U.S. Fish and Wildlife Service

Leavenworth National Fish Hatchery Annual Report, 2015

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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, 2015.

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Executive Summary- Leavenworth National Fish Hatchery (LNFH) was constructed as partial mitigation for anadromous fish loses associated with the construction of Grand Coulee Dam. The hatchery is located on Icicle Creek in central Washington State and produces spring Chinook Salmon (*Oncorhynchus tshawytscha*) as a segregated-harvest program. In release year 2015, LNFH force-released 1,139,567 juvenile spring Chinook Salmon into Icicle Creek, which was 5% under the performance goal for a release number of 1,200,000. The juveniles released were 17 fish per pound, which met the performance goal for yearling size at release. In return year 2015, it was estimated 9,993 spring Chinook Salmon returned to Icicle Creek, of which 6,565 were captured at LNFH. An estimated 433 fish were harvested in the Icicle Creek sport fishery and an estimated 1,616 fish were harvested in the Icicle Creek Tribal Fishery. Of the 6,565 fish that were captured in the adult holding ponds, 4,838 were excessed to regional Native American tribes and 947 were used as broodstock. Testing of the female broodstock showed 96% were in the "very low" and "low" risk levels for transmitting BKD from mother to progeny. After culling, LNFH began rearing brood year 2015 with 1,301,654 eyed eggs.

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Introduction

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 is situated on approximately 85 hectares of ponderosa pine/pinegrass forest (Figure 2). Icicle Creek, a fifth-order stream draining high relief mountains, provides water for hatchery operations and serves as the release and collection point for the cultured fish. LNFH has water rights to 99,010 L/min (26,160 gallons per minute, gpm) of water, though the average flow through the hatchery is 70,410 L/min (18,400 gpm). Additionally, LNFH has seven wells that can provide up to 15,000 L/min (3,963 gpm) of pathogen-free water.

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 (Table 1). Indoor facilities include: 540 Heath type incubation trays in 36 stacks and 122 starter tanks.

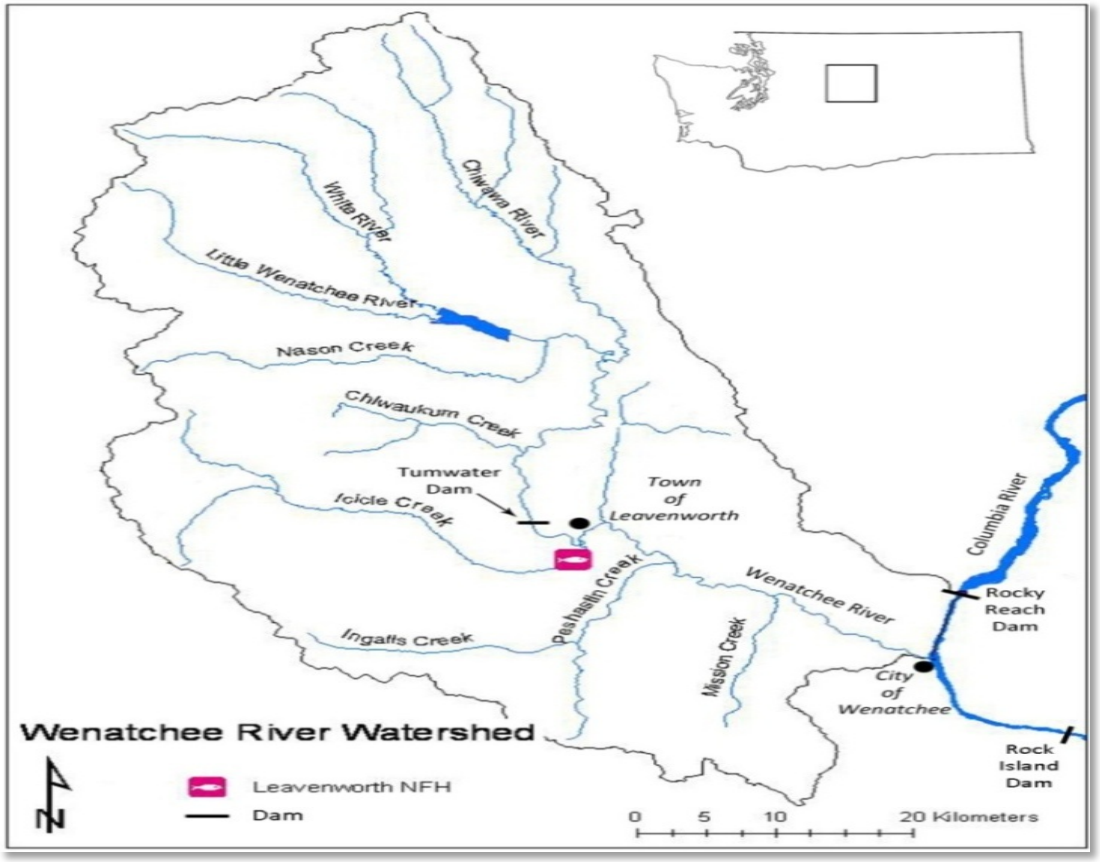

Figure 1. Map of the Wenatchee River watershed.

Figure 2. Aerial photograph of the Leavenworth National Fish Hatchery.

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*).

From 1940-1943, spring Chinook Salmon were collected from upriver-bound stocks captured at Rock Island Dam. Some early imports of spring Chinook Salmon 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. Although spring Chinook Salmon have been produced at LNFH since 1940, Sockeye Salmon were the primary species produced. Beginning in the early 1970's, due to the limited benefits and significant disease risk, Sockeye Salmon were phased out and spring Chinook Salmon became the primary species produced at LNFH (USFWS 1986). 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 program producing spring Chinook Salmon, and aids in the production of coho salmon (*O. kisutch*) for the Yakama Nation Mid-Columbia Coho Reintroduction Program, however only spring Chinook Salmon production will be discussed in this report.

LNFH has produced spring Chinook Salmon annually, except for brood years 1967 and 1968. The stock used by LNFH is not included in the ESA-listed Upper Columbia River spring Chinook Salmon Evolutionarily Significant Unit (ESU). Genetic analysis indicates that the current stock is more closely related to the lower Columbia River stocks than the natural population in the Wenatchee River (Ford et al. 2001). Spring Chinook Salmon produced at LNFH are commonly referred to as "Carson stock", referring to the Carson National Fish Hatchery, where the majority of imported eggs originated. However, considering the number of generations that this stock has been propagated at LNFH, it is increasingly being referred to as an "Icicle Creek" or "Leavenworth" stock.

Hatchery Evaluation

The Mid-Columbia Fish and Wildlife Conservation Office (MCFWCO) conducts monitoring and evaluation of LNFH spring Chinook Salmon program under its Hatchery Evaluation (HE) program. Hatchery Evaluation responsibilities involve tasks that monitor the progress each facility makes toward achieving goals and providing feedback for increased program effectiveness. There are four main goals that guide the HE program: evaluate the progress of LNFH to effectively and efficiently meet mitigation goals and responsibilities, identify factors affecting smolt quality and survival to adult, facilitate coordination and cooperation among hatchery programs in the Columbia River basin, and evaluate and minimize the impacts of hatchery operations on natural fish populations and the environment. Drawing from the LNFH governing documents; the HE program has developed a Hatchery Evaluation Plan (HEP) as a guiding document. The HEP outlines objectives, assigns tasks, and directs monitoring and evaluation to assist LNFH in meeting its mitigation goals and ESA responsibilities.

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 completed by the Columbia River Fish and Wildlife Conservation Offices' hatchery marking team. This team marks fish for all USFWS in the Columbia River basin hatcheries, 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 of LNFH fish culture facilities, biological surveys and experiments related to fish conservation. The hatchery is currently funded by the U.S. Bureau of Reclamation (BOR) and operated by the U.S. Fish and Wildlife Service (USFWS). The *U.S. v. Oregon* decision of 1969, and subsequent agreements, such as the 2008-2017 *U.S. v. Oregon* Columbia River Fish Management Agreement, set production goals for the facility.

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 (*Salvilinus confluentus*), all of which 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.

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 progeny on ESA listed species. The HGMP sets broad performance standards that are used by the National Marine Fisheries Service for the purpose of evaluating hatchery programs under the ESA.

Performance Goals

To accurately monitor and evaluate the spring Chinook Salmon program at LNFH, specific performance goals are tracked throughout the year (Table 2). Performance goals are derived from the legal authorities, HGMP's, Olympia Fish Health Center recommendations and peer-reviewed literature. 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. Brood year will not be discussed in this report.

Release Year - Release year performance goals apply to the rearing of juveniles from egg eye-up through smolt release (Table 2). 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 2).

Table 2. LNFH production protocols as described in the HEP outlining current practices and production goals by life stage in 2015.

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 pre-spawn survival	88%
Eggs	***green egg target***	1,740,000 eggs
	prophylaxis	Disinfect, water harden, formalin treat
	incubation units	Heath trays
	water source	Well
	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
Fry	***% green egg to eyed egg***	≥90% / 1,330,000 eggs
	% eyed egg to fry	≥95% / 1,260,000 fry
	rearing unit	Starter tanks
	water source	Well
	water quality monitoring	temperature and flow rates, dissolved gases when needed
	feed type	Bio-Starter
	feeding frequency	6-8 times/day
	feed amount (%BW/Day)	1.0% BW/Day
	cleaning frequency	Daily
	monitoring	Monthly biometrics

Table 2 cont. LNFH production protocols as described in the HEP outlining current practices and production goals by lifestage in 2015.

Life Stage	Attribute	Current Practices and Goals
Sub-yearlings	***rearing units***	8X80 raceways
	water source	Well/river
	water quality monitoring	Temperature, dissolved gases when needed, & flow rates
	feed	BioVita
	feeding frequency	4-6 times/day
	feed amount	1% BW/Day
	feed application	Hand
	cleaning frequency	Every other day
	marking	17%CWT, 100% Adclip, inventory, 15K PIT's
	monitoring	Monthly fish health & biometrics, CWT retentions
Yearlings	***rearing units***	8X80's, 10X100's (covered), ADHP's
	water source	River/well/1 pass re-use in emergency situation
	water quality monitoring	Temp., dissolved gases when needed, & flow rates
	feed	BioVita
	feeding frequency	Daily
	feed amount (%BW/Day)	1.0% 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	1.0
	size	17 fish per pound
	early male maturation	< 20%
	release type	forced
	release time	3rd week of April
	release goal	1,200,000
Survival Targets	***green egg to smolt survival***	81%
	fry to smolt survival	$\geq$95%
	smolt to adult survival	0.35%-0.40%

Release Year 2015

Juvenile Rearing

Spring Chinook Salmon smolts released in 2015 were derived from 1,546,017 eggs taken from adults that returned to LNFH in 2013. This was 11% below the green egg goal of 1,740,000. Juvenile rearing of this cohort began in December 2013, when 1,166,534 fry were placed into 113 starter tanks. This was 97% of the release number and below the fry ponding performance goal of 1,236,000. The highest mortality occurred in the egg stage due to ELISA culling, poor egg quality, and premature water hardening (Tables 3, 15, and 16).

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 were desired as a disease risk reduction strategy; however this had to be balanced against rearing space and water availability. For the release year 2015 rearing cycle, the mean monthly Density Index (DI) and Flow Index (FI) was 0.13 and 0.48, respectively. Only in the months of February and March, 2014, were the rearing goals of both indices exceeded due to limited rearing space and water supply (Table 3).

Piper et al. (1982) suggest calculating a Density Index (DI) as:

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

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 April of 2014, the fish were moved from the nursery into 30 of the 8x80 raceways, each receiving approximately 38,000 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.

In May of 2014, all fish were adipose clipped and 196,151 were given a CWT (Table 4, Appendix B). During marking, inventory was taken and the exact numbers of fish per raceway were determined. To reduce densities, the fish were split into 30-8x80 and 14-10x100 raceways.

In October of 2014, PIT tags were implanted into 14,994 fish as part of the Fish Passage Centers' smolt monitoring program (Table 4). 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 ascertain. Warm surface water and late-summer parasite load caused mortality to peak in October at 0.24%.

At the time of PIT tagging, the fish were 24 fish per pound (fpp), which was below the performance goal of 22 fpp. In December of 2014, fish from 15 of the 8x80 raceways were moved into and divided into the two adult holding ponds to complete their rearing. This was done to make room for the next generation of juveniles.

Table 3. Juvenile rearing performance for release year 2015.

Month	Life Stage	Production Inventory[a]	% Mort[b]	% Total Surv.	Temp (^{0}F) Ave[c]	Water Source[d]			Flow GPM[e]	Flow Index (lbs./in *GPM) [f]	Density Index (lbs./in* ft^3)[f]
						% Well	% River	% Reuse			
August-2013	Egg	349,497	NA	NA	NA	100	0	0	NA	NA	NA
September	Egg	1,563,980	NA	100.0	NA	100	0	0	NA	NA	NA
October	Egg (cull)	1,303,452	16.1	83.9	NA	100	0	0	NA	NA	NA
November	Sac Fry	1,166,185	8.2	77.1	NA	100	0	0	NA	NA	NA
December	Fry	1,158,546	2.1	75.5	48.7	100	0	0	2,800	0.29	0.08
January	Fry	1,154,922	0.7	75.0	46.5	100	0	0	2,800	0.54	0.14
February	Fry	1,154,070	0.3	74.7	46.7	90	10	0	2,800	0.85	0.23
March	Sub-yearlings	1,153,674	0.1	74.7	46.5	90	10	0	3,360	1.00	0.32
April	Sub-yearlings	1,153,296	0.0	74.6	41.8	40	60	0	8,120	0.60	0.08
May	Sub-yearlings	1,151103	0.3	74.5	44.0	40	60	0	16,800	0.25	0.06
June	Sub-yearlings	1,150,723	0.0	74.4	48.0	0	100	0	16,800	0.29	0.07
July	Sub-yearlings	1,150,263	0.0	74.4	57.5	0	100	0	16,800	0.43	0.11
August	Sub-yearlings	1,149,859	0.0	74.4	59.7	0	100	0	16,800	0.57	0.14
September	Sub-yearlings	1,148,552	0.1	74.3	53.0	0	100	0	17,600	0.55	0.14
October	Sub-yearlings	1,145,805	0.2	74.1	48.9	0	100	0	17,800	0.57	0.15
November	Yearling	1,144,475	0.1	74.0	37.7	0	100	0	17,800	0.57	0.15
December	Yearling	1,143,441	0.1	74.0	36.3	0	100	19	21,900	0.46	0.14
January	Yearling	1,142,647	0.1	73.9	35.2	0	100	19	21,900	0.47	0.15
February	Yearling	1,141,607	0.1	73.8	38.6	0	100	19	21,900	0.50	0.15
March	Yearling	1,140,388	0.1	73.8	40.8	0	100	19	21,900	0.54	0.17
April-2015	Smolt	1,139,567	0.1	73.7	41.1	0	100	19	21,900	0.58	0.18

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 by automated counting at 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]Data indicates approximate water source usage. Actual usage depends on a variety of factors including disease and maintaining water (through well water inclusion) temperatures to minimize the formation of slush ice in winter and not to exceed 68^0 during summer months.

[e]Estimated GPM used by brood including re-use.

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

Release

The release of 1,139,567 spring Chinook Salmon smolts occurred on April 15th, 2015. Fish were force-released using a Heathro Fish Pump into Icicle Creek at 17 fpp. This was 95% of the performance goal for release number of 1,200,000 and was at target size according to the performance goal for yearling size at release.

Smolt Outmigration

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 monitoring facilities. McNary Dam is located at rkm 470, roughly half way downstream from LNFH to the Pacific Ocean. Multiple juvenile monitoring facilities downstream of McNary Dam enable mark-recapture methodologies to derive survival estimates at McNary Dam.

For the 2015 smolt release, the average travel time to McNary Dam was 24.7 days (Table 5). This is slightly faster than the average from the previous 12 years of 26 days. The survival of this cohort to McNary Dam was estimated at 50%. Other spring Chinook Salmon programs from the upper Columbia River basin had similar survivals to LNFH, suggesting a comparable hatchery effect (Figure 3). Survival and travel time data are provided by the Fish Passage Center and PTAGIS using PIT tagged fish as representatives of the population.

Table 4. LNFH release dates, release numbers and tagging information for 2003–2015.

Release Year	Date Released[a]	Total Released	# CWT	% CWT	% Adipose Clip	# PIT
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	19	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	26	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
2004	Apr. 19	1,422,100	822,022	58	100	216,698
2003	Apr. 21	1,288,893	771,756	60	100	240,558

[a]If released over multiple days, last day is given.

Table 5. LNFH-origin spring Chinook Salmon smolt out-migration metrics, 2003–2015.

Release Year	Release Day	McNary Dam Mean Travel Time (Days)	Survival to McNary Dam	Confidence Limits (95%)	
2015	Apr. 15	24.7	0.57	0.54	0.60
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	0.60	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	0.50	0.55
2004	Apr. 19	25.3	0.48	0.47	0.49
2003	Apr. 21	28.2	0.66	0.66	0.67
Mean (03–14)		**26.04**	**0.57**	**0.53**	**0.61**
St. Dev. (03–14)		**3.15**	**0.07**	**0.07**	**0.09**

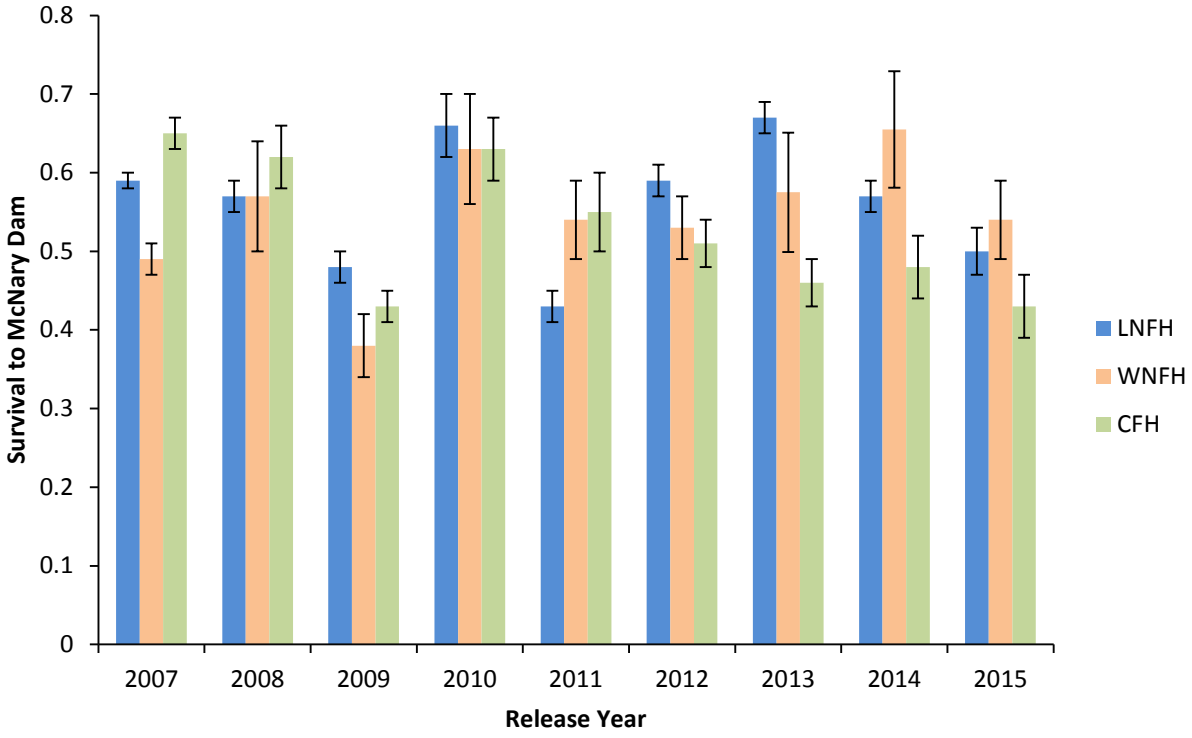

Figure 3. Upper Columbia River spring Chinook Salmon smolt survival comparing LNFH with the Winthrop National Fish Hatchery (WNFH) and the Chiwawa Fish Hatchery (CFH), 2007–2015.

Early Maturation

Spring Chinook Salmon most commonly mature in the ocean (after outmigration) at age 3 or older. Early maturation of spring Chinook Salmon is defined as the complete development of primary sexual characteristics (gonads) and/or the expression of reproductive behavior before age 3. They are more commonly referred to as "precocial parr" or "minijacks" and are quite often males. 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 (Mullen 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 difficult to quantify or remove from the river system.

Beckman and Larsen (2005) suggested estimating the occurrence of minijacks by monitoring upstream migration of PIT tagged juvenile (via PIT detections at dams) during the year of their intended outmigration. Within the 2015 release year cohort there were four PIT tagged fish that were detected at dams and displayed upstream migration through dams (Table 6). The rate of early maturation for LNFH-origin fish is <1% for release years 2003–2015, 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.

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.

Table 6. Rate of early maturation (minijacks) of LNFH-origin fish by release year, 2003–2015.

Release Year	Release Number	# PIT	PIT Ratio Non-Tag/Tag	Observed Minijacks	Expanded Minijacks[a]	Minijack Rate (%)
2015	1,139,567	14,994	76.0	4	532	0.05
2014	1,239,025	13,380	92.6	13	1,204	0.10
2013	1,289,293	14,951	86.2	13	1,121	0.09
2012	1,186,622	14,901	79.6	9	716	0.06
2011	1,189,400	14,875	80.0	9	720	0.06
2010	1,284,653	14,948	85.9	41	3,444	0.27
2009	1,685,038	14,931	112.9	21	2,371	0.14
2008	1,539,668	15,968	96.4	36	3,470	0.23
2007	1,177,568	14,969	78.7	15	1,181	0.10
2006	1,005,505	14,700	68.4	2	137	0.01
2005	1,476,046	14,825	99.6	1	100	0.01
2004	1,422,100	216,698	6.6	22	145	0.01
2003	1,288,893	240,558	5.4	65	351	0.03

[a]"Expanded" refers to the number of minijacks x the PIT tag ratio.

Adult Return 2015

Columbia River

LNFH-origin spring Chinook Salmon that were PIT tagged as juveniles were first detected returning as adults at PIT tag antenna arrays located at Bonneville Dam. The PIT tag antenna arrays at Bonneville Dam are reported to have a detection efficiency of greater than 90% (Burke et al 2006). For 2015 the 50% passage date occurred on April 28th, four days earlier than the 12- year average of May 2nd (Table 7). Adults took an average of 13 days to travel from Bonneville Dam to Rock Island Dam in 2015, which is four days faster than the five year average of 17days (Figure 4).

Table 7. Passage dates for LNFH-origin spring Chinook Salmon at Bonneville Dam, 2003–2015.

	Passage Dates							
Year	**First**	**1%**	**5%**	**10%**	**50%**	**90%**	**95%**	**Last**
2015	8-Feb	2-Apr	15-Apr	18-Apr	28-Apr	23-May	27-May	27-Aug
2014	1-Jan	9-Apr	17-Apr	21-Apr	2-May	22-May	26-May	9-Aug
2013	13-Feb	8-Apr	22-Apr	25-Apr	3-May	22-May	27-May	4-Aug
2012	25-Jan	20-Apr	23-Apr	25-Apr	9-May	20-May	25-May	8-Jul
2011	26-Jan	19-Apr	26-Apr	28-Apr	6-May	16-May	23-May	9-Jul
2010	3-Jan	8-Apr	14-Apr	16-Apr	29-Apr	16-May	26-May	9-Jul
2009	2-Mar	13-Apr	22-Apr	25-Apr	8-May	24-May	28-May	9-Jul
2008	5-Feb	10-Apr	14-Apr	20-Apr	5-May	19-May	26-May	1-Aug
2007	19-Jan	12-Apr	17-Apr	19-Apr	2-May	21-May	27-May	9-Jul
2006	22-Feb	25-Apr	30-Apr	2-May	10-May	21-May	24-May	3-Jul
2005	27-Feb	16-Apr	21-Apr	23-Apr	4-May	27-May	30-May	19-Jul
2004	10-Feb	6-Apr	13-Apr	15-Apr	24-Apr	20-May	25-May	16-Jul
2003	18-Jan	10-Mar	27-Mar	1-Apr	21-Apr	20-May	26-May	13-Aug
Min	1-Jan	10-Mar	27-Mar	1-Apr	21-Apr	16-May	23-May	3-Jul
Max	2-Mar	25-Apr	30-Apr	2-May	10-May	27-May	30-May	27-Aug
Mean (03-14)	1-Feb	9-Apr	17-Apr	20-Apr	2-May	20-May	26-May	22-Jul

Icicle Creek Basin

The average travel time of LNFH-origin adults from Rock Island Dam to the Lower Icicle Creek instream PIT tag antenna array was six days in 2015. This was 11 days faster than the average for the previous three years (Figure 4). In 2015, an estimated 9,993 spring Chinook Salmon returned to Icicle Creek. In-basin estimates were generated from sport harvest creels, estimated tribal harvest, spawning ground survey estimates, and LNFH fish ladder returns. The 2015 adult return was 157% of the average return for the previous 12 years (Table 8).

Spring Chinook Salmon were subject to 72 days of a mark selective (i.e. adipose clip) sport fishery in the Wenatchee River and Icicle Creek. Washington Department of Fish and Wildlife (WDFW) creel census on both the Wenatchee River and Icicle Creek estimated the sport fishery harvested 647 (214 and 433, respectively) LNFH origin spring Chinook Salmon in 2015. Additionally, Icicle Creek spring Chinook Salmon were subjected to an 85 day tribal harvest. Tribal harvest estimates were calculated using a linear regression of sport harvest to tribal harvest from 1999–2008. Using this methodology, it was estimated the tribal fishery harvested 1,616 fish from Icicle Creek (Table 8).

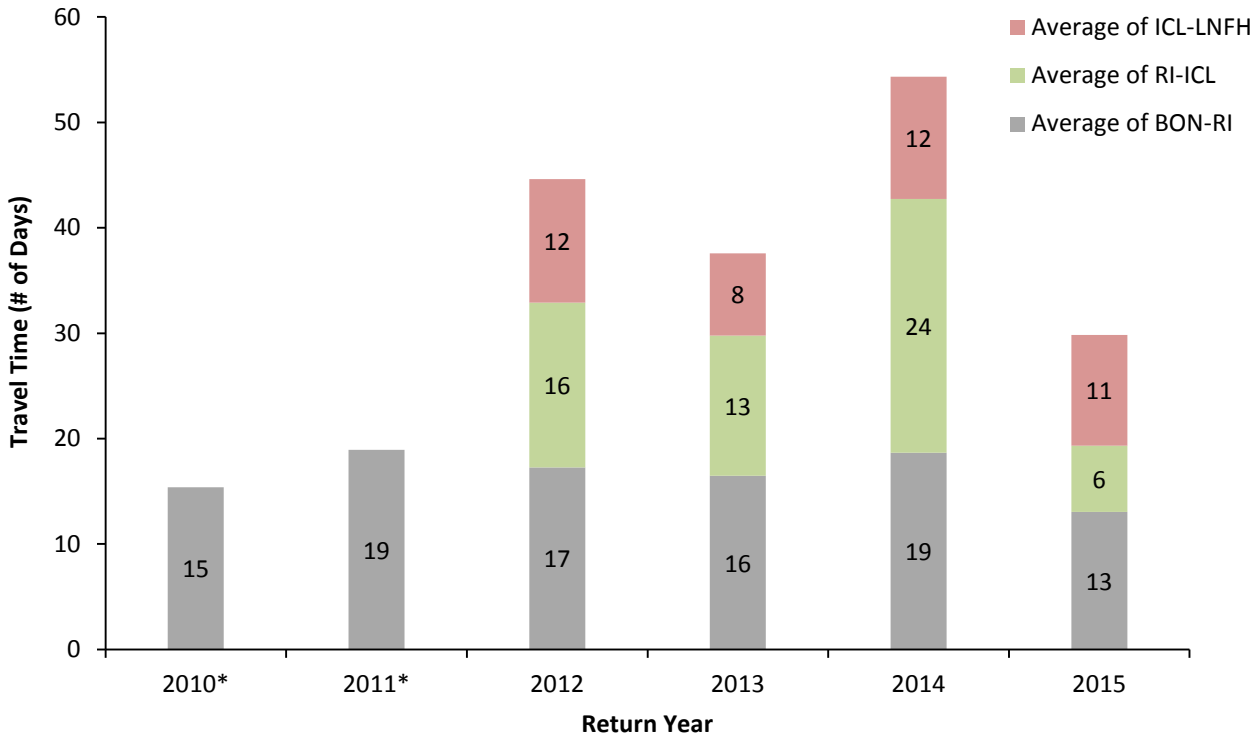

Figure 4. Travel time of adult LNFH-origin spring Chinook Salmon returns from Bonneville to Rock Island Dam (BON -RI), Rock Island Dam to the Lower Icicle array (RI-ICL) and the Lower Icicle Array to LNFH (ICL-LNFH). The average number of days is given for each reach in the data bars. * ICL was installed in 2012.

Fish Ladder Operation

The fish ladder at LNFH was opened on May 7th. The fish ladder was opened and closed intermittently to capture portions of the run, minimize strays, and to maximize catch opportunity by sport and tribal harvest fisheries (Figure 5). During this time, 6,565 spring Chinook Salmon adults ascended the fish ladder and entered the adult holding pond (Table 9). This is 103% of the 12 year average of 6,364 fish. The fish ladder was closed for the season on July 10th.

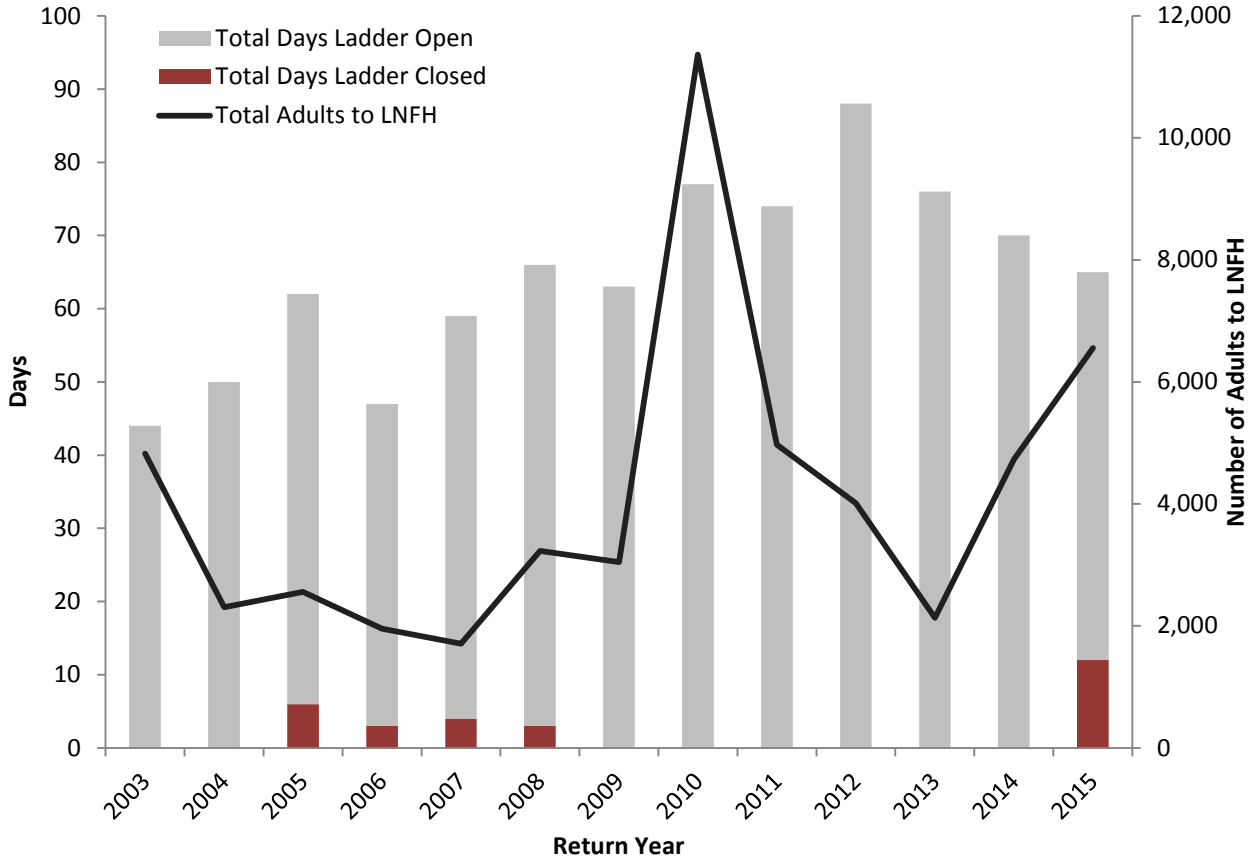

Figure 5. LNFH fish ladder operations and spring Chinook Salmon returns to LNFH adult holding pond.

Table 8. Abundance and fate of LNFH-origin adult spring Chinook Salmon returning to Icicle Creek from 2003-2015.

Return Year	Total Run to Icicle Cr.	Returned to LNFH	Sport Harvest	Tribal [a]	Remaining in River
2015	9,993	6,565	647	1,616	1,165
2014	7,930	4,729	685	1,818	698
2013	3,627	2,082	323	934	288
2012	7,565	4,009	971	2,298	287
2011	7,951	4,970	873	2,091	17
2010	14,871	11,297	993	2,344	237
2009	5,489	3,053	640	1,601	195
2008	4,892	3,226	347	1,036	283
2007	2,622	1,708	115	751	48
2006	2,947	1,757	529	588	73
2005	3,724	2,491	103	1,063	67
2004	3,370	1,946	347	863	214
2003	7,747	4,411	935	1,852	549
Min	2,622	1,708	103	588	17
Max	14,871	11,297	993	2,344	1,165
Mean (03–14)	6,364	4,019	578	1,450	317

[a] Estimated tribal harvest, 2009-present

Tumwater Dam Stray Removal

Within the Wenatchee River basin, nearly all natural spawning of spring Chinook Salmon 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 every spring Chinook Salmon attempting to enter the upper basin spawning grounds. Natural-origin spring Chinook Salmon are released above Tumwater Dam so they can complete their spawning migration and hatchery-origin fish are transferred to Eastbank Hatchery for spawning.

In 2009, LNFH partnered with WDFW to remove potential stray LNFH-origin and other hatchery adults attempting to migrate above Tumwater Dam. If the fish was adipose clipped and did not have a CWT, it was removed from the river, assuming that it likely originated at LNFH. In 2015, 52 presumably LNFH-origin, spring Chinook Salmon were removed at Tumwater Dam, euthanized and discarded. Due to treatment with MS-222 (anesthesia), the removed fish were not excessed for consumption.

Contribution of LNFH-origin spring Chinook Salmon 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. In 2015, there was a single LNFH-origin CWT recovery on the spawning ground, expanded to 20 LNFH-origin fish straying to the upper Wenatchee River (Table 10).

Table 9. Escapement abundance of spring Chinook Salmon to the upper Wenatchee River, sampling rates, and LNFH-origin fish data and expansions 2004–2015.

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]	Percent LNFH-origin in Upper Wenatchee SCS Escapement [g]
2015	1,663	380	22.9	*1*	4	20	1.2
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
2004	1,607	407	29.0	5	17	51	3.2
Min	940	290	9.7	0	0	0	0.0
Max	2,990	828	56.3	5	17	51	3.2
Mean (04–14)	1,905	536	31.0	2	5	13	0.7

[a] From CCPUD M&E report (Hillman et al 2016)
[b] Upper Wenatchee SCS Carcass Recoveries/Upper Wenatchee SCS Escapement
[c] From RMIS
[d] LNCH-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 2009-2015.
[g] LNFH-origin Expanded Recoveries/ Upper Wenatchee SCS Escapement

Age Metrics

In 2015, age composition of spring Chinook Salmon returning to LNFH was 9.1% (n=102) age-3 fish, 85.8% (n=960) age-4, and 5% (n=56) age-5 based on CWT recoveries (Table 10). The age-4 component of this run was above average for the past 16 years, and the age-5 returns were lower than average. In 2015, 31.4% of the returning fish were sampled for sex and length. The sex composition of the 2015 LNFH adult return had a male:female ratio of 0.93:1 (Table 11)

The mean fork lengths for sampled fish returning to LNFH are given in Table 12. Fork lengths for returning adult male spring Chinook Salmon were shorter than the 12- year mean in 2015. All of the mean fork lengths for returning females in 2015 are within the standard deviation of the previous 14 years, with the exception of the one age-3 female sampled, which was larger than the 12-year mean.

Of the adult spring Chinook Salmon that entered the adult holding pond, four non LNFH-origin spring Chinook Salmon CWTs were identified (Table 13).

Table 10. LNFH-origin spring Chinook Salmon age compositions by return year, 2003–2015.

	% MALE AGE				% FEMALE AGE				% COMBINED AGE			
Return Year	2	3	4	5	2	3	4	5	2	3	4	5
2015	0.1	9.0	35.8	2.1	0.0	0.1	50.0	2.9	0.1	9.1	85.8	5.0
2014	1.8	15.5	31.8	0.7	0.0	0.1	48.2	1.9	1.8	15.6	80.0	2.6
2013	3.8	18.2	19.0	9.4	0.0	0.2	35.9	13.5	3.8	18.4	54.9	22.9
2012	0.1	1.4	31.7	4.4	0.0	0.1	56.0	6.3	0.1	1.5	87.7	10.7
2011	0.9	34.8	14.3	11.6	0.0	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	0.0	60.7	0.7	0.0	0.9	97.7	1.4
2009	0.0	24.3	25.2	5.6	0.0	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	0.0	47.5	9.1	0.0	3.3	78.9	17.8
2007	0.0	19.9	16.2	12.4	0.0	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	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	0.0	57.1	3.0	0.0	2.5	91.9	5.6
2004	0.5	9.5	32.6	3.5	0.0	0.1	49.2	4.5	0.5	9.6	81.9	8.0
2003	0.5	3.1	8.2	37.7	0.0	0.0	9.0	41.5	0.5	3.1	17.2	79.2
Min	0.0	0.7	8.2	0.7	0.0	0.0	9.0	0.7	0.0	0.7	17.2	1.4
Max	3.8	34.8	36.9	37.7	0.0	0.2	60.7	41.5	3.8	34.9	97.7	79.2
Mean (03–14)	0.5	9.7	27.5	8.1	0.0	0.1	45.2	8.9	0.5	9.7	72.7	17.1

Table 11. Sex composition of sampled spring Chinook Salmon returning to LNFH, 2006–2015.

Return Year	**% of Return Sampled**	**# Males**	**# Females**	**Male/Female Ratio**
2015	31.4	997	1,062	0.9
2014	45.4	1,067	1,081	1.0
2013	46.0	478	479	1.0
2012	37.3	565	929	0.6
2011	38.2	1,198	700	1.7
2010	14.7	658	1,004	0.7
2009	96.2	1,864	1,073	1.7
2008	98.0	1,380	1,781	0.8
2007	34.3	281	305	0.9
2006	35.3	246	374	0.7
Min	14.7	246	305	0.6
Max	98.0	1,864	1,781	1.7
Mean (06–14)	49.5	860	858	1.0

Table 12. LNFH spring Chinook Salmon mean fork length (cm) by return year, 2003–2015.

	Males			Females		
Return Year	**age-3**	**age-4**	**age-5**	**age-3**	**age-4**	**age-5**
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 (03–14)	51.5	78.0	93.3	62.3	74.0	86.0
St. Dev. (03–14)	1.7	1.4	2.0	5.0	1.3	1.7

[a] *N=1*

Table 13. Fate of non-LNFH-origin fish that entered the LNFH adult holding pond in 2015.

CWT/Origin	# Observed	Age	% Marked	Deposition	Origin	Expanded #
055363[a]	1	4	56%	Surplus	Entiat NFH	2
100240	2	4	99%	Surplus	Clearwater Hatchery	2
190326	1	4	100%	Surplus	Cle Elum Hatchery	1
636094	1	4	99%	Surplus	Chiwawa Hatchery	1
636177	1	4	99%	Surplus	Dryden Pond	1
636553[b]	1	1	97%	Surplus	Chiwawa Hatchery	1

[a] summer Chinook Salmon
[b] summer steelhead

Broodstock

Of the 6,565 spring Chinook Salmon that returned to LNFH in 2015, 4,838 were excessed, 124 died while being held in the adult holding pond (DIP), eight were not usable at spawning due to poor condition, and 947 were spawned (Table 14). This resulted in 84% broodstock utilization, which was below the performance goal of 88% (Table 2).

To minimize pre-spawn mortality of adults, formalin was administered for one hour at 200 ppm three times a week to the adult holding ponds to control fungus and parasites.

In late July, all females are given a single injection of Draxxin to reduce the transmission of Bacterial Kidney Disease (BKD). *Renibacterium salmoninarum* (the causative agent of BKD) can be transmitted horizontally between fish sharing the same water supply (Mitchum and Sherman, 1981) and vertically from infected parents to eggs.

Spawning

In 2015, spring Chinook Salmon spawning occurred on August 18th, August 25th, and September 1st at LNFH. There were 476 (50.3%) females, 448 (47.3%) adult males, and 23 (2.4%) age-3 (males) available at the time of spawning. Of these, 2 females were green/spent/bad, and 6 males were spent. The male:female spawning ratio was 0.9:1, slightly below the performance goal of 1:1. The average fecundity between the three takes was 4,104 eggs (Table 16). The green egg take of 1,953,690 was 12.3% above the performance goal of 1,740,000 (Table 2).

Portions of the returning adults were tested for pathogens, including: Viral Hemorrhagic Septiciemia Virus (VSHV), 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 14. Fate of spring Chinook Salmon that entered the adult holding ponds at LNFH, 2003–2015.

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 Collected	Natural Origin
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
2004	1,946	34	924	987	1	0	0	5	0
2003	4,411	184	3,392	833	2	0	0	1	1
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 (03–14)	3,807	96	2,705	889	28		18	17	0

Virology and ELISA Results

Enzyme-Linked Immunosorbent Assay (ELISA) is used to detect the prevalence of Bacterial Kidney Disease (BKD) from females used in propagation. ELISAs aid in determining the degree of risk for vertical transmission of BKD from mother to progeny. In salmonids, the Olympia Fish Health Center divides risk into six levels, ranging from "No Detection" to "Very High" risk (Table 15). In 2015, over 93.5% 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, "High" and "Very High" risk groups were culled and progeny from the "Moderate" risk females were isolated as much as possible throughout the rearing cycle. On average approximately 19% of the tested spring Chinook Salmon females rank moderate or higher. However, the average has been inflated due to an increase in moderate risk detections from 2010-2014.

Egg Survival

In 2015, 96.9% of the green eggs survived to eye-up, meeting the stage survival target of 90% (Table 16). This percentage does not include the 600,636 culled eggs, of which 127,224 eggs were culled as a result of ELISA testing. In December, the emergent fry were placed in the indoor starter tanks to begin the rearing cycle.

Table 15. Summary of BKD detection from female spring Chinook Salmon at LNFH, 2013–2015.

Year	No Detection (%)	Very Low (%)	Low (%)	Moderate (%)	High (%)	Very High (%)	N
2015	0.0	11.6	81.9	3.4	1.5	1.7	476
2014	0.0	0.0	30.6	42.8	19.4	7.2	572
2013	0.0	0.2	60.3	35.5	2.7	1.2	408
2012	0.0	1.0	77.7	19.6	1.0	0.8	520
2011	0.0	2.2	74.7	19.2	1.7	2.2	463
2010	0.0	0.7	75.9	21.6	1.0	0.7	402
2009	0.0	31.8	64.7	2.1	0.3	1.1	380
2008	0.0	46.7	50.3	0.8	0.2	1.9	473
2007	0.0	26.2	69.0	1.9	0.8	2.1	523
2006	0.0	14.8	74.6	6.8	0.9	2.9	547
2005	0.3	77.7	17.2	1.2	1.2	2.4	337
2004	15.2	74.1	4.3	0.4	1.2	4.9	494
2003	25.3	46.8	7.8	3.1	3.4	13.6	447
Min	0.0	0.0	4.3	0.4	0.2	0.7	337.0
Max	25.3	77.7	77.7	42.8	19.4	13.6	572.0
Mean (03-14)	3.4	26.9	50.6	12.9	2.8	3.4	463.8

Table 16. Eyed egg survival for LNFH spring Chinook Salmon for return years 2006–2015.

Return Year	Fecundity	Green Eggs	Bad Eggs	Culled[a]	Eyed Eggs Kept	% Eyed Survival
2015	4,104	1,953,690[b]	41,400	600,636	1,301,654	96.9
2014	3,960	2,391,794	39,988	1,044,168	1,307,638	96.6
2013	3,909	1,557,224	123,802	260,528	1,172,894	92.2
2012	3,656	1,857,748	58,748	504,000	1,295,000	95.8
2011	3,993	1,809,216	74,257	428,609	1,306,350	92.6
2010	4,111	1,651,881	46,416	385,597	1,219,868	96.4
2009	4,252	1,620,733	25,635	326,349	1,268,749	98.0
2008[c]	3,980	1,949,442	20,910	652,857	1,275,675	98.4
2007	3,546	2,125,339	36,755	377,454	1,711,130	97.9
2006	3,766	1,845,443	68,090	199,388	1,577,965	95.9
Min	3,546	1,557,224	20,910	199,388	1,172,894	92.2
Max	4,252	2,259,815	123,802	937,156	1,711,130	98.4
Mean (06–14)	3,973	1,863,053	53,600	467,257	1,342,196	96.1

[a] Includes ELISA culling
[b] Shipped 10,000 eggs to Pacific Northwest National Laboratory
[c] Beginning in return year 2008, the release number goal was reduced to 1,200,000.

Summary

- The 2015 LNFH release of 1,139,567 spring Chinook Salmon was 95% of the production goal of 1,200,000. This production number was low due to abnormally high egg mortality from the 2013 broodstock.

- Juvenile survival to McNary dam was calculated to be 50%, which was comparable to other spring Chinook Salmon hatcheries in the upper Columbia River basin.

- In 2015 an estimated 9,993 spring Chinook Salmon returned to Icicle Creek. Of which 2,263 (23%) were harvested, 6,565 (65%) were trapped in the adult holding ponds and 1,165 (12%) remained in Icicle Creek.

- Age composition of spring Chinook Salmon returning to LNFH in 2015 was 9.1% (n=102) age-3 fish, 85.8% (n=960) age-4, and 5% (n=56) age-5. Based on CWT recoveries no age-6 fish were detected.

- In 2015, 23 jacks, 442 males, and 474 females were spawned at LNFH. Females used for broodstock had average fecundity of 4,104.

- In 2015, LNFH had a green egg take of 1,953,690. This was 12% above the performance goal of 1,740,000.

- LNFH culled 600,636 eggs and began rearing brood year 2015 with 1,301,654 eyed eggs.

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Appendix A: Release Year 2015 Coded Wire Tag Codes.

Table A1. Release year 2015 coded wire tag codes

Tag Code	N tagged
055491	96,598
055576	49,460
055577	49,510

Appendix B: LNFH Coded Wire Tag Recoveries from Outside-of-Icicle Creek Basin for 2014 and 2015

		Brood Year				
Recovery Year	**Recovery Location**	**2008**	**2009**	**2010**	**2011**	**2012**
2015						
	Columbia River Net			1	24	6
	Columbia River Sport				12	2
	Total	0	0	1	36	8
2014						
	Columbia River Net	1		11	4	
	Columbia River Sport			24	3	
	The Dalles Pool Upper			2		
	Wenatchee River		1	11	2	
	Total	1	1	48	9	0

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