932	568	11.5			1,012	20.5	532	10.8	465	9.4	1,880	38.1	476	9.6
2008	10,725	1,943	18.1			704	6.6	2,222	20.7	1,407	13.1	4,095	38.2	353	3.3
2009	2,841	108	3.8	15	0.5	566	19.9	424	14.9	465	16.4	482	17.0	780	27.5
2010	6,744	930	13.8	544	8.1	157	2.3	825	12.2	1,070	15.9	2605	38.6	613	9.1
2011	9,403	746	7.9	34	0.4	469	5.0	1,094	11.6	1,112	11.8	5,650	60.1	298	3.2
Mean (03–10)	7,670	1,498	17.0	280	1.1	555	9.3	981	14.1	850	13.7	3,149	34.9	567	10.0
St. Dev	5,887	1,471	9.5	374	2.8	345	7.2	645	4.5	362	5.9	3,590	11.7	254	7.6

Summary

- The targeted density and flow indices of < 0.20 and < 0.60, respectively, were met for release year 2017.
- The 2017 LNFH release of 1,131,913 spring Chinook was 94% of the production goal of 1,200,000. The production number was low due to epizootic levels of "Ich" in August and outbreak of Bacterial Kidney Disease and Bacterial Cold Water Disease in April.
- Fish were released at 18 fish per pound (fpp) which was slightly below the goal of 17 fpp.
- Juvenile survival to McNary dam was 54%, which was lower than other spring Chinook hatcheries in the upper Columbia River basin. This lower survival could be due to disease outbreaks during rearing.
- Of the 1,417 spring Chinook that returned to Icicle Creek, 185 (13%) were harvested, 1,156 (82%) were trapped in the adult holding ponds and 76 (5%) remained in Icicle Creek.
- Age composition of spring Chinook returning to LNFH in 2017 was 15.1% age-3 fish (n = 78), 77.8% age-4 (n = 403), and 7.1% (n = 37) age-5. Based on CWT recoveries no age-6 fish were detected.
- In 2017, 20 jacks, 352 adult males, and 430 females were spawned at LNFH. Females used for broodstock had average fecundity of 3,986.
- In 2017, LNFH had a green egg take of 1,719,396. This was slightly below the performance goal of 1,740,000.
- LNFH culled 336,672 and began rearing brood year 2017 with 1,326,892 eyed-eggs.
- The 2011 Brood Year had a SAR of 0.73%.

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Personal Communications

Travis Maitland, 2017. Washington Department of Fish and Wildlife. Wenatchee, Washington.

Michael Hughes,2018. Washington Department of Fish and Wildlife. Wenatchee, Washington.

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 2017 Coded Wire Tag Codes.

Table C1. Release year 2017 coded wire tag codes

Tag Code	N Released
055716	101,598
055649	99,919

Appendix D: Pre-Release Density Trial for Reducing Outbreak of BKD

Memo to File

To: Interested Parties
From: Dr. Trista Becker, Veterinary Medical Officer

Brood year 2015 spring Chinook Salmon at Leavenworth National Fish Hatchery experienced epizootic levels of Bacterial Kidney Disease due to the agent *Renibacterium salmoninarum* beginning in March 2017. Coinfections with *Flavobacterium psychrophilum* were also seen.

High level mortalities began close to release when densities were high. To prevent further disease outbreaks in additional raceways, "early" release was initiated and two raceways with epizootic mortality levels were euthanized. Prior to euthanasia, a one week trial was conducted to study the impacts of splitting fish at this stage of infection into lower densities. Fish were moved from raceway 10 into two additional empty raceways. Approximately a third of the fish were scooped in nets and transferred by hand to each raceway (8 and 12). Samples were collected for ELISA testing from (10) dead/ moribund, and (20) random healthy fish the day before and 20 healthy/random fish from each raceway one week following the move (Table 20).

ELISA values remained the same for raceway 10 (fish not moved) and were higher in raceways 8 and 12 following the move. The results of this trial suggest that disease progression can be slowed by lowering density in a raceway, but that the stress of handling could cause worsening of disease in fish that are handled.

This disease is always persistent and difficult to treat once clinical signs develop. Stress experienced over a long period of time in certain salmonids – especially spring chinook – can leave them more susceptible. Once clinical disease manifests, treatment is very difficult and rarely successful. Fish will often succumb to secondary infections due to the immunosuppressive nature of the bacterium.

Stress reduction can be accomplished in part by density reduction, but as exhibited in this case may be best done prior to development of clinical signs and could be tracked with ELISA testing.

Table 20. ELISA values from fish sampled at Leavenworth National Fish Hatchery pre- and post- movement. Values in green on the left are raw ELISA values. Values on the right in red are log-rank values.

	Signal: OD-diluent(OD-BLK)					Ranks				
Date:	4/14/17	4/14/17	4/21/17	4/21/17	4/21/17	4/14/17	4/14/17	4/21/17	4/21/17	4/21/17
Raceway:	10	10	10	8	14	10	10	10	8	14
Mb/Normal:	Mort	N	N	N	N	Mort	N	N	N	N
	1.832	0.011	0.019	0.032	0.023	10	3	3	4	4
	1.858	0.013	0.021	0.041	0.027	10	3	3	4	4
	1.875	0.026	0.023	0.055	0.027	10	4	4	5	4
	1.879	0.027	0.027	0.093	0.040	10	4	4	6	4
	1.933	0.049	0.039	0.236	0.060	10	5	4	7	5
	1.948	0.076	0.062	0.311	0.374	10	5	5	7	8
	2.009	0.117	0.081	0.324	0.386	10	6	5	7	8
	2.055	0.181	0.082	0.387	0.502	10	7	5	8	8
	2.065	0.196	0.212	1.095	1.110	10	7	7	9	9
	2.125	0.216	0.235	2.003	1.665	10	7	7	10	10
		0.331	0.345	2.019	1.681		7	8	10	10
		0.502	0.666	2.068	1.872		8	8	10	10
		0.763	1.183	2.085	1.992		9	9	10	10
		1.767	1.646	2.099	2.014		10	10	10	10
		2.011	1.795	2.107	2.052		10	10	10	10
		2.036	1.953	2.128	2.053		10	10	10	10
		2.068	1.989	2.169	2.101		10	10	10	10
		2.117	2.055	2.170	2.136		10	10	10	10
		2.146	2.062	2.171	2.161		10	10	10	10
		2.209	2.177	2.199	2.209		10	10	10	10
Quartiles										
25%	1.876	0.069	0.056	0.292	0.295	10	5	4.75	7	7.25
50%	1.940	0.273	0.290	2.011	1.673	10	7	7.5	10	10
75%	2.043	2.017	1.834	2.112	2.052	10	10	10	10	10

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

February 2018