U.S. Fish and Wildlife Service

Leavenworth National Fish Hatchery Annual Report, 2009

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U.S. Fish and Wildlife Service
Mid-Columbia River Fisheries Resource Office
Leavenworth, WA 98826

***On the cover**: Adult spring Chinook salmon sampling at the Leavenworth National Fish Hatchery. USFWS photograph by Matt Cooper.*

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LEAVENWORTH NATIONAL FISH HATCHERY ANNUAL REPORT, 2009.

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Disclaimers

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Executive Summary- The 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 as a *segregated-harvest* program. In Release Year 2009, the LNFH force-released 1,689,038 juvenile spring Chinook salmon into Icicle Creek, exceeding the Performance Goal for Release Number by 5%. The juveniles released were 18.3 fish per pound, which was 7.5% smaller than the Performance Goal for Yearling Size at release. In Return Year 2009, a total of 5,627 LNFH-origin spring Chinook salmon returned, with 1,027 of these fish being intercepted outside of the Icicle Creek basin. Of the 4,600 fish that returned to Icicle Creek, 3,045 were captured at the LNFH. An estimated 640 fish were harvested in the Icicle Creek non-Tribal fishery, and an estimated 868 fish were harvested in the Icicle Creek Tribal fishery. An estimated 47 fish escaped to the Icicle Creek spawning grounds. Brood Year 2002, which is the most recent year with which reasonably complete data is available, had an SAR of 0.26%, which is below the 1995-2001 mean of 0.60%, and continues the trend of lower SARs in recent years.

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Introduction

Location

The 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, WRIA 45, Figure 1). Icicle Creek is a tributary to the Wenatchee River, which flows into the Columbia River, at Wenatchee, Washington. The LNFH is approximately 800 rkm from the Pacific Ocean, and upstream of seven Columbia River hydroelectric dams.

Facilities

The hatchery is situated on approximately 85 hectares of ponderosa pine/pinegrass forest in the central Cascade Mountains (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. The LNFH also has seven wells to provide constant temperature, pathogen free water when needed. The hatchery has water rights to 99,010 L/min of water, though the average flow through the hatchery is 70,410 L/min.

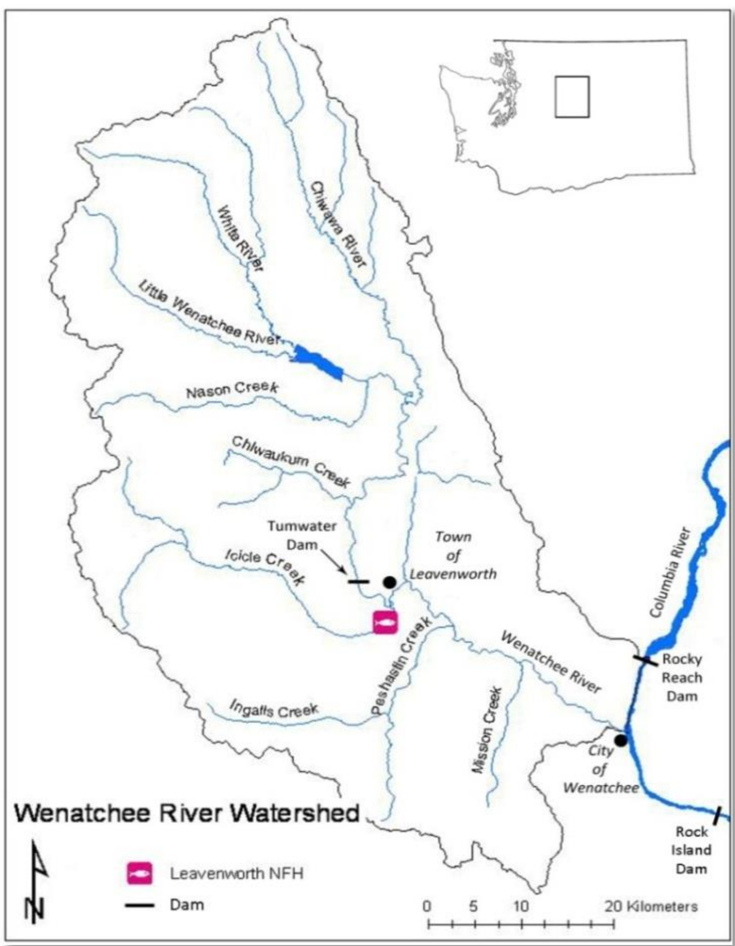

Figure 1. Map of the Wenatchee River watershed.

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

The LNFH has 59 outdoor rectangular raceways and 2 outdoor rectangular adult holding ponds. The hatchery also has 53 Foster-Lucas style ponds that are no longer used for production (Table 1). Indoor facilities include 540 Heath type incubation trays in 36 stacks and 122 starter tanks.

Table 1. LNFH outdoor facilities descriptions.

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 pond	2	15x150	No	Yes	rectangular	adult collection/juvenile rearing
rearing pond	39	small	No	NA	Foster/Lucas	not used
rearing pond	14	large	No	NA	Foster/Lucus	not used

Historic Operations

The LNFH has produced several trout and salmon species since production began in 1940. Species have included spring and summer/fall Chinook salmon (Oncorhynchus tshawytscha), steelhead and rainbow trout (O. mykiss), and sockeye salmon (O. nerka).

Spring Chinook salmon have been the primary species produced since the hatchery was constructed. From 1940-1943, spring Chinook salmon were collected from upriver-bound stocks captured at Rock Island Dam. Some early imports of spring Chinook salmon 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, the LNFH has imported eggs from other Columbia River hatcheries, including Carson, Cowlitz, and Little White Salmon National Fish Hatcheries. Fish and/or eggs have not been imported to the LNFH since 1985.

Current Operations

The LNFH operates a *segregated-harvest* program producing spring Chinook salmon, and aids in the production of coho salmon (*O. kisutch*) for the Yakama Nation coho reintroduction program. The hatchery also has a few rainbow trout on station for educational purposes. Only spring Chinook salmon production will be discussed in this report.

The LNFH has produced spring Chinook salmon annually since 1940, except for brood years 1967 and 1968. The stock utilized by the LNFH is not included in the ESA-listed UCR spring Chinook salmon 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 the LNFH are commonly referred to as "Carson stock", referring to the Carson NFH, where the majority of imported eggs originated. However, considering the number of generations that this stock has been propagated at the LNFH, it is increasingly being referred to as an "Icicle Creek" stock.

Hatchery Evaluation

The Mid-Columbia River Fisheries Resource Office (MCRFRO) conducts monitoring and evaluation of the LNFH spring Chinook salmon program under its Hatchery Evaluation (HE) program. Hatchery Evaluation is responsible for coordinating coded-wire tagging (CWT), adipose fin clipping, and biological sampling of the produced fish.

The Olympia Fish Health Center provides analysis and guidance on all fish health issues. Juvenile health and disease reduction/containment are of concern at any animal culturing facility, and the LNFH works closely with the veterinarians at the Olympia Fish Health Center to ensure the vitality of the program.

Hatchery Evaluation Plan- The Hatchery Evaluation Plan (HEP) is a guiding document for the HE program. It directs HE to utilize: *"monitoring, evaluation, and targeted research to assist the Leavenworth Hatchery Complex in effectively meeting both its mitigation goals and ESA responsibilities"*. The HEP draws from the hatcheries governing documents, outlines objectives and assigns tasks.

Date Sources- Data used in evaluation can come from direct collection, collection by other management agencies, and/or industry-specific databases. Most of the data used in this report are directly collected. When data collected by other management agencies are used, appropriate citations are given. When industry-specific databases are used, appropriate citation is given, however a more detailed explanation is warranted for the three databases most often used:

1) *RMIS*- The Regional Mark Information System (RMIS) is an online database operated by the Pacific States Marine Fisheries Commission and designed to house 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 also submitted. This system allows managers to calculate survival and contribution metrics for the fisheries they are evaluating. More information can be found at www.rmpc.org.

2) *PTAGIS*- The 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 code 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. This 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. This system allows managers to track movement of the tagged fish. More information can be found at www.ptagis.org.
3) *DART*- The 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. It is designed to house the identity and counts of fish passing hydroelectric facilities on the Columbia River and its tributaries. More information can be found at www.cbr.washington.edu/dart/.

At the LNFH, CWT's, adipose fin clipping, and PIT tags are applied by the Columbia River Fisheries Program Offices' Hatchery Marking Team. This team marks fish for all USFWS hatcheries, as well as other hatchery facilities in the region.

Legal Authorities

The LNFH was constructed and operates under the authority of Section II of the Rivers and Harbors Act of August 30, 1935 (49 Stat. 1028) as partial mitigation for the construction of Grand Coulee Dam. 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, through subsequent management agreements, sets production goals for the facility.

Fish culture facilities, biological surveys, and experiments related to the conservation of fisheries resources were authorized in the Mitchell Act of 1938. The US/Canada Pacific Salmon Treaty of 1985 selected the LNFH stock of spring Chinook as an indicator stock for the mid-Columbia River contribution to the mixed-stock US and Canadian ocean fisheries.

Endangered Species Act - The LNFH operates within the requirements of the Endangered Species Act of 1973. Though the stock produced is not listed, Biological Opinions (BiOp) are issued for ESA listed upper Columbia River spring Chinook salmon and steelhead by the National Oceanic and Atmospheric Administrations' National Marine Fisheries Service (NOAA Fisheries), and for bull trout (*Salvilinus confluentus*) by the USFWS. Permits are issued for any incidental "take" of listed species through impacts from LNFH operations and/or production.

Hatchery and Genetics Management Plan - A Hatchery and Genetics Management Plan (HGMP) is a Biological Assessment provided by the LNFH and the MCRFRO to describe the effects of the LNFH on ESA listed species. It contributes to the development of the BiOp's and the subsequent permits that are issued by NOAA Fisheries. The HGMP sets broad Performance Standards that relate to the legal requirements and environmental impacts of the LNFH.

Performance Goals

To accurately monitor and evaluate the spring Chinook salmon program at the LNFH, specific Performance Goals are tracked throughout the year (Tables 2-4). These Performance Goals are derived from the legal authorities, HGMP's, and peer-reviewed literature, and are intended to give a point of comparison between generations and amongst similar hatchery programs. They are divided into three broad categories: Release Year, Adult Return/Broodstock, and Brood Year.

Release Year - Release Year Performance Goals apply to the rearing of juveniles from egg eye-up through smolt release (Table 2). The current Release Year cohort is the progeny from the previous year's Adult Return/Broodstock collection, and is on-station for 1.5 years.

Table 2. LNFH Release Year Performance Goals and Hatchery Evaluation Plan tasks.

Life Stage	Timeframe	Performance Category	End Stage Performance Goal	HEP Task
Fry	Dec.	Fry Ponded	1.7M[1] (or 97%)	2.1
Sub-yearling	May-Nov.	Summer Rearing	1.68M (or 99%)	2.1
Sub-yearling	Nov.	Sub-Yearling Size	22 fpp	2.1
Yearling	Nov.-Apr.	Winter Rearing	1.66M (or 99%)	2.1
Yearling	Apr.	Yearling Size	17 fpp	2.1
Yearling	Entire rearing cycle	Density Index	<0.20	2.1
Yearling	Entire rearing cycle	Flow Index	<0.60	2.1
Smolt	Apr.	Release Number	1.625M	2.1

[1]Release Year 2009 had a release goal of 1.625M.

Adult Return/Broodstock - The Adult Return/Broodstock collection Performance Goals reflect the ability of the 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).

Table 3. LNFH Adult Return/Broodstock Performance Goals and Hatchery Evaluation Plan tasks.

Life Stage	Timeframe	Performance Category	End Stage Performance Goal	HEP Task
Adult	Feb.	Run Forecast	Accurately forecast the adult return to maximize harvest opportunity.	5.1
Adult	Jan.-May	Columbia River Run Timing	Commensurate with run at-large	6.1
Adult	May-Jul.	Adult Ladder Operation	Collect all available LNFH-origin adults. Minimize straying	6.6
Adult	May-Jul.	Stray Rate	<5%	6.6
Adult	May.-Sep.	Broodstock Utilization	>95%	6.2
Adult	Aug.-Sep.	Green Egg take	125% of Release Number. 1.5M[1] for RY 2011.	2.1
Eggs	Oct.	Eyed Eggs	106% of Release Number (after ELISA culling). 1.275M for RY 2011 (or 96%).	2.1

[1]The release goal for 2011, for which these eggs are taken, is 1.2M.

Brood Year- Brood Year Performance Goals apply to adult fish, assessing survival and contribution to harvest (Table 4). 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 4. LNFH Brood Year Performance Goals and Hatchery Evaluation Plan tasks.

Life Stage	Timeframe	Performance Catagory	End Stage Performance Goal	HEP Task
Adult	7 years post Brood Year	Smolt to Adult Return (SAR)	Maximize	4.1
Adult	7 years post Brood Year	Return Composition	Minimize 3YO component	4.2
Adult	7 years post Brood Year	Harvest Contribution	Maximize Harvest	4.3

Environmental Conditions

In 2009, central Washington experienced a cool spring followed by a hot summer (Figure 3). This pattern allowed the snowpack to linger well into the summer. The summer high air temperature 7-Day Average Daily maximum (7DADmax) of 41.1C^{o} was higher than in most recent years (Figure 4). Icicle Creek discharge was more condensed than average, with low flow conditions persisting through the spring, followed by a shortened burst of higher than average flows (Figure 5).

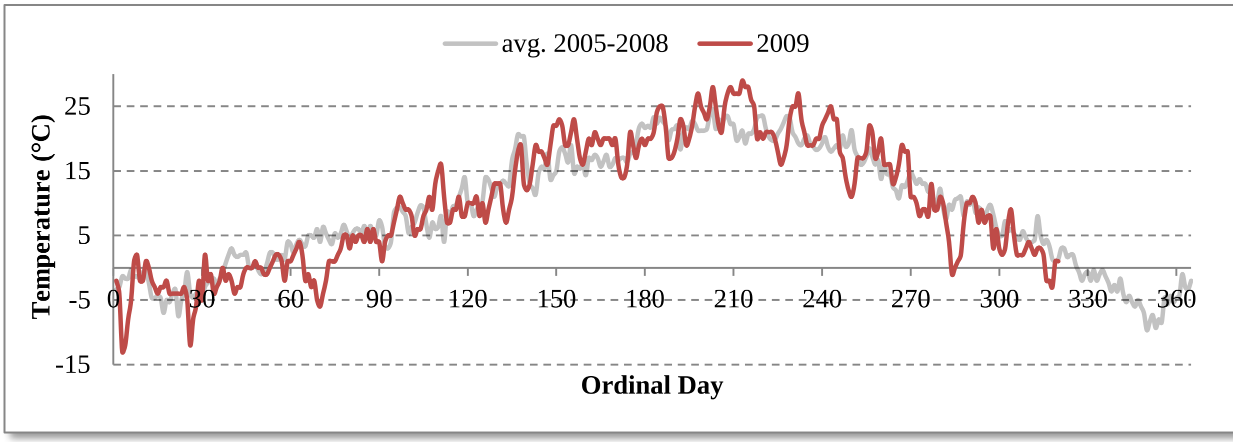

Figure 3. Air temperature as recorded at the MCRFRO.

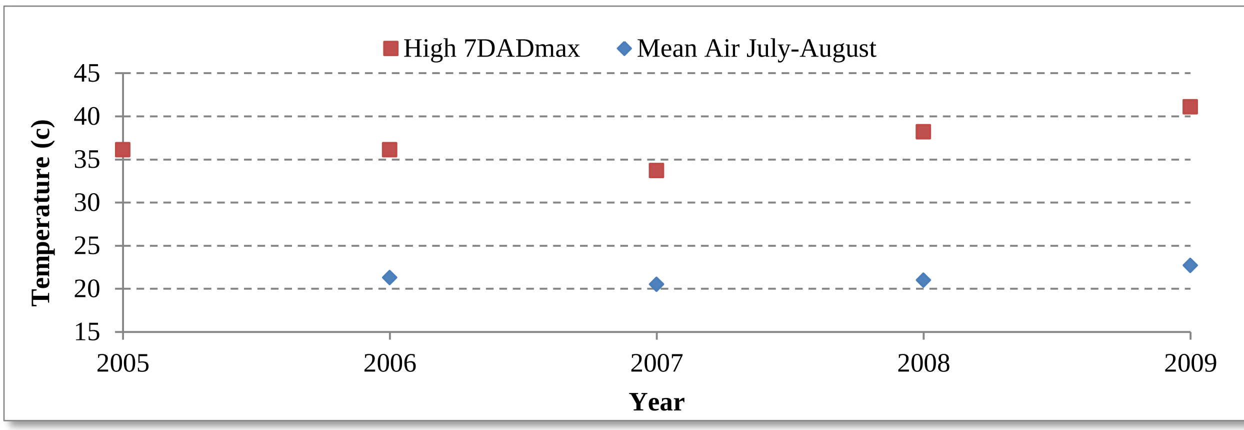

Figure 4. Mean summer air temperature and high 7DADmax of air temperature, as recorded at the MCRFRO. Note: 2005 has no Mean value.

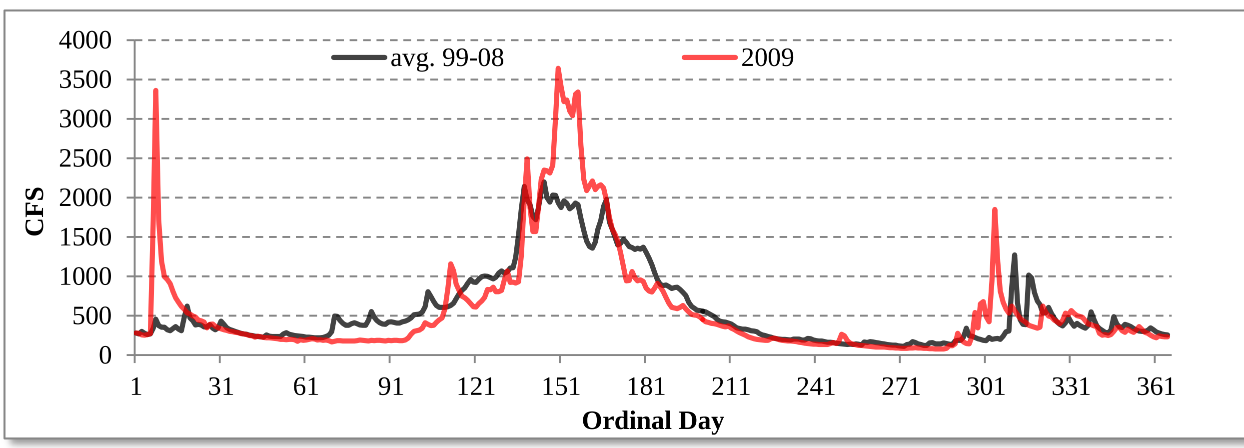

Figure 5. Icicle Creek discharge.

Release Year 2009

The ongoing negotiations within *US vs. Oregon* Management Agreement set the LNFH spring Chinook salmon smolt Release Number Performance Goal for Release Year 2009 at 1.6 million. This is the lowest release goal in the modern history of the hatchery, and represents the theory that improved rearing and release practices will return the same number of adult fish from a lower release number.

Juvenile Rearing

Spring Chinook salmon smolts released in Release Year 2009 were derived from eggs taken in Brood Year 2007. Juvenile rearing of these fish began in February of 2008, when 1,701,942 fry were ponded in 30 of the 8x80 raceways at approximately 55,000 fish per raceway. This was 101% of the Performance Goal of 1.7M. In May of 2008, the fish were 100% adipose clipped and 196,529 were given a CWT (Table 5, Appendix A). During marking, inventory was taken and the exact numbers of fish per raceway were determined. The fish were split into 30-8x80 and 14-10x100 raceways.

During the rearing cycle, the density of fish per rearing vessel, and the flow of water through the rearing vessel are monitored. Reduced densities and increased flow are desirable as a disease risk reduction strategy, however this has to be balanced against rearing space and water availability. 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:

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

For the Release Year 2009 rearing cycle, the mean monthly DI was 0.14. The DI Performance Goal of 0.20 was exceeded during the early ponding months of January and February, however shortly thereafter the fish were split into more ponds, and the DI remained below the Performance Goal until release.

For the Release Year 2009 rearing cycle, the mean monthly FI was 0.57. The FI Performance Goal of 0.60 was exceeded 9 out of the 17 rearing months.

In October of 2008, 14,931 fish were PIT tagged as part of the Fish Passage Centers' smolt monitoring program (Table 6). Opportunistic shed tag recoveries and mortalities were removed from the tag files during rearing, however total tag loss due to sheds and predation is difficult to ascertain.

At the time of PIT tagging, the fish were 33 fpp, approximately 30% smaller than the Performance Goal of 22 fpp. It is unknown as to why these fish were smaller at this time, however this condition continued throughout the rearing cycle and release. Shortly after, fish from 30 of the 8x80 raceways were moved into the adult holding ponds to complete their rearing.

Table 5. Juvenile rearing metrics for Release Year 2009.

Month	N	Size (FPP)	Mort (%)[1]	Temp (F)	DI	FI	Conv[2]	Comments
Dec.-07	1,705,068	734.6	0.36	48	0.14	0.5	0.35	Ponded into 30 8x80's at approx. 55k each
Jan.-08	1,701,942	399.7	0.18	48	0.21	0.57	0.67	
Feb.-08	1,700,428	215.4	0.09	46	0.31	0.73	0.60	
Mar.-08	1,699,421	158.3	0.06	44	0.12	0.63	0.64	
Apr.-08	1,699,085	121.5	0.02	45	0.14	0.75	0.74	
May-08	1,714,058[3]	99.0	0.04	42	0.07	0.33	0.77	Tagged with CWT and adipose-fin clipped. Split into 45 8x80's and 14 10x100's
Jun.-08	1,713,090	78.2	0.06	49	0.09	0.38	0.84	
Jul.-08	1,712,368	55.8	0.04	53	0.12	0.42	0.87	
Aug.-08	1,708,697	41.0	0.21	56	0.09	0.55	0.89	
Sep.-08	1,700,119	32.9	0.50	51	0.10	0.63	0.91	
Oct.-08	1,695,463	32.8	0.27	39	0.10	0.65	1.00	15k PIT tagged and 30 8x80's moved to the 2 adult ponds
Nov.-08	1,693,334	32.7	0.13	38	0.10	0.62	1.09	
Dec.-08	1,692,675	32.1	0.04	34	0.10	0.62	1.11	
Jan.-09	1,692,157	31.4	0.03	35	0.16	0.54	1.11	
Feb.-09	1,691,489	26.0	0.04	35	0.18	0.62	0.96	
Mar.-09	1,690,256	22.6	0.07	37	0.20	0.68	0.91	
Apr.-09	1,689,038	18.3	0.07	41			0.88	Force released

[1]Includes monthly picking. Does not include predation.
[2]Conversion is the pounds of feed/pounds gained.
[3]N is corrected by automated counting at time of marking.

Table 6. LNFH Release Year metrics, 1999-2009.

Release Year	Date Released	Total Released	# CWT	% CWT	% Adipose Clip	# PIT	PIT Ratio Non-Tag/Tag
2009	Apr. 28	1,685,038	196,529	12%	100%	14,931	112.9
2008	Apr. 28	1,539,668	389,100	26%	100%	15,968	96.4
2007	Apr. 18	1,177,568	547,049	46%	100%	14,969	78.7
2006	Apr. 17	1,005,505	470,174	47%	100%	14,700	68.4
2005	Apr. 15	1,476,046	782,602	53%	100%	14,825	99.6
2004	Apr. 19	1,422,100	822,022	58%	100%	216,698	6.6
2003	Apr. 21	1,288,893	771,756	60%	100%	240,558	5.4
2002	Apr. 22	1,554,362	444,493	29%	100%	317,278	4.9
2001	Apr. 17	1,630,089	242,732	15%	15%	7,592	214.7
2000	Apr. 18	1,680,904	193,411	12%	12%	7,387	227.5
1999	Apr. 19	1,636,402	187,841	11%	12%	7,404	221.0

Release

On April 28, 2009, 1,685,038 spring Chinook salmon smolts were force released into Icicle Creek at 18.3 fpp. This was 105% of the Performance Goal for Release Number, however the fish were 7.5% smaller than the Performance Goal for Yearling Size at release, continuing the condition seen earlier in the rearing cycle. This release date was one of the latest in recent years due to delayed mountain snow pack and run-off (Table 7).

Smolt Outmigration

Survival and travel time of outmigrating smolts produced at the 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. It also has the benefit of being upstream of other hydroelectric projects with juvenile monitoring facilities, allowing mark-recapture methodologies to derive survival estimates.

For the 2009 smolt release, the average travel time to McNary Dam was 25.7 days (Table 7). This is slightly less than average, and may have reflected the condensed and higher than average regional run-off. The survival of this cohort to McNary Dam was estimated at 48.1%. This is lower than in recent years, however other comparable spring Chinook salmon programs also had lower survival in 2009, suggesting an extra-hatchery effect (Figure 6). Survival and travel time data is provided by the Fish Passage Center using the PIT tagged fish as representatives of the population.

Table 7. LNFH smolt out-migration metrics, 1999-2009.

Release Date	Release Year	McNary Dam Mean Travel Time (Days)	10% Passage Date	50% Passage Date	90% Passage Date	McNary Survival	Confidence Limits (95%)	
Apr. 28	2009	25.7	May 16	May 24	Jun. 1	48.1%	44.2%	52.1%
Apr. 28	2008	21.1	May 13	May 19	May 27	57.8%	53.3%	62.2%
Apr. 18	2007	30.8	May 7	May 19	May 31	59.2%	56.9%	61.5%
Apr. 17	2006	22.9	May 11	May 16	May 21	55.8%	53.1%	58.6%
Apr. 15	2005	31.8	May 5	May 15	Jun. 3	52.6%	50.0%	55.3%
Apr. 19	2004	25.3	May 3	May 14	May 27	48.3%	47.3%	49.4%
Apr. 21	2003	28.2	May 7	May 19	May 31	66.2%	65.5%	66.9%
Apr. 22	2002[1]	26.3	May 11	May 20	May 28	56.0%	55.3%	56.7%
Apr. 17	2001	36.3	May 15	May 24	May 31	50.1%	48.4%	51.7%
Apr. 18	2000	35.6	May 12	May 23	Jun. 3	59.3%	52.0%	66.7%
Apr. 19	1999	27.3	May 7	May 17	May 25	58.6%	55.0%	62.2%

[1]An additional release occurred on Apr. 24.

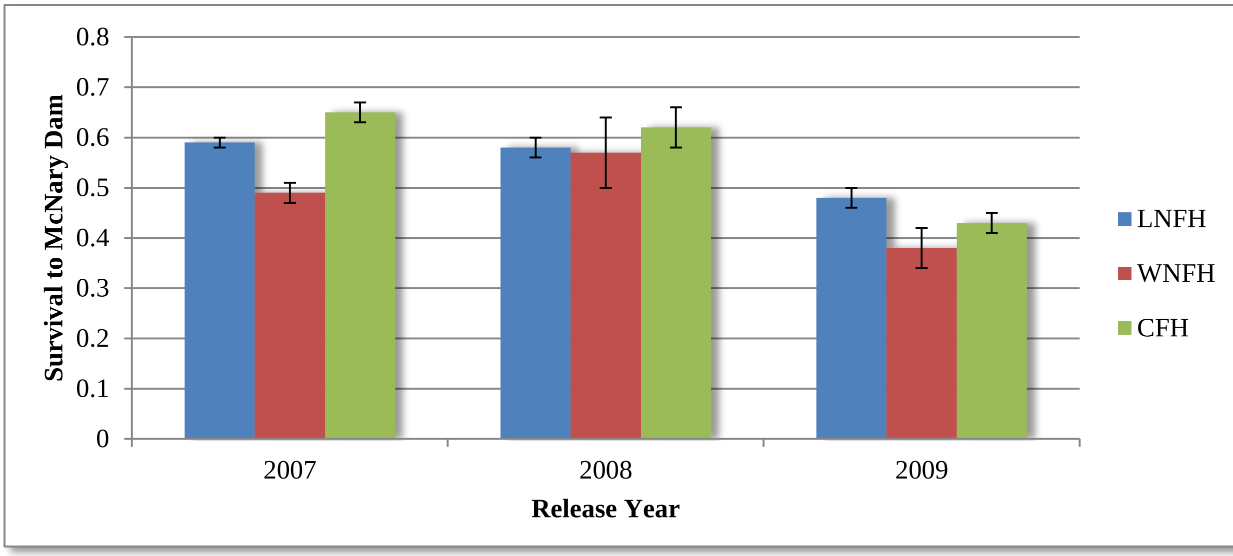

Figure 6. Upper Columbia River smolt survival comparing the LNFH with the Winthrop National Fish Hatchery (WNFH) and the Chiwawa Fish Hatchery (CFH), 2007-2009.

Early Maturation

Spring Chinook salmon most commonly mature in the ocean (after outmigration) as 3YO's (years old) 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. These fish mature as 2YO or younger, and are almost always males. They are colloquially known as "precocial parr" or "minijacks". In a hatchery, these fish may mature prior to release and residualize at the point of release, or they may initiate out migration only to reverse course and migrate upstream and attempt to spawn (Mullen et al. 1992, Beckman and Larsen 2005).

Minijacks are of interest to the LNFH because they represent hatchery effort that results in non-harvestable fish. They may also pose a risk of straying and spawning with natural origin populations, as minijacks are too small to be trapped effectively at the LNFH adult ladder.

Beckman and Larsen (2005) suggest estimating the occurrence of minijacks by monitoring PIT tagged juvenile upstream migration (via PIT detections at dams) during the year of their intended outmigration. They suggest that after June 1, those fish remaining in the middle and upper Columbia River hydrosystem could be considered minijacks. Using this method, in 2009 there were 21 PIT tagged fish that were detected at dams after June 1 and/or displayed upstream migration through dams. Of the fish that showed upstream migration, all were first detected moving upstream at Priest Rapids Dam (mean date July 5), and all were subsequently detected at the next upstream dam (Rock Island, mean date July 17). Of these fish, 3 returned to the LNFH adult ladder (mean date August 15), and 1 passed over Rocky Reach Dam (August 27), further upstream (Table 8). The rate of early maturation for LNFH-origin fish is >1% for the Release Years 2003-2009, 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 (Table 9).

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). The 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 8. Suggested instances of early maturation of juveniles (minijacks) released from the LNFH in 2009.

PIT code	Bonneville	Priest Rapids	Rock Island	Rocky Reach	LNFH
3D9.1C2CD461C3	6/28				
3D9.1C2CAAED4A	6/29				
3D9.1C2CAAF300	7/1				
3D9.1C2CAB0E7D	7/3				
3D9.1C2CABCB50	7/10				
3D9.1C2CD48787	7/15				
3D9.1C2CD47C0C	7/18				
3D9.1C2CAAE8FD		6/30	8/6		
3D9.1C2CAAE9B8		6/28	8/24	8/27	
3D9.1C2CAAF86B		7/23	8/3		
3D9.1C2CAB15D3		7/8	8/12		
3D9.1C2CAC1F66		7/2	8/8		
3D9.1C2CD4759F		7/7	8/10		8/18
3D9.1C2CD47B3E		7/13	8/22		
3D9.1C2CD47C22		7/2	8/12		
3D9.1C2CD48473		7/1	8/6		
3D9.1C2CD4AC13		7/1	8/7		8/13
3D9.1C2CDDA45D		7/7	8/10		
3D9.1C2CDDE8A5		7/2	8/10		
3D9.1C2CDF77C2		7/1	8/11		
3D9.1C2CDF7DCE		7/5	8/9		8/14

Table 9. Rate of early maturation (minijacks) of LNFH-origin fish by Release Year, 2003-2009.

Release Year	Release Number	# PIT	PIT Ratio Non-Tag/Tag	Observed Minijacks	Expanded Minijacks[1]	Minijack Rate (%)
2009	1,685,038	15,000	112.9	21	2,371	0.14
2008	1,539,668	16,000	96.4	36	3,470	0.22
2007	1,177,568	15,000	78.7	15	1,181	0.10
2006	1,005,505	15,000	68.4	2	137	0.01
2005	1,476,046	15,000	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

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

Adult Return/Broodstock 2009

Run Forecast

Accurate run forecasts allow harvest managers to maximize the harvest of LNFH-origin spring Chinook salmon. Multiple models are used, each with their own inputs and assumptions. These models can be characterized into two general types: Predictive linear regressions and survival estimates by age class (Appendix B). The mean of all the models is used as the final forecast.

In 2009, 4,980 adult spring Chinook salmon were forecasted to return to Icicle Creek. Because the LNFH needs approximately 1,000 adult fish for production, this forecast estimated that 3,980 fish are available for a Tribal and non-Tribal harvest of spring Chinook salmon in Icicle Creek. This forecast over-predicted the actual adult return by 8% (Table 10).

Table 10. Forecasted adult returns to Icicle Creek, 2002-2009.

Return Year	Actual	Forecast	% of Actual
2009	4,600	4,980	108
2008	4,782	5,897	123
2007	2,600	3,191	123
2006	3,151	3,836	122
2005	3,726	7,646	205
2004	3,571	11,459	321
2003	7,635	8,726	114
2002	11,831	12,651	107

Adult Return

Columbia River- A subset of returning LNFH-origin adults are PIT tagged as juveniles, and, as returning adults, these fish can first be accounted for via interrogation at Bonneville Dam. The adult fish ladders are wired with PIT tag interrogation antennas with a reported >90% efficiency (Burke et al 2006). The 2009 LNFH-origin adult return over Bonneville was estimated utilizing the PIT tag detections of adults, and expanded by age class to account for differences in annual tagging rates.

The mean 50% passage date for LNFH adults to Bonneville Dam for return years 2004-2008 is May 2. For 2009 the 50% passage date occurred on May 7, five days later than the average (Figure 7).

By age class, in 2009, 50% of the 5YO's passed Bonneville on May 2, 4YO's on May 3, and 3YO's on May 14. This reflects the typical oldest-to-youngest return pattern of Columbia River entry by spring Chinook salmon.

The 50% passage dates for LNFH spring Chinook salmon over Bonneville, McNary, and Rock Island Dams from 2004-2009 are given in Figure 8.

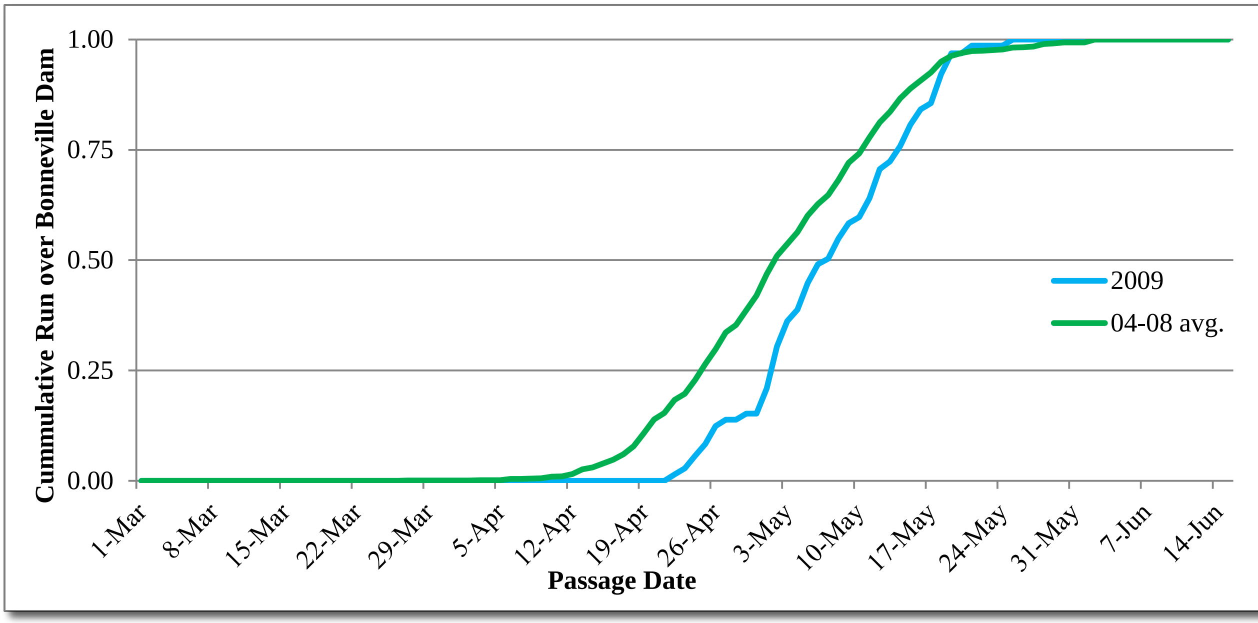

Figure 7. LNFH-origin adult return timing over Bonneville Dam, based on PIT tags.

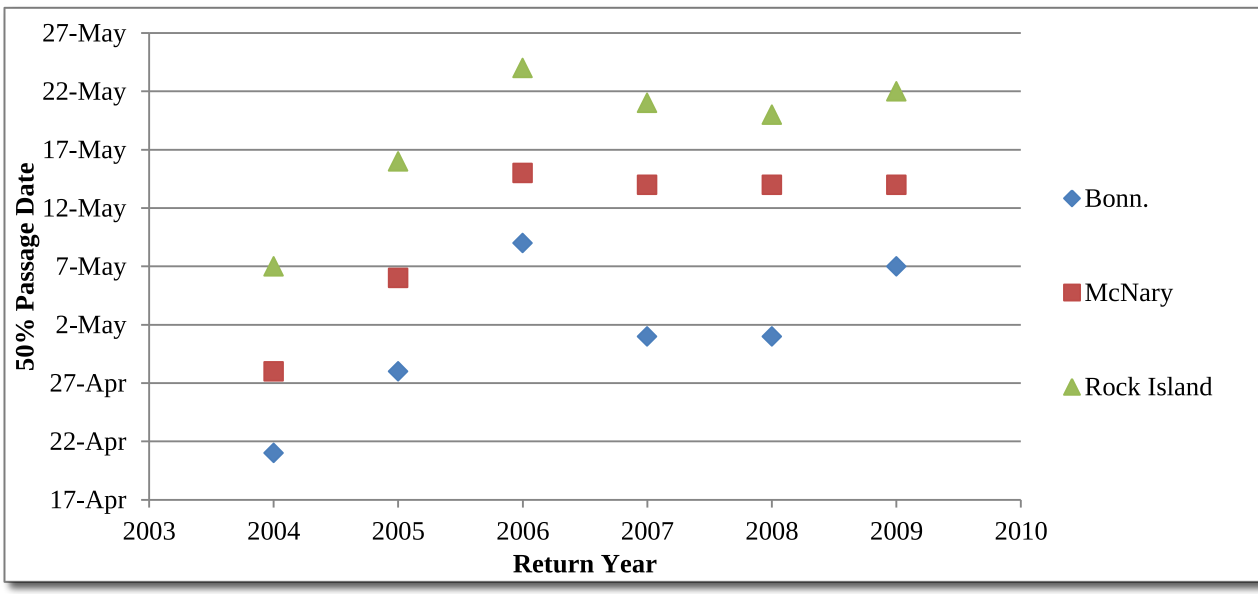

Figure 8. LNFH-origin adult returns 50% passage dates for selected dams.

Estimated Total- In 2009, an estimated 5,627 LNFH-origin spring Chinook salmon "returned", meeting all of the following conditions: 1) Were harvested, returned to a hatchery, or were found on a spawning ground, 2) Were 3YO (Years Old) or greater (Figure 9, Table 11, Appendix C). Adults recovered from outside of the Icicle Creek basin were determined from CWT recoveries, and recoveries from the Peshastin Creek basin in Return Years 2001-2004 were not included, as these were intentional outplants. Icicle Creek in-basin estimates were generated from Tribal and non-Tribal harvest creels, spawning ground survey estimates, and LNFH adult ladder returns. This total estimated adult return for 2009 was 71% of the average for the previous 10 years (7,953 fish, range = 2,103 to 18,915).

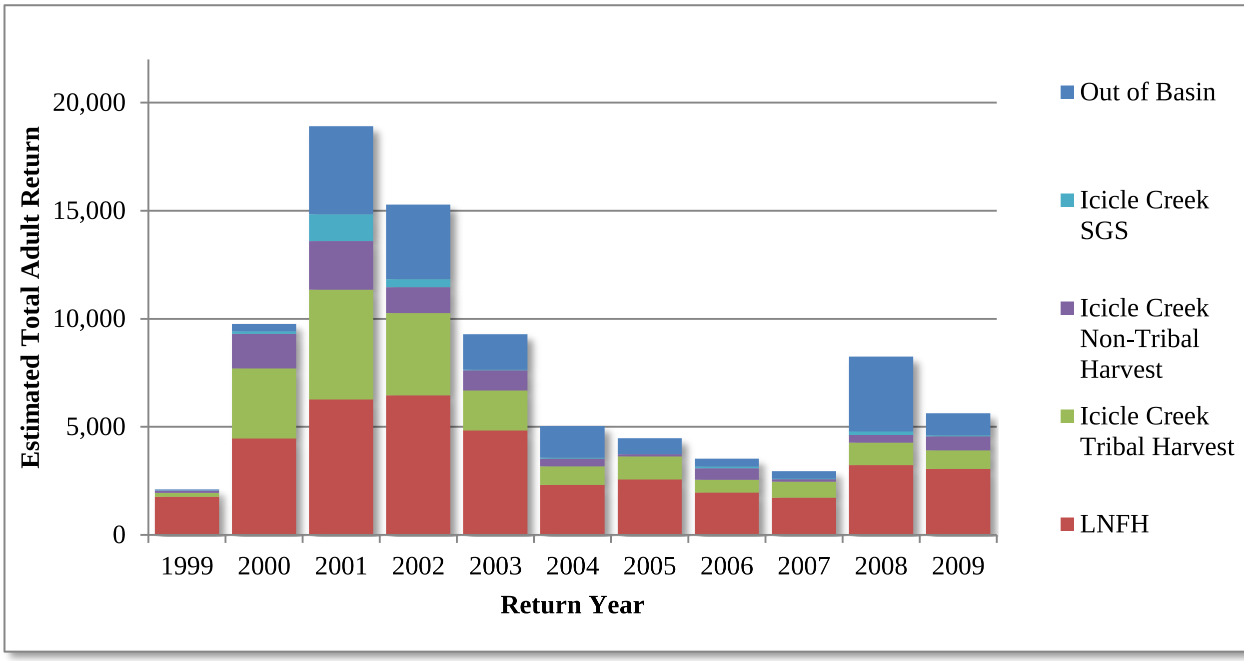

Figure 9. Final deposition of LNFH-origin estimated total adult returns. Note: "SGS" = spawning ground surveys within Icicle Creek basin. In 2001, 1,090 spring Chinook salmon were intentionally left in Icicle Creek. "Out of Basin" estimates include all expanded CWT recoveries outside of the Icicle Creek basin.

Table 11. Final deposition of LNFH-origin estimated total adult returns.

Return Year	Total Return	LNFH	Icicle Creek Tribal Harvest	Icicle Creek non-Tribal Harvest	Icicle Creek Spawning Ground Survey	Out of Basin[2]
2009	5,627	3,045	868	640	47	1,027
2008	8,242	3,229	1,036	347	170	3,460
2007	2,950	1,708	751	115	26	350
2006	3,517	1,957	588	529	77	366
2005	4,465	2,560	1,063	103	0	739
2004	5,026	2,307	863	347	54	1,455
2003	9,287	4,825	1,852	935	23	1,652
2002	15,275	6,459	3,796	1,201	375	3,444
2001	18,915	6,260	5,075	2,260	1240[1]	4,080
2000	9,753	4,457	3,238	1,606	116	336
1999	2,103	1,763	175	108	7	50

[1] 1,090 of these fish were intentionally left in Icicle Creek.

[2] Includes all estimates outside of the Icicle Creek basin.

Icicle Creek Basin- In 2009, 4,600 adult spring Chinook salmon returned to Icicle Creek (Figure 10). This is 72% of the average return for the previous 10 years (6,360 fish, range = 2,053 to 14,835). This return was composed of 3,045 (66.1%) returning to the hatchery, 1,508 (32.7%) harvested in non-Tribal (640) and Tribal (868) fisheries, and 47 (1.2%) remaining in Icicle Creek.

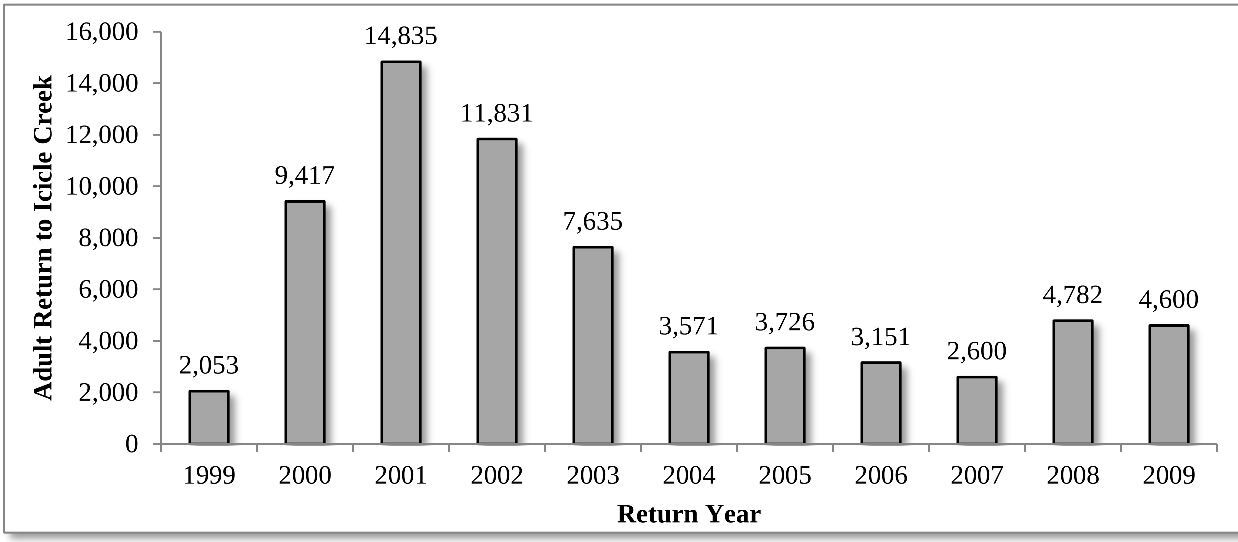

Figure 10. Estimated LNFH-origin adult returns to Icicle Creek.

Harvest- Icicle Creek spring Chinook salmon were subject to a 71 day non-selective harvest by non-Tribal anglers in 2009. This fishery harvested an estimated 640 fish. Additionally, Icicle Creek spring Chinook salmon were subject to a 85 day non-selective Tribal harvest of 868 fish (Figure 11).

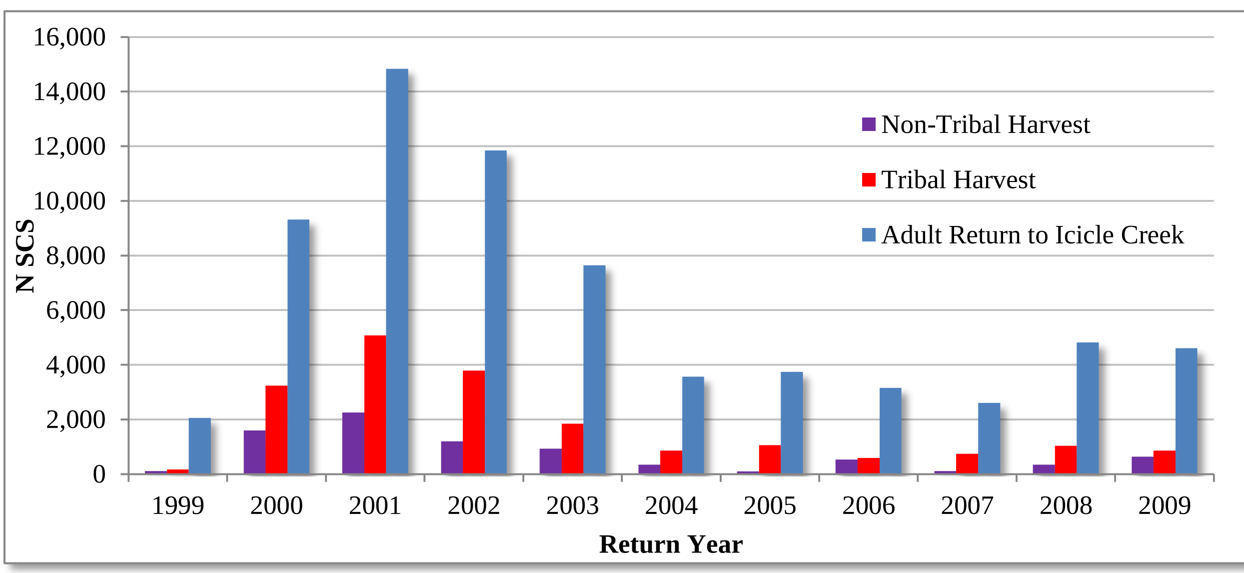

Figure 11. Tribal and non-Tribal harvest of LNFH-origin spring Chinook salmon within Icicle Creek.

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. While the structure is not used for power production, the Washington Department of Fish and Wildlife (WDFW) uses it as a collection point for every spring Chinook attempting to enter the upper basin spawning grounds. The WDFW also operates an integrated spring Chinook hatchery above Tumwater Dam on the Chiwawa River (Chiwawa Fish Hatchery, CFH), with the goal of supplementing the ESA listed stock. The WDFW adipose-fin clips and CWT's 100% of the fish produced at the Chiwawa facility.

In 2009, the LNFH partnered with WDFW to remove stray LNFH-origin adults attempting to migrate above Tumwater Dam. The majority of the return of LNFH-origin adults (the 4YO age class) would be adipose clipped and 50% would have received a CWT. If a fish was collected at Tumwater Dam with an adipose clip and a CWT, the fish was passed upstream with the assumption that it was part of the CFH program. If the fish was adipose clipped and did not have a CWT, it was removed from the river, assuming that it likely originated at the LNFH. All adipose present fish were passed upstream. This agreement would reduce the LNFH spring Chinook stray rate into the upper basin spawning grounds by 50% verses not removing adipose clipped fish without a CWT.

In 2009, 21 females and 41 males were removed from Tumwater Dam and transferred to the LNFH (Table 12). Of these, 7 actually did have a CWT, and of these, 5 were of CFH origin.

Table 12. Tumwater Dam stray removal, 2009.

Return Year	Number Removed
2009	62

Because of treatment with MS-222 (anesthesia), the removed fish were not excessed for consumption. In 2009, the carcasses were donated to the Yakama Nation for a carcass outplanting/nutrient enhancement program.

The 2009 adult return is the final year that the 50% of the 4YO fish would have received a CWT. Future adult returns will have a lower percentage of fish with a CWT, resulting in a further reduction in potential straying into the upper basin spawning grounds.

Straying by Return Year- The straying of spring Chinook salmon produced at the LNFH is much more likely influenced by hatchery and in-stream structure operations during the Return Year of the adults than from conditions experienced by the juveniles during rearing. Juveniles are reared on-station with consistent and distinct water sources, with no off-site acclimation, transfers, trucking, or barging. However, during their return, adults may encounter intense harvest pressure, closed or pulsed ladders, and weir entrapment (and subsequent labeling as a stray) in places where they may not have intended to spawn.

Return Year 2009 had an estimated stray rate of 1.28% (Figure 12). This rate is an estimate of all LNFH-origin fish that were not captured at the LNFH or in a harvest fishery, and based on CWT recoveries for all strays except Icicle Creek spawning ground surveys, which used total estimated escapement. This rate does not include CWT recoveries from LNFH-origin fish outplanted into the Peshastin Creek basin from 2001-2004. This stray rate is below the mean of 2.64% (SD=1.21) observed for the previous 10 years.

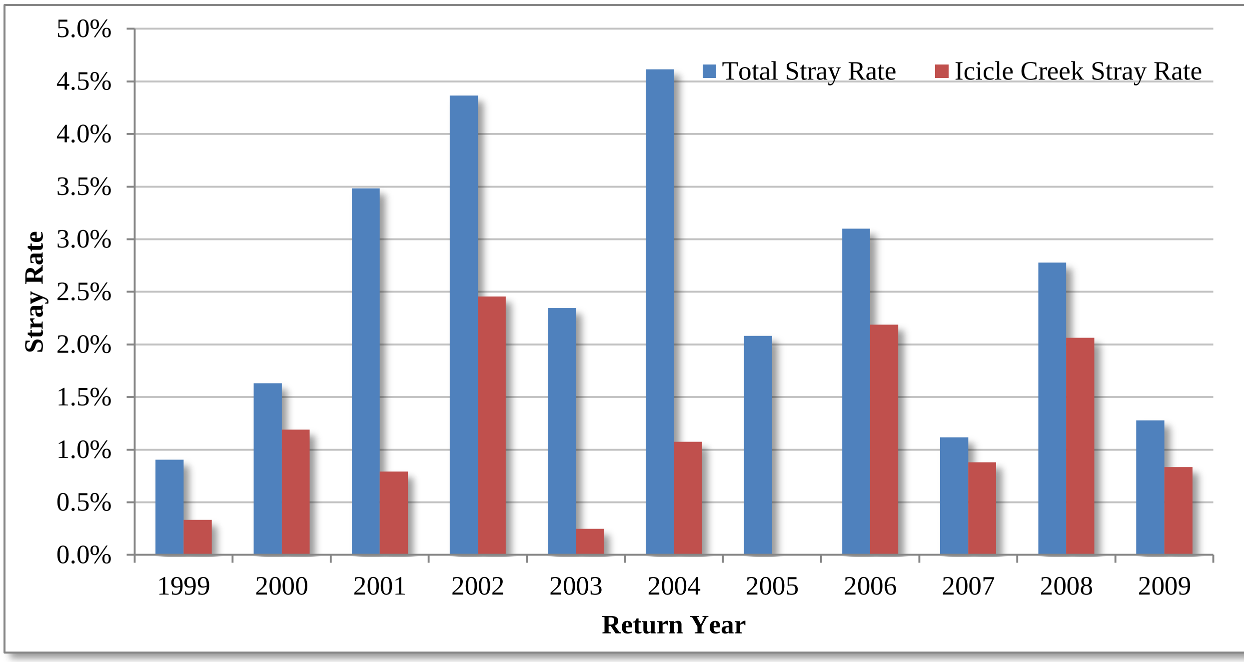

Figure 12. Rate of straying of LNFH-origin fish. Strays include all adults not captured at the LNFH or in a harvest fishery. Does not include the 1,090 fish intentionally left in Icicle Creek in 2001.

In 2009, 65.3% of the straying of LNFH-origin spring Chinook salmon occurred within Icicle Creek, where fish attempted to spawn in the creek rather than ascend (or were kept from ascending) the LNFH adult ladder (Table 13). This is above the average of 44.4% for the previous 10 years.

Table 13. Composition of LNFH-origin strays.

Return Year	Total Returns	Total Strays	Icicle Creek SGS[1]		Wenatchee River SGS		Other SGS		Other Hatcheries[3]	
2009	5,627	72	47	65.3%	14	19.4%	7	9.7%	4	5.6%
2008	8,242	229	170	74.2%	34	14.8%	9	3.9%	16	7.0%
2007	2,950	33	26	78.8%	0	0.0%	0	0.0%	7	21.2%
2006	3,517	109	77	70.6%	0	0.0%	22	20.2%	10	9.2%
2005	4,465	93	0	0.0%	4	4.3%	19	20.4%	70	75.3%
2004	5,026	232	54	23.3%	59	25.4%	48	20.7%	71	30.6%
2003	9,287	218	23	10.6%	174	79.8%	0	0.0%	21	9.6%
2002	15,275	667	375	56.2%	283	42.4%	0	0.0%	9	1.3%
2001	18,915	659	150[2]	22.8%	501	76.0%	0	0.0%	8	1.2%
2000	9,753	159	116	73.0%	3	1.9%	0	0.0%	40	25.2%
1999	2,103	20	7	35.0%	0	0.0%	0	0.0%	13	65.0%
Mean (99-08)	**7,742**	**226**	**95**	**46.3%**	**97**	**24.0%**	**10**	**6.8%**	**24**	**22.8%**
St. Dev. (99-08)	**5,324**	**228**	**109**	**28.7%**	**162**	**29.8%**	**15**	**9.2%**	**25**	**25.4%**

[1] Icicle Creek strays are based on spawning ground survey escapement estimates.
[2] Does not include 1,090 fish that were intentionally left in Icicle Creek.
[3] Includes expanded CWT recoveries at all other hatcheries and spawning grounds.

LNFH Adult Ladder- The LNFH opened the adult ladder on May 18, 2009 and operated it until July 22. During this time, 3,045 spring Chinook salmon adults entered the adult pond (Figure 13). This is 86% of the 10 year average of 3,552 fish. The LNFH adult ladder is equipped with a PIT interrogation antenna, and based on PIT detections, the mean adult entry time for 2009 was June 15, 9 days earlier than the average of 2006 and 2008 (June 24, Figure 14). The average travel time of LNFH-origin adults from Rock Island Dam to the LNFH was 22.5 days in 2009.

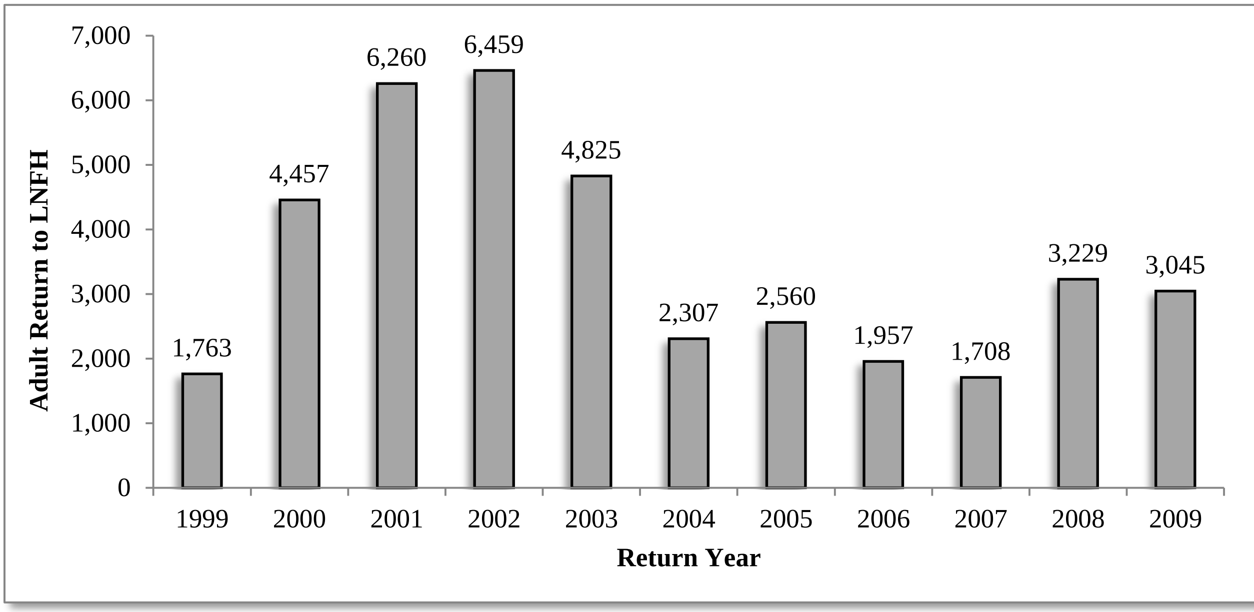

Figure 13. Adult returns to the LNFH adult pond.

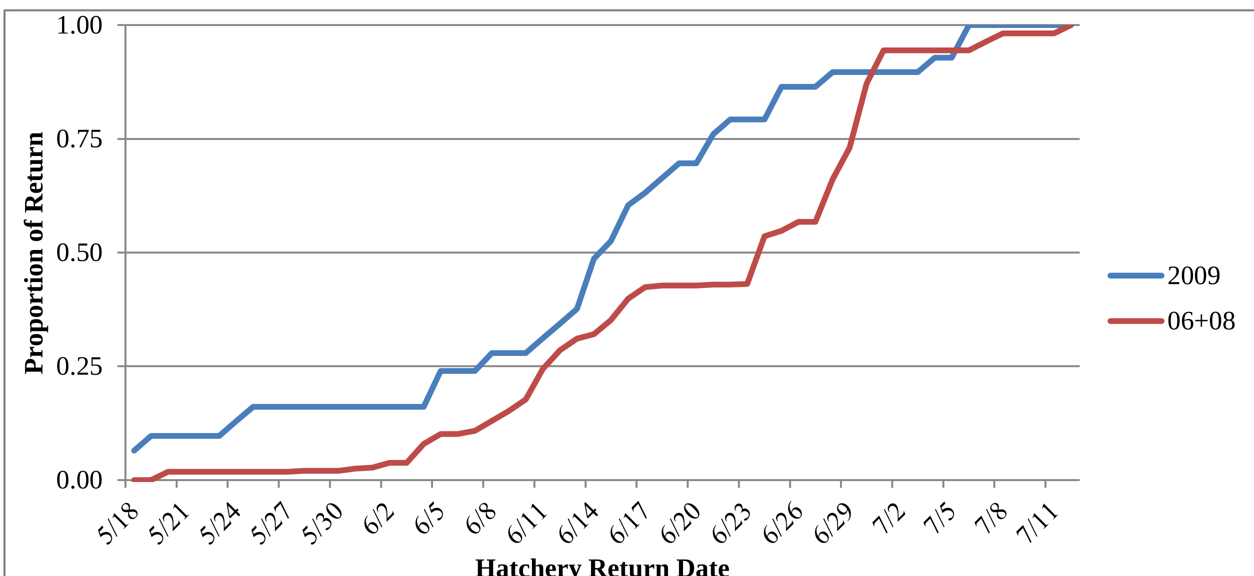

Figure 14. Timing of adults entering the LNFH adult pond, based on PIT tags.

In 2009, adult spring Chinook salmon returning to the LNFH were composed of 25% 3YO fish, 63% 4YO fish, and 12% 5YO fish (Figure 15). This return had the largest 3YO component of the previous 10 years.

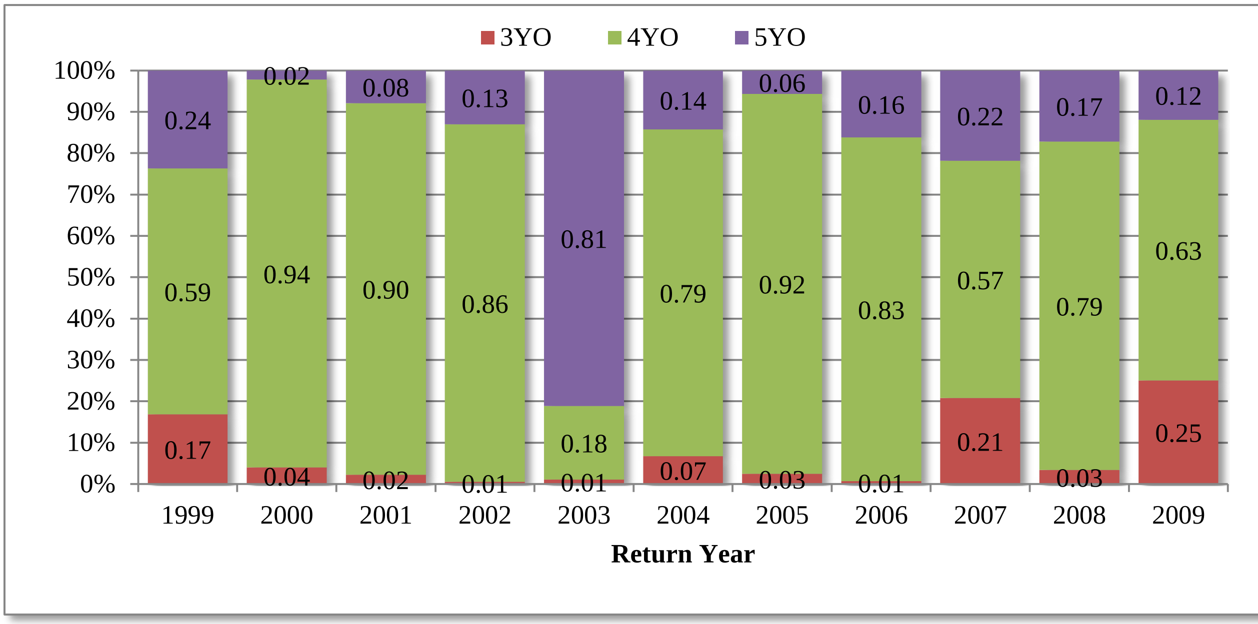

Figure 15. Age composition of LNFH adult returns.

In 2009, 96% of the returning fish were sampled for sex, length, and marks. The sex composition of the 2009 LNFH adult return is shown in Table 14. This year had a very large 3YO return (almost entirely male), accounting for 25% of the total return. The male-to-female ratio was the greatest in recent years at 1.7:1, and this is attributable to the large 3YO component. Without 3YO's, the male-to-female ratio was 1:1.

Table 14. Sex composition of sampled adults returning to the LNFH.

Return Year	# Females	# Males	M:F Ratio	Sampling Rate
2009	1,073	1,864	1.7	.96
2008	1,781	1,380	0.8	.98
2007	305	281	0.9	.34
2006	374	246	0.7	.32
2005	680	453	0.7	.44
2004	256	192	0.8	.19
2003	438	406	0.9	.17
2002	773	436	0.6	.19
2001	654	478	0.7	.18
2000	535	375	0.7	.20
1999	263	307	1.2	.32

The run timing to the LNFH ladder by sex is shown in Figure 16. To illustrate a pattern, PIT tags from Return Years 2006, 2008, and 2009 were combined. The average 50% arrival date for males (4YO+) was June 19 (range May 24 – July 6), for females it was June 18 (range May 18 – July 1.), and for 3YO's was June 15 (June 12 – June 30). In general, females appear first in mid-May, readily followed by adult males later in the month. Both males (age 4+) and females closely track each other into the hatchery, whereas 3YO's tend to surge into the hatchery in a shortened time period.

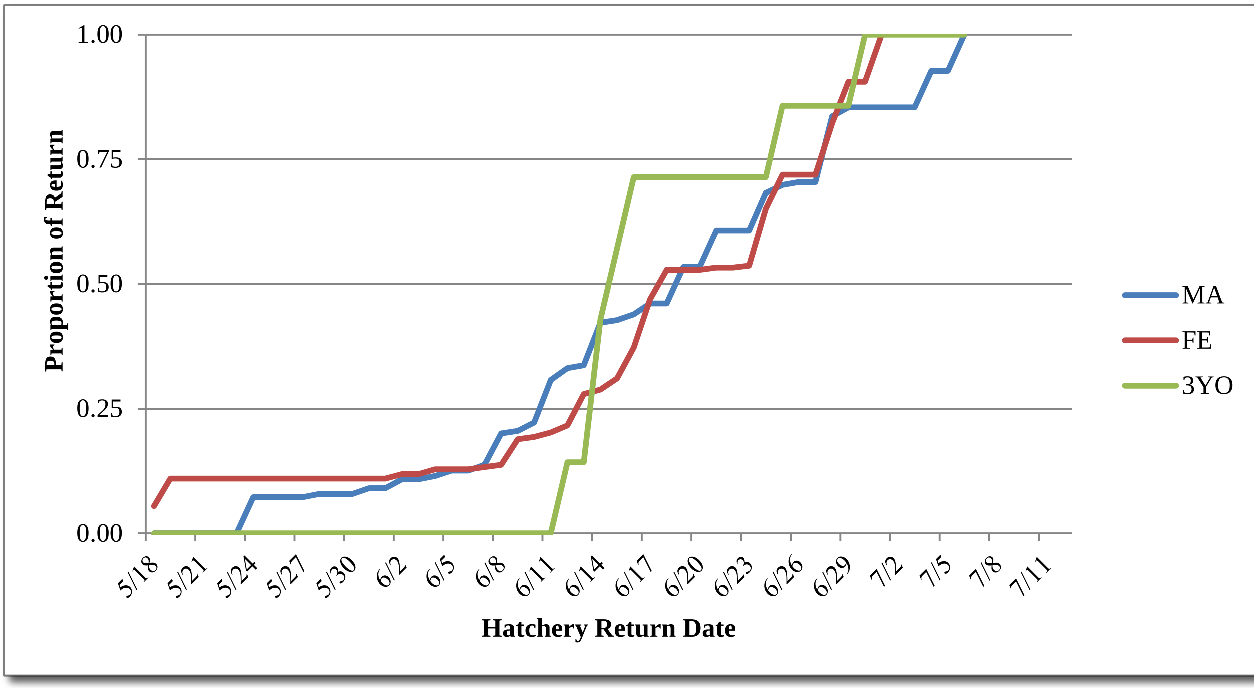

Figure 16. Run timing of returning fish by sex, 2006, 2008, and 2009 combined.

Run timing to the LNFH ladder by age class is shown in Figure 17. To illustrate a pattern, PIT tags from Return Years 2006, 2008, and 2009 were combined. The average 50% arrival date for 3YO's was June 14 (range June 5 – July 6), for 4YO's it was June 19 (range May 20 – July 12), and for 5YO's it was June 29 (range June 2 – June 30).

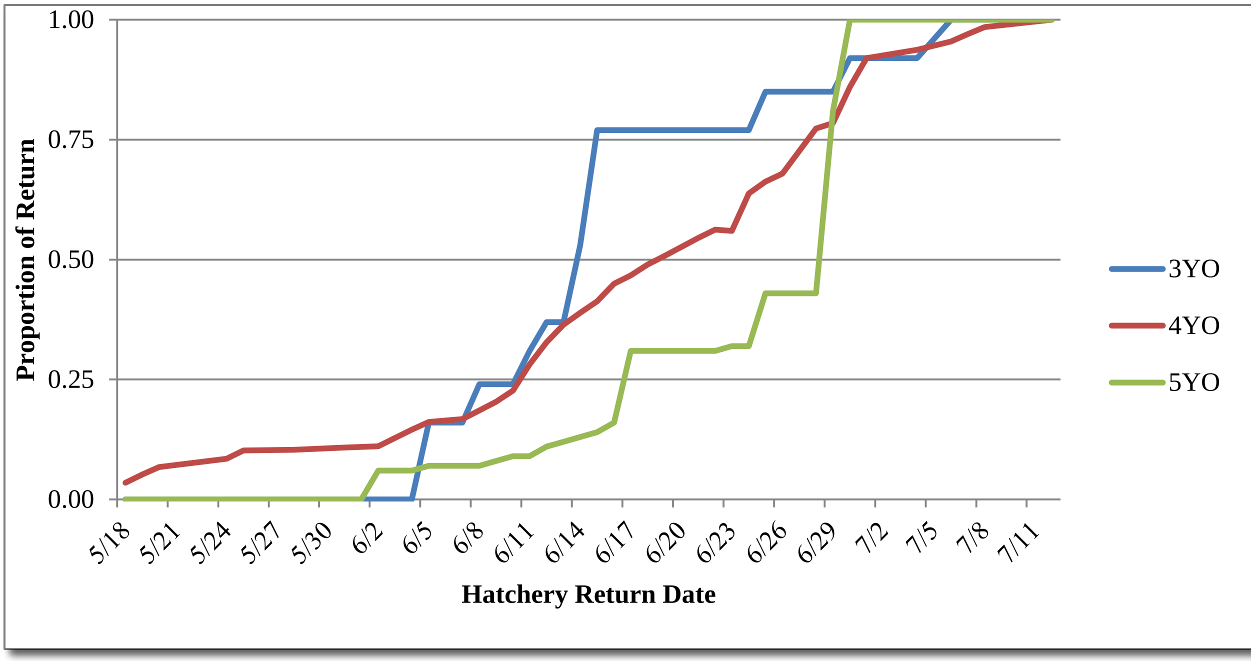

Figure 17. Run timing of returning fish by age, 2006, 2008, and 2009 combined.

The mean fork length for sampled fish returning to the LNFH is given in Table 15. All of the mean fork lengths for returning fish in 2009 are within the standard deviation of the previous 10 years, with the exception of 5YO males, which were smaller than the 10 year mean.

Table 15. Mean fork length, in centimeters, by age and sex for returning adults.

Males				**Females**		
Return Year	**3YO**	**4YO**	**5YO**	**3YO**	**4YO**	**5YO**
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
2002	45.7	80.0	96.2		75.3	88.3
2001	53.1	80.1	94.5		76.3	89.2
2000	52.5	78.3	98.0		75.8	87.0
1999	52.0	79.9	97.2		76.4	89.6
Mean (99-08)	51.5	78.8	95.2		75.0	87.3
St. Dev. (99-08)	2.57	1.17	1.85		1.30	1.83

Broodstock- Of the 3,045 spring Chinook salmon that returned to the LNFH in 2009, 2,178 were excessed, 92 died in pond (DIP), 61 were not usable at spawning, and 714 were spawned. This resulted in a 95% Broodstock Utilization, which met the Performance Goal of 95% (Table 16). High water temperatures late in the summer likely accounted for the high number of DIP's in 2009.

Of the adult spring Chinook salmon that entered the pond, 18 non-LNFH-origin CWT's were found, as well as one summer Chinook salmon, and one "natural origin" (NO) spring Chinook salmon (Table 17).

To minimize prespawn mortality of adults, daily formalin treatments were added to the holding ponds to control fungus and parasites. Formalin was administered by adding the chemical to the water as it entered the holding pond, for one-hour at a concentration of 167 ppm.

Beginning in late July, all females are given a single injection of erythromycin prevent the vertical transmission of Bacterial Kidney Disease (BKD). Portions of the returning adults are tested for pathogens, including BKD, Infectious Pancreatic Necrosis Virus (IPNV), and Infectious Hematopoietic Necrosis Virus (IHNV). The Olympia Fish Health Center provides health profiles for the broodstock utilized for production. Sampling protocols include testing all females for the presence and extent of BKD. Additionally, bacteriology (kidney/spleen) is conducted on a minimum of sixty males and virology (ovarian fluid) on a minimum of 150 females (Ray Brunson pers. comm.).

Table 16. LNFH broodstock collection metrics.

Return Year	Adult Ladder Opened	Adult Ladder Closed	Total Days Open	Total Returns to LNFH	DIPS	Adults Excessed	Adults Spawned	Green/ Spent/ Bad	Broodstock Utilization %	Non-LNFH origin CWT's Collected	Natural Origin	Sampling Rate
2009	18-May	20-Jul	63	3,045	92	2,178	714	61	95%	19	1	100%
2008	13-May	18-Jul	63	3,229	64	2,189	968	NA	98%	10	0	100%
2007	17-May	12-Jul	51	1,708	41	712	955	NA	98%	4	1	37%
2006	17-May	30-Jun	37	1,957	6	677	981	93	85%	3	0	32%
2005	16-May	17-Jul	56	2,560	8	1,830	676	2	98%	0	2	44%
2004	20-May	9-Jul	50	2,307	34	924	987	3	83%	5	0	46%
2003	28-May	11-Jul	44	4,825	181	3,392	833	5	88%	1	1	30%
2002	17-May	14-Jul	58	6,459	35	5,070	986	16	94%	0	1	27%
2001	22-May	5-Jul	38	6,260	33	4,875	859	5	92%	3	0	26%
2000	16-May	11-Jul	53	4,457	24	3,428	975	14	99%	3	0	36%
1999	24-May	14-Jul	51	1,763	86	740	892	12	93%	2	0	98%

Table 17. Non-LNFH-origin adults sampled at the LNFH in 2009.

CWT/Origin	# Observed	Age	% Marked	Deposition	Origin	Expanded #
053174	1	4	47%	Excessed	Entiat NFH	2
104080	1	3	4%	Excessed	IDFG Rapid River	25
104280	1	3	97%	Excessed	IDFG Clearwater	1
104380	2	3	97%	Excessed	IDFG Clearwater	2
632373	2	5	100%	(1) Ex. + (1) Spwn	Chiwawa SFH	2
632581	1	6	98%	Excessed	Wenatchee R. SUS	1
632896	5	4	99%	Spawned	Chiwawa SFH	5
632898	2	5	100%	Spawned	Chiwawa SFH	2
633296	3	4	99%	(1) Ex. + (2) Spwn	Chiwawa SFH	3
612713	1	3	NA	Excessed	CRITFC	NA
Natural Origin	1	3	NA	Excessed	NA	1

Spawning- In 2009, spawning occurred in 3 egg takes on August 18, August 25, and September 1. There were 378 (53%) females, 297 (42%) males, and 39 (5%) 3YO (males) available at the time of spawning. Of these, 50 females were green/spent/bad, and 11 jacks were spent. The male-to-female spawning ratio was 0.89:1, below the performance goal of 1:1, and was due to the high number of jacks and few adult males available. The green egg take of 1,620,733 was 8% above the Performance Goal of 1.5M due to a higher than projected fecundity of 4,288 eggs/female. The preseason estimated fecundity of 4,000 eggs/female would have met the green egg take Performance Goal at these broodstock collection numbers.

In 2009, it is estimated that 50% of the females were either spawned or ready to spawn by August 20 (Figure 18). Spawn timing is estimated using the 50% cumulative spawn date each year, assuming linear ripening between spawn dates (ie. 25% spawned on August 14, and 75% on August 21 = 7.143% per day, ~ 50% spawn date of August 18). For the period of 1994-2009 the average 50% spawn date was August 18 (SD = 2.9 days).

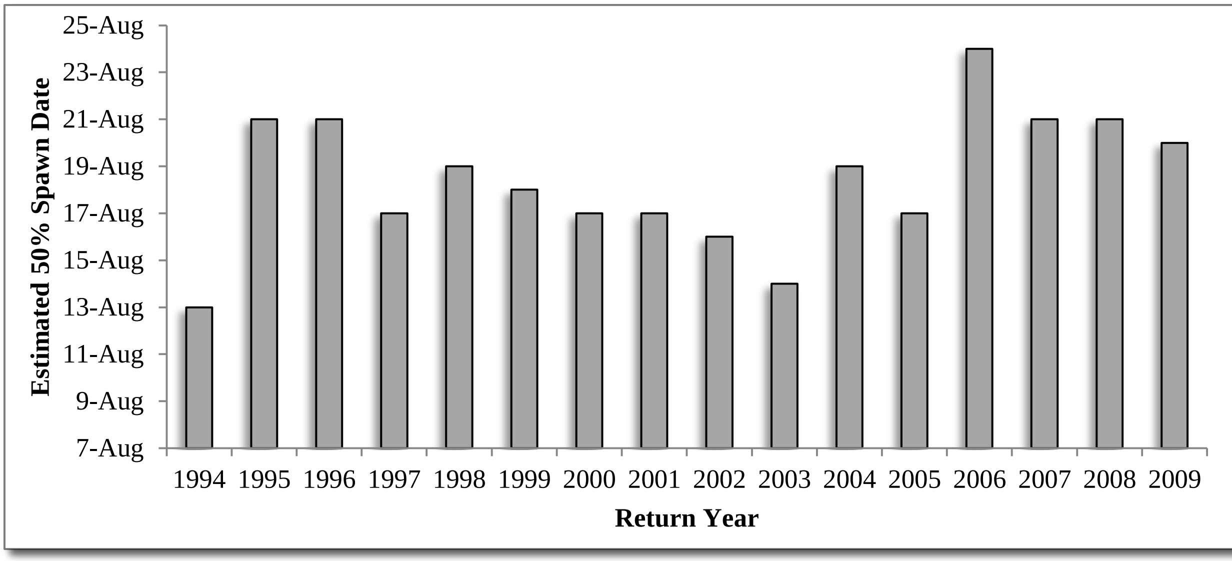

Figure 18. Estimated 50% spawn date for females at the LNFH.

The Enzyme-Linked Immunosorbent Assay (ELISA) is used to detect the prevalence of Bacterial Kidney Disease (BKD) from females used in propagation. This assay aids 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. In 2009, over 96% of the females were in the “Very Low” and “Low” risk levels (Table 18). At the time of spawning, the eggs from each female are held in separate trays. When the ELISA results are complete, “High” and “Very High” risk groups are isolated as much as possible throughout the rearing cycle. If the hatchery has more eggs than necessary for production, eggs from the higher risk females may be culled.

Table 18. ELISA results for LNFH spawned females.

Year	No Detection	Very Low	Low	Moderate	High	Very High	N
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
2002	0.2%	44.0%	45.9%	3.1%	1.4%	5.4%	484
2001	1.0%	65.4%	28.1%	1.0%	1.6%	2.9%	306
2000	15.1%	50.8%	28.4%	2.1%	0.8%	2.7%	482
1999	2.4%	43.2%	41.9%	4.9%	1.9%	5.8%	468

In 2009, 98.0% of the green eggs survived to eye-up (Table 19). This does not include the 326,349 eggs culled as a result of ELISA testing. This exceeds the Performance Goal of 96% stage survival. In December, the emergent fry were placed in the indoor starter tanks to begin the rearing cycle.

Table 19. Eyed egg survival for LNFH Return Years 2006-2009.

Return Year	Green Eggs	Bad Eggs	ELISA Culling	Eyed Eggs Kept	% Eyed Survival[1]
2009	1,620,733	25,635	326,349	1,268,749	98.0
2008[2]	1,949,442	20,910	652,857	1,275,675	98.4
2007	2,125,339	36,755	377,454	1,711,130	97.9
2006	1,845,443	68,090	199,388	1,577,965	95.9

[1] Eyed Survival does not include ELISA culling.
[2] Beginning in Return Year 2008, the Release Number goal was reduced to 1.2M.

Brood Year 2002

Analysis of Brood Year performance is delayed by several factors: It will take at least 5 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 2002 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.

Juvenile Rearing Recap

The 2002 Brood Year was produced from a large adult return to the LNFH. The hatchery captured 6459 adults in 2002, with large numbers excessed in the process. The LNFH kept 484 females for production, resulting in a green egg take of 1,831,940. This resulted in a back-calculated average fecundity of 3,785 eggs per female. This green egg take is below the estimated 2.0M needed to meet the Performance Goal of 125% of the Release Number Performance Goal of 1.6M (for the 2004 Release Year). The LNFH would have needed a fecundity of 4,132 eggs per female, or to have retained 528 females at the actual fecundity to have met this end stage Performance Goal.

Many of the Adult Return/Broodstock metrics for the 2002 Brood Year fell in the "average" category. Broodstock Utilization, 50% spawn date, sizes, and ELISA results were all on par for this program. Brood Year 2002 ultimately released 1,422,100 smolts into Icicle Creek on April 19, 2004. This Release Number was below the Performance Goal of 1.6M, and can be accounted for by the low female fecundity and/or low number of females spawned.

Brood Year 2002 was the final year of an Army Corp of Engineers PIT tagging study, for which 216,698 of the produced juveniles were PIT tagged. This massive PIT tagging effort took place at the LNFH in the months preceding the April 19 (2004) release, requiring extensive crowding and handling. It is unclear if this effort had deleterious effects on smolt performance. The Brood Year 2002 smolt survival to McNary Dam, based on the PIT tags used in this study, was among the lowest in recent years at 48.3%, however the 2000 and 2001 Brood Years were also massively PIT tagged as part of this study, and their survival was 59.3% and 50.1%, respectively, suggesting that the large PIT tagging effort did not affect downstream smolt survival. Brood Year 2002 migration timing, based on PIT tags, was also within the average values for recent years (see Release Year section, “2004” release).

Brood Year 2002 Performance

Population Cohort- At the population level, the Smolt-to-Adult Return (SAR) is the primary metric for evaluating program performance for a Brood Year. In hatcheries, an SAR is the number of adults that are produced from a single release of juveniles, and is expressed as a percent. The LNFH calculates an SAR by using a variety of data sources, including hatchery returns, harvest creels, and spawning ground surveys. The methods are given in Appendix D.

Brood Year 2002, begetting adults returning from 2005-2007, had an SAR of 0.26%. This is below the 1995-2001 average of 0.60%, and continues a trend of lower LNFH SAR’s in recent years (Figure 19). In comparing the LNFH’s SAR performance to that of similar programs, the CFH and the Entiat National Fish Hatchery (ENFH) are the most relevant. The CFH program produces spring Chinook within the Wenatchee basin, and the ENFH produces spring Chinook salmon in the adjacent Entiat River basin. The SAR for each program is given in Figure 20 (RMIS, Hillman 2011). Note that the CFH did not have a program in Brood Years 1995 and 1999. The year-to-year pattern of SAR’s between programs appears similar, and a trend of lower SAR’s in recent years is seen among all programs. Overall, the mean SAR between programs is not different (p=0.263 one way ANOVA on ranks, Figure 21).

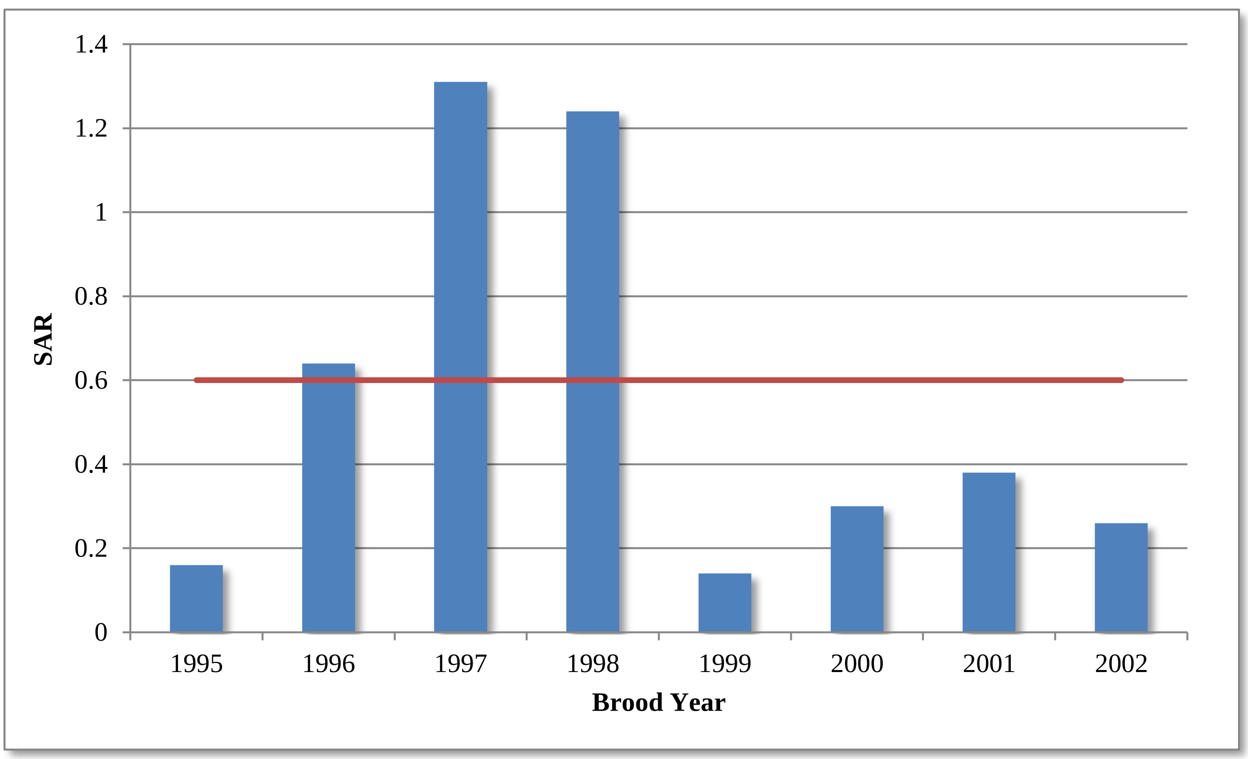

Figure 19. LNFH SAR's, 1995-2002, with red line indicating 1995-2001 mean.

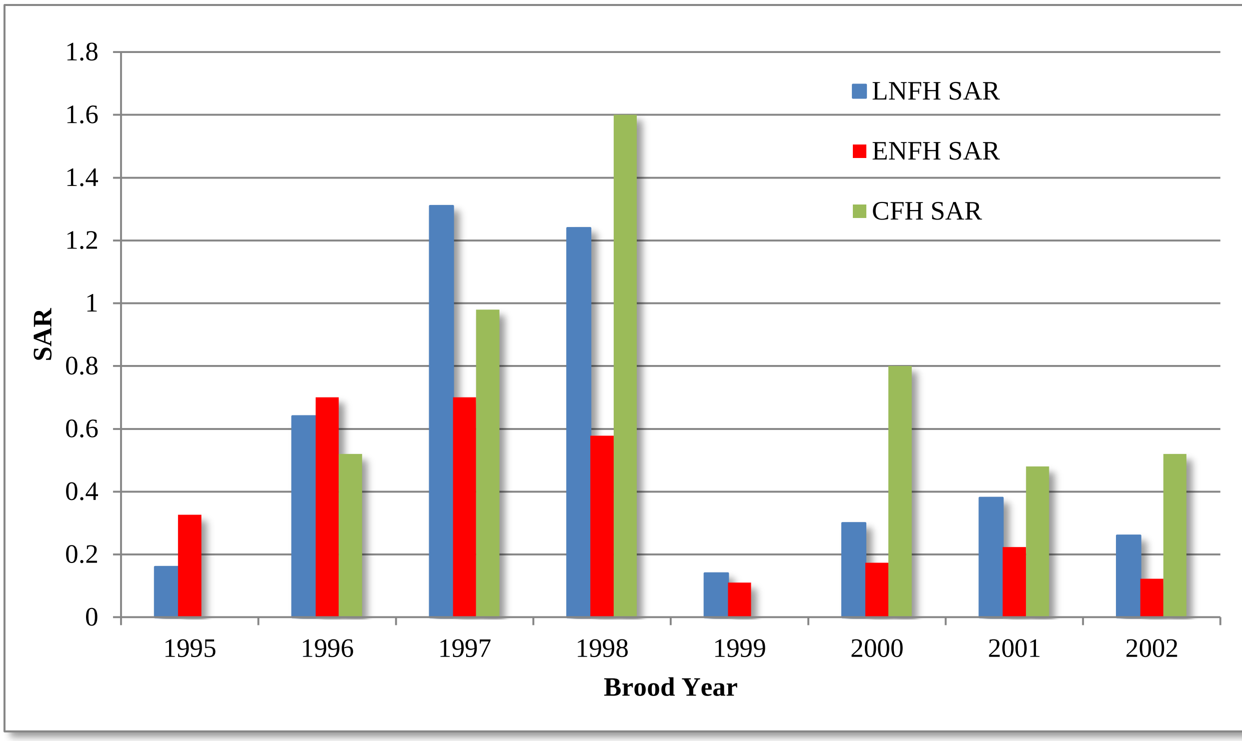

Figure 20. LNFH, ENFH, and CFH SAR's, 1995-2002.

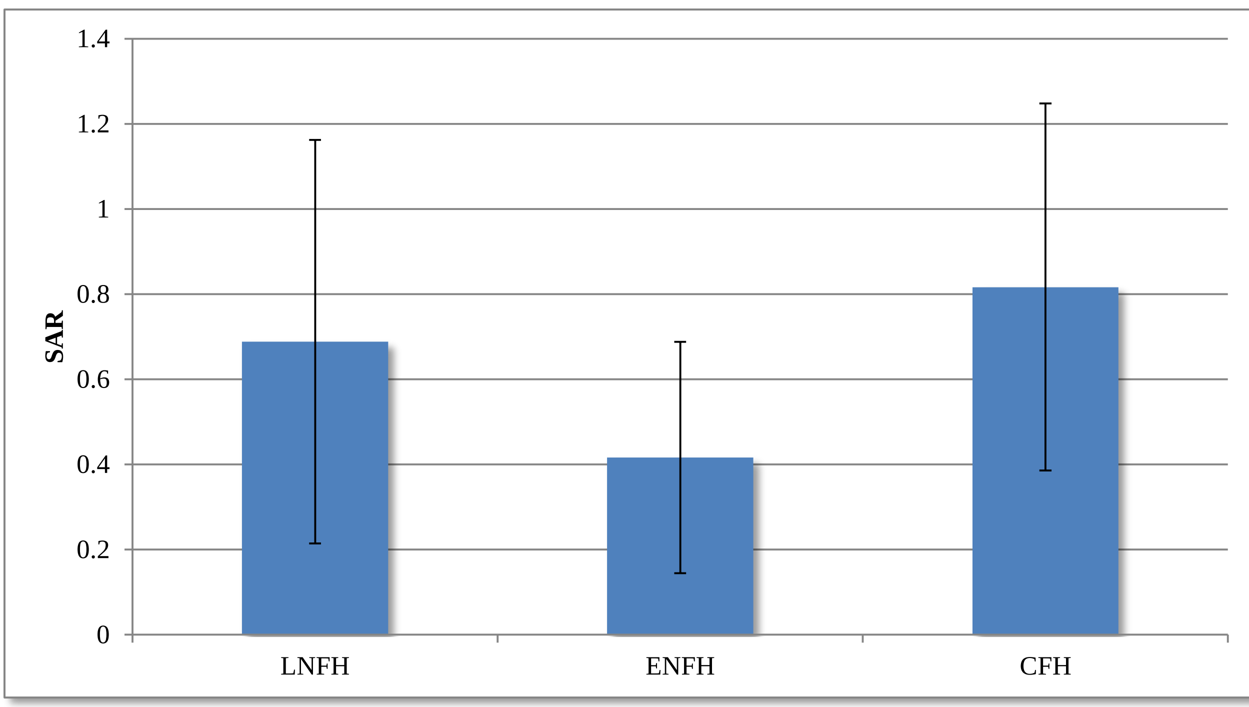

Figure 21. Mean and standard deviation for SAR at the LNFH, ENFH, and CFH. Data from Brood Years 1996-1998 and 2000-2002.

Year-to-year variation in the LNFH's SAR may be explained by a one or more variables either unique to the LNFH (intra-hatchery), or common among similar hatchery programs (extra-hatchery). Intra-hatchery variables could be any of the rearing parameters that occur on-site. At the population level, two potentially important variables are the size of the fish at release, and the date that they are released. However, at the LNFH, neither of these variables correlates to the SAR (Table 20).

The similar pattern of SAR variation seen among different hatchery programs suggests an extra-hatchery effect, with off-site variables influencing survival. Off-site variables appear to have mixed correlations; smolt survival and travel time have little relationship to the LNFH SAR, while Columbia River discharge has much stronger correlation. As a whole, it appears that the survival of LNFH fish is increased in years of high Columbia River discharge, and though these variables are environmental in nature, anthropogenic influences on the Columbia River may play a role. Of particular interest, the mean discharge experienced during smolt travel may have a positive effect on survival. As such, management actions that place smolts in the Columbia River during the time of maximum discharge may have positive results. More detailed analysis is needed with respect to these relationships.

Table 20. Juvenile rearing and environmental variables and their correlation to SAR.

On Site (Intra-hatchery)	**Regression R^2 when predicting SAR (1996-2002)**
Mean fish size at release (fish per pound)	0.054 (p=0.574)
Release Date	0.000 (p=0.648
Off Site (Extra-hatchery)	
Smolt survival to McNary Dam	0.165 (p=0.370)
Smolt travel time to McNary Dam	0.018 (p=0.822)
Rock Island Dam discharge: Day of release	0.055 (p=0.638)
Rock Island Dam discharge: Cumulative up to day of release	0.812 (p=0.004)
Rock Island Dam discharge: Sum for year	0.686 (p=0.050)
Bonneville Dam discharge: Sum for year	0.628 (p=0.050)
Bonneville Dam mean discharge during smolt travel: Release to Bonneville Dam	0.621 (p=0.034)

Age Class- Brood Year 2002 beget 3.7% 3YO fish, 74.9% 4YO fish, and 21.1% 5YO fish (Figure 22). This data is 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.

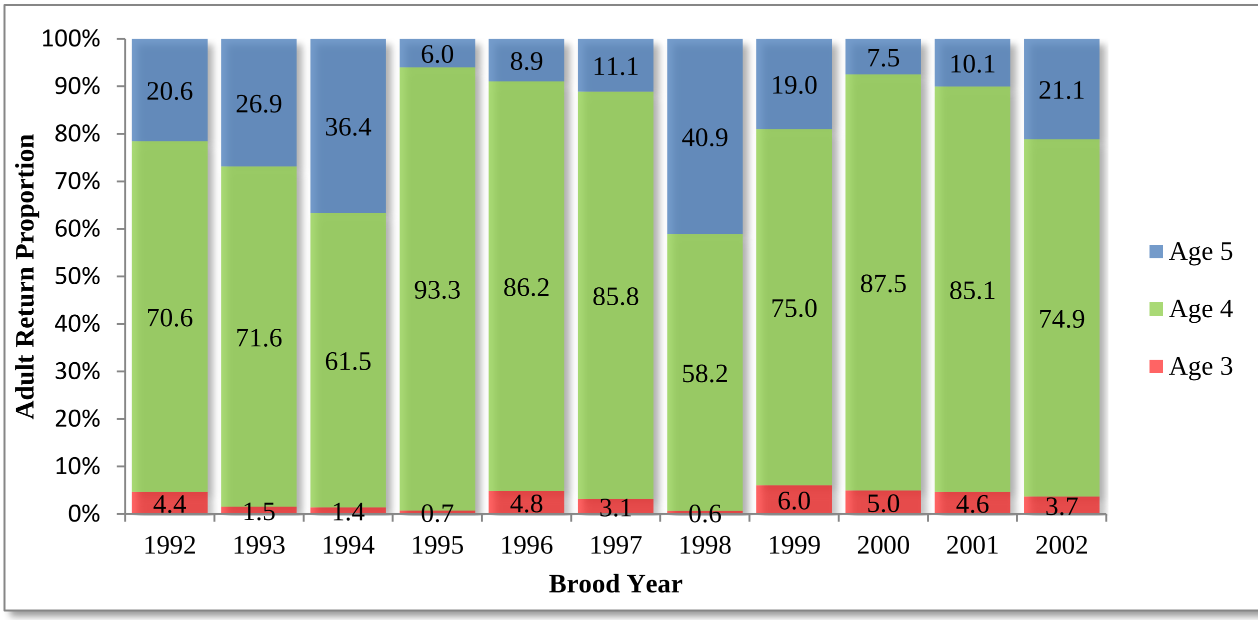

Figure 22. Proportion of age's produced, by Brood Year. Note: Percentages may not equal 100% due to rounding and outliers (i.e, 2YO, 7YO, etc.).

Gender- Brood Year 2002 returned a gender composition of 54.5% females and 45.5% males (3YO+) (Figure 23).

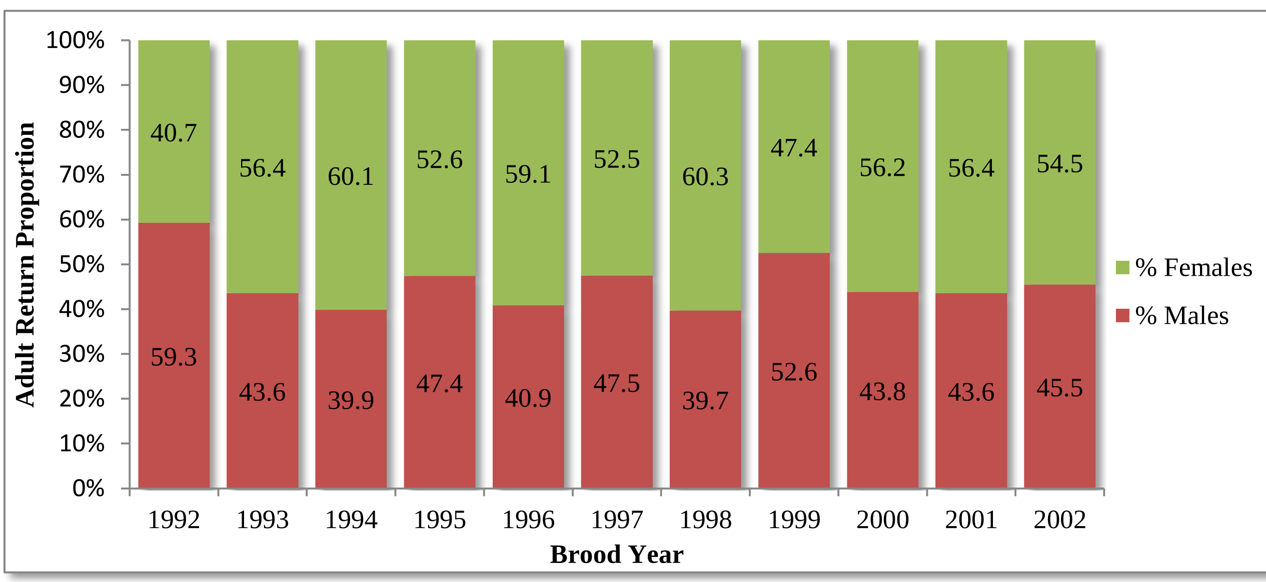

Figure 23. Sex composition produced by Brood Year.

Harvest Contribution- Brood Year 2002 produced an estimated 3,646 returning adults. Of these, 1,729 adults ended up in the possession of Tribes, either through excessing or harvest. Another 1,040 adults were used in hatchery production. Non-Tribal fishing in Icicle Creek harvested 467 adults, and non-Tribal fishing outside of Icicle Creek harvested 304 adults. The remaining 106 fish (Other) were found on spawning grounds, at other hatcheries, on ocean research vessels, etc. (RMIS, Figure 24, Table 21, Appendix E). The largest portion of Brood Year 2002 returning adults ended up in Tribal possession either through excessing or harvest (48%, Figure 25). This is slightly lower than the Brood Years 1995-2001 average of 57%.

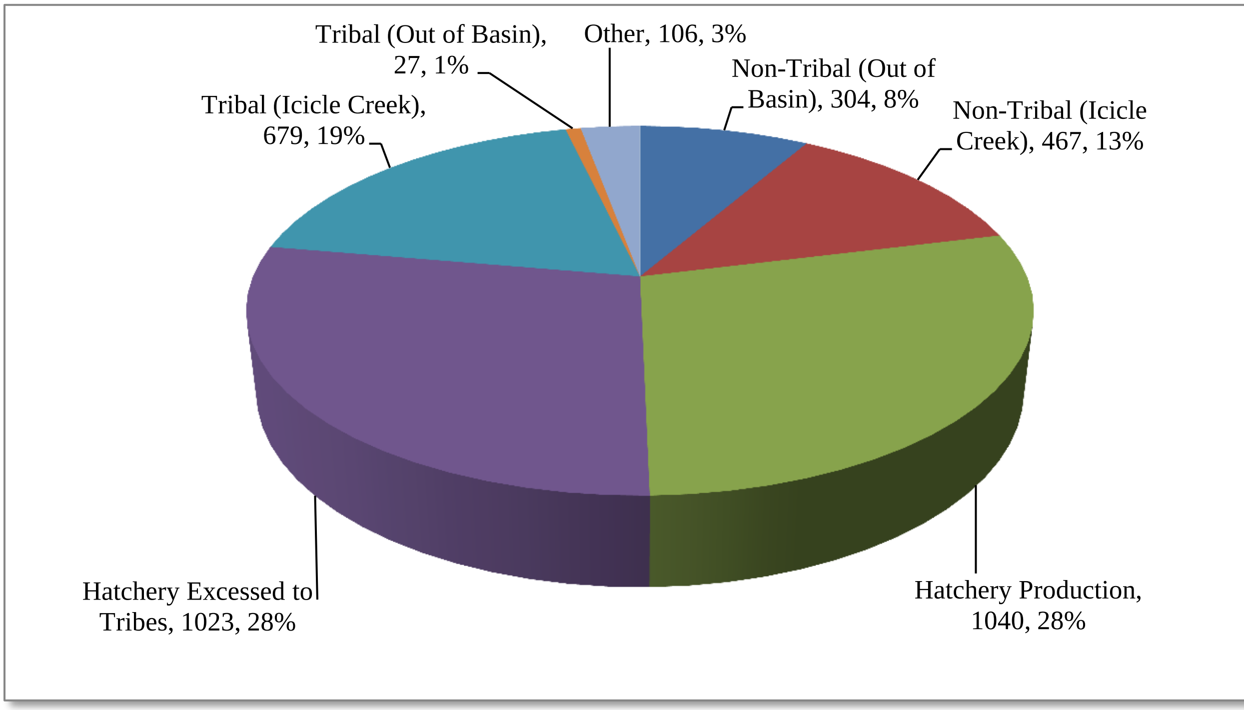

Figure 24. LNFH-origin adult deposition, Brood Year 2002.

Table 21. LNFH-origin adult return deposition by Brood Year.

Brood Year	Total Return Produced	Hatchery Production		Excessed to Tribes		Icicle Creek Tribal Harvest		Out of Basin Tribal Harvest		Icicle Creek Non-Tribal Harvest		Out of Basin Non-Tribal Harvest		Other (Spawning Grounds, Hatchery Returns, etc.)	
2002	3,646	1,040	28.5%	1,023	28.1%	679	18.6%	27	0.7%	467	12.8%	304	8.3%	106	2.9%
2001	4,916	844	17.2%	1,980	40.3%	1,130	23.0%	2	0.0%	204	4.1%	672	13.7%	84	1.7%
2000	4,787	831	17.4%	1,191	24.9%	763	15.9%	0	0.0%	290	6.1%	1,325	27.7%	387	8.1%
1999	2,398	294	12.3%	925	38.6%	471	19.6%	0	0.0%	222	9.3%	271	11.3%	215	9.0%
1998	21,422	1,548	7.2%	8,092	37.8%	4,897	22.9%	108	0.5%	1,848	8.6%	3,414	15.9%	1,515	7.1%
1997	21,796	938	4.3%	5,705	26.2%	5,182	23.8%	138	0.6%	2,239	10.3%	5,493	25.2%	2,101	9.6%
1996	10,895	1,134	10.4%	3,840	35.2%	3,468	31.8%	211	1.9%	1,422	13.1%	395	3.6%	425	3.9%
1995	1,522	562	36.9%	601	39.5%	180	11.8%	27	1.8%	95	6.2%	24	1.6%	33	2.2%
Mean	8,923	899	16.8%	2,920	33.8%	2,096	20.9%	64	0.7%	848	8.8%	1,487	13.4%	608	5.6%
St. Dev.	8,317	375	11.0%	2,730	6.4%	2,080	6.0%	79	0.8%	853	3.2%	1,952	9.4%	770	3.2%

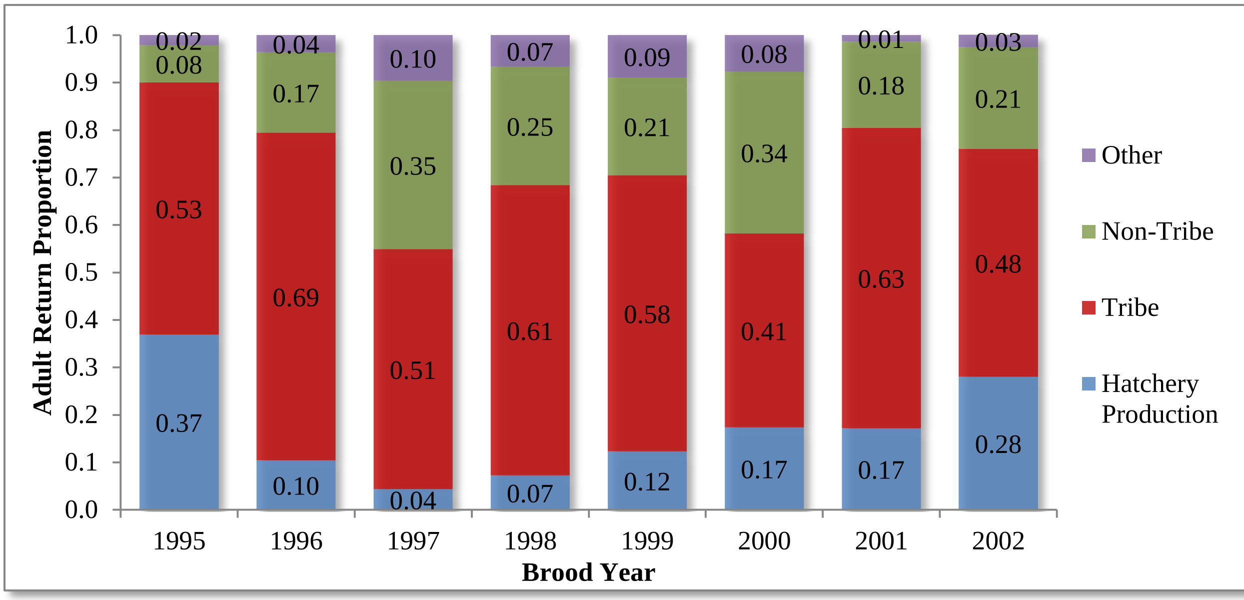

Figure 25. Proportion of disposition of LNFH-origin adult returns by Brood Year.

Discrete Rearing Cohort- By rearing bank is the finest level of juvenile rearing performance evaluated at the LNFH. At finer levels, such as individual raceways, insufficient numbers of marked adults return to explain population characteristics. The LNFH uses 3 different banks of raceways to rear juvenile spring Chinook salmon. A portion of the juveniles are reared in the 10x100's for their entire outdoor rearing cycle. Another portion of the juveniles are reared in the 8x80's for the entire outdoor rearing cycle. A third portion of the juveniles are reared in the 8x80's for the first half of the rearing cycle, then are transferred to the 15x150 adult holding ponds to complete the rearing cycle. This is done because of constraints to water availability and rearing space.

Each of these rearing banks has a portion of juveniles marked with CWT's. Their survival, by Brood Year, is given in Table 22 and shown in Figure 26.

Table 22. LNFH-origin SAR by rearing bank, Brood Years 1995-2002.

	10x100			8x80-AP			8x80		
Brood Year	N Marked	Estimated Adult Return	SAR(%)*	N Marked	Estimated Adult Return	SAR(%)*	N Marked	Estimated Adult Return	SAR(%)*
2002	628,319	748	0.18	193,683	182	0.14	209,368	225	0.16
2001	452,080	1,282	0.42	179,147	414	0.34	124,517	327	0.39
2000	276,654	536	0.29	46,472	446	1.42	121,367	269	0.33
1999	121,173	96	0.12	57,024	93	0.24	64,535	44	0.10
1998	97,173	752	1.15	46,590	588	1.86	49,648	347	1.03
1997	91,757	773	1.25	46,080	360	1.16	49,176	262	0.79
1996	87,034	341	0.58	47,753	152	0.47	166,257	559	0.50
1995	133,835	184	0.20	49,705	53	0.16	115,650	116	0.15
Mean			0.52			0.72			0.43
St. Dev.			0.44			0.66			0.33

*SAR is locally-derived using the following relationship: SAR=1.479(RMIS SAR). See Appendix D.

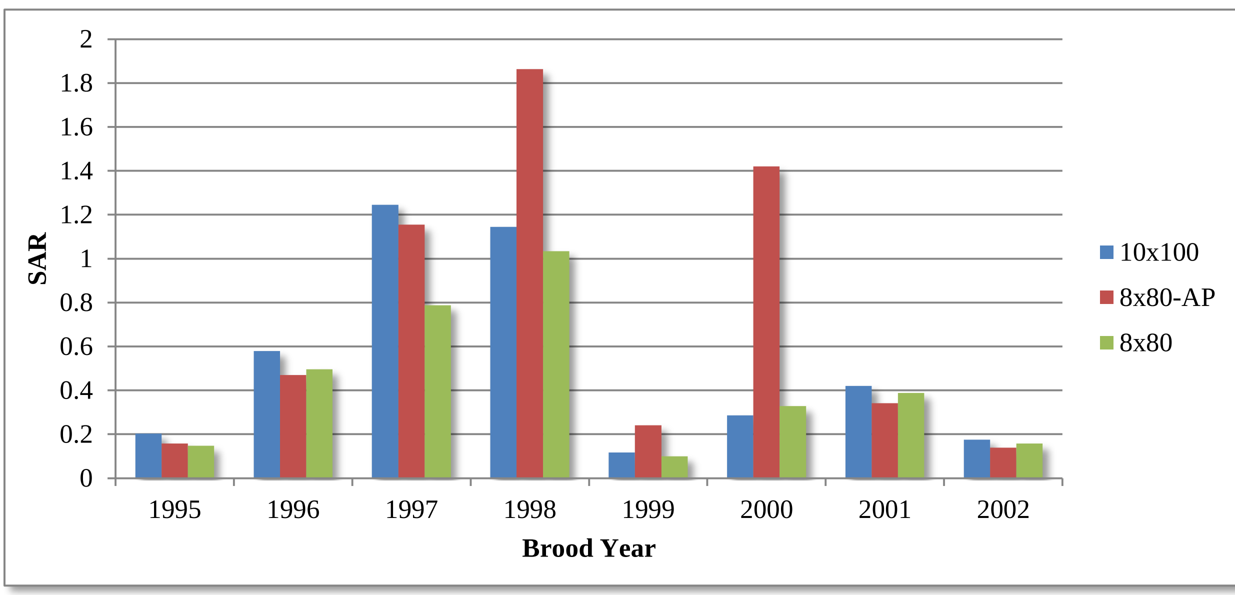

Figure 26. LNFH SAR by rearing bank, Brood Years 1995-2002.

The year-to-year variation in SAR by rearing bank is large, resulting in no significant difference in SAR between rearing banks at the LNFH (p=0.677, one-way ANOVA on ranks) for the Brood Years 1995-2002 (Figure 27).

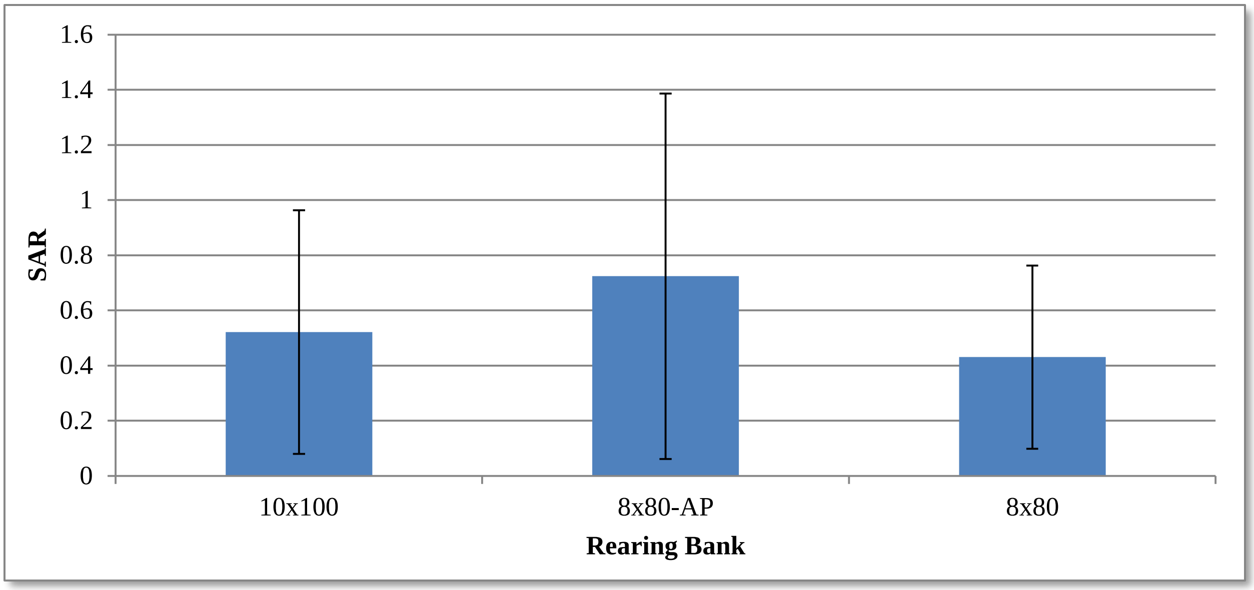

Figure 27. Mean LNFH SAR by rearing bank with error bars, 1995-2002.

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Appendix A: Release Year 2009 Coded Wire Tag Codes.

Table A1. Release Year 2009 coded wire tag codes

Release Year	Tag Code	N tagged
2009	054195	196,529

Appendix B: Methods for Forecasting Adult Spring Chinook Salmon Returns to the Leavenworth National Fish Hatchery Complex

Methods for Forecasting Adult Spring Chinook Salmon Returns to the Leavenworth National Fish Hatchery Complex

by

Matt Hall and Matt Cooper

Hatchery Evaluation Program

Mid-Columbia River Fisheries Resource Office

U.S. Fish and Wildlife Service

Introduction

Accurately forecasting the number of anadromous salmon and steelhead that will return to hatcheries and spawning basins is a critical tool for fisheries managers. This information facilitates improved harvest management and ensures sufficient escapement. Numerous models can be constructed for making this forecast, each with different inputs, variables, and assumptions. Rather than relying on one model, we examine the tendencies of several, in an attempt to forecast the number of returning adults several months in advance of their arrival.

Methods

Technical Advisory Committee

Most of our models begin with the *U.S. v. Oregon* Technical Advisory Committee (TAC) upper Columbia River spring Chinook salmon forecast. This forecast predicts the number of spring Chinook salmon returning to the mouth of the Columbia River, and is distributed through an annual Joint Columbia River Management Staff report, usually released in January (www.wdfw.wa.gov/fishing/crc/staff_reports.html). This report disseminates official fish return numbers, harvest numbers, and run composition, as well as the TAC forecast (the entirety of this report will henceforth be referred to as "TAC"). All of the return and harvest data used in constructing Leavenworth Complex-specific forecasts are found within the TAC report, unless otherwise noted.

The forecasted fish returns provided by TAC are utilized as the initial input value for most of the Leavenworth Complex run forecast models. Other sources of data included the Regional Mark Information System (RMIS), which houses Coded Wire Tag (CWT) data used for some survival and harvest estimates, and annual reports from Leavenworth Complex hatcheries. All linear regressions used in the Leavenworth Complex forecasts have the following minimum criteria: parameter and ANOVA values $p<0.10$, coefficient of determination of $r^2>50\%$, correlation coefficient $R>0.60$, degrees of freedom >6, and a significant ($p>0.05$) relation and intercept.

Forecasting the Adult Return

The various models will return a range of forecasts, so the median forecast is calculated. Historical model accuracy for 2004-2012 is given in Table A1. The mean accuracy of the forecast is 141% of the actual return. This mean accuracy is heavily influenced by the poor performance of the first 2 years of forecasting (2004-2005). If those years are excluded, the mean accuracy is 106%.

Table B1. Accuracy of adult return forecasts to Icicle Creek, 2004-2012.

Year	Forecasted	High Model	Low Model	Actual Return	% of Actual Return
2012	7,668	9,747	5,200	6,727	114.0
2011	6,003	6,959	3,565	6,868	87.4
2010	9,592	16,278	5,287	13,921	68.9
2009	4,980	5,625	3,735	4,607	108.1
2008	5,897	8,901	3,363	4,821	122.3
2007	3,191	4,251	2,984	2,606	122.4
2006	3,836	4,113	3,272	3,159	121.4
2005	7,646	11,436	6,415	3,740	204.4
2004	11,459	13,615	8,373	3,571	321.0

Models

Historical Model- The Historical model uses the TAC forecast to the Columbia River mouth as the only input, and uses linear regressions to predict the number of spring Chinook salmon that will arrive at subsequent forecast locations (Table A2). This model assumes consistent survival and harvest conditions from year to year throughout the Columbia River basin. The linear regressions are built with actual historical dam counts and hatchery (or spawning) basin return estimates (Fish Passage Center, Cooper et al. 2006). The Historical model removes a percentage of the TAC forecasted run to the Columbia River mouth to account for harvest below Bonneville Dam. These historical harvest rates are provided in the TAC forecast reports.

Table B2. Variables, methods, and sources of data for Historical adult return forecasting model.

Variable	Methods	Source of data
TAC forecast to Columbia River mouth	TAC	TAC
Forecast to Bonneville Dam	TAC**x* (*x*=escapement rate form harvest below Bonneville Dam)	TAC
Forecast to The Dalles Dam	Linear regression using Bonneville Dam counts as predictor.	Fish Passage Center
Forecast to John Day Dam	Linear regression using The Dalles Dam counts as predictor.	Fish Passage Center
Forecast to McNary Dam	Linear regression using John Day Dam counts as predictor.	Fish Passage Center
Forecast to Priest Rapids Dam	Linear regression using McNary Dam counts as predictor.	Fish Passage Center
Forecast to Rock Island Dam	Linear regression using Priest Rapids Dam counts as predictor.	Fish Passage Center
Forecast to Rocky Reach Dam	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center
Forecast to Wells Dam	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center
Forecast of LNFH-origin SCS to Icicle Creek	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of natural-origin SCS to Entiat River	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of WNFH origin SCS to Methow River	Linear regression using Wells Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006

Maximum Harvest Model- The Maximum Harvest model begins with the TAC forecast, and assumes a maximum harvest for the section of the Columbia River below Priest Rapids Dam (Table A3). The maximum harvest is the highest harvest rate observed on Upper Columbia River (UCR) spring Chinook salmon since 2000 (the earliest year that we have reliable Coded Wire Tag recovery data, RMIS). Above Priest Rapids Dam, consistent survival and harvest conditions are assumed. To apply harvest rates to the appropriate fisheries, the TAC forecasted return to the Columbia River mouth must be reduced to its Upper Columbia River (UCR) hatchery-origin and natural-origin spring Chinook salmon components.

For the UCR hatchery-origin component, the maximum harvest rate was calculated using LNFH Coded Wire Tag (CWT) recoveries below Priest Rapids Dam to represent the UCR hatchery-origin component (CWT data via RMIS). For the UCR natural-origin spring Chinook salmon component, only the Columbia River gill net fisheries harvest rate was applied, as it is a non-selective fishery. This data is available in the TAC report.

Table B3. Variables, methods, and sources of data for Maximum Harvest adult return forecasting model.

Variable	**Methods**	**Source of data**
TAC forecast to Columbia River mouth	TAC	TAC
TAC estimated UCR hatchery-origin component of forecasted return.	TAC	TAC
TAC estimated UCR natural-origin component of forecasted return.	TAC	TAC
Estimated highest harvest rate of hatchery-origin return.	LNFH CWT recoveries used to represent UCR SCS run at large. Highest harvest rate since the year 2000 is applied.	RMIS, TAC
Estimated highest harvest rate of natural-origin return.	TAC Columbia River gill net fisheries highest harvest rate is applied.	TAC
Forecast to Priest Rapids Dam	(hatchery-origin component *harvest rate) +(natural-origin component*harvest rate).	TAC, RMIS
Forecast to Rock Island Dam	Linear regression using Priest Rapids Dam counts as predictor.	Fish Passage Center
Forecast to Rocky Reach Dam	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center
Forecast to Wells Dam	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center
Forecast of LNFH-origin SCS to Icicle Creek	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of natural-origin SCS to Entiat River	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of WNFH-origin SCS to Methow River	Linear regression using Wells Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006

Proportional Harvest Model – The Proportional Harvest model also begins the UCR hatchery-origin and natural-origin spring Chinook salmon components of the TAC forecasted adult return to the Columbia River mouth (Table A4). This model has a proportional harvest rate assumption for the section of the Columbia River below Priest Rapids Dam, and assumes consistent survival and harvest conditions from year to year above Priest Rapids Dam. The hatchery-origin and natural-origin components are calculated as per the *Maximum Harvest* model. The proportional harvest rate is calculated by scaling the maximum harvest rate (as calculated in the *Maximum Harvest Rate* model) to the forecasted run size. This calculation is made as follows:

$$\frac{\text{Maximum Harvest Rate}}{\text{Run Size}} = \frac{X}{\text{Forecasted Run Size}}$$

where: Maximum Harvest Rate is calculated as per the *Maximum Harvest* model for each component (hatchery or natural-origin).

Run Size is the total run size of the component (hatchery or natural-origin) that occurred the same year that the maximum harvest rate.

X is the proportional harvest rate (of the hatchery or natural-origin component).

Forecasted Run Size is the TAC forecasted size of the hatchery or natural-origin component of the spring Chinook salmon run.

The derived harvest rates are applied to the hatchery-origin and natural-origin UCR forecast, and a total forecast is made for Priest Rapids Dam by summing the two components. Subsequent forecasts are made via linear regressions, based on historical dam counts and Icicle basin return estimates.

Table B4. Variables, methods, and source of data for Proportional Harvest adult return forecasting model.

Variable	**Methods**	**Source of data**
TAC forecast to Columbia River mouth	TAC	TAC
TAC estimated UCR hatchery-origin component of forecasted return.	TAC	TAC
TAC estimated UCR natural-origin component of forecasted return.	TAC	TAC
Estimated proportional harvest rate of hatchery-origin return.	Estimated highest harvest rate (as per Maximum Harvest model) is scaled to forecasted run size.	RMIS, TAC
Estimated proportional harvest rate of natural-origin return.	Estimated highest harvest rate (as per Maximum Harvest model) is scaled to forecasted run size.	TAC
Forecast to Priest Rapids Dam	(hatchery-origin component *harvest rate)+(natural-origin component*harvest rate)	TAC, RMIS
Forecast to Rock Island Dam	Linear regression using Priest Rapids Dam counts as predictor.	Fish Passage Center
Forecast to Rocky Reach Dam	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center
Forecast to Wells Dam	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center
Forecast of LNFH-origin SCS to Icicle Creek	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of natural-origin SCS to Entiat River	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of WNFH-origin SCS to Methow River	Linear regression using with Wells Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006

Jack Model- The Jack model uses the previous years' 3YO component of the Bonneville Dam return as an assumption of 4YO survival (Table A5). This count is then used to predict the return to Bonneville Dam, using a linear regression created from historical dam counts (Fish Passage Center). Linear regressions are then created using these Bonneville Dam forecasted returns to predict returns to subsequent dams and the Icicle Creek basin.

Table B5. Variables, methods, and source of data for Jack adult return forecasting model.

Variable	Methods	Source of data
Previous years' 3YO component of Bonneville Dam return.	Fish Passage Center dam count.	Fish Passage Center
Predicted total return to Bonneville Dam.	Linear regression using previous years' 3YO's as predictor of total return.	Fish Passage Center
Forecast to Priest Rapids Dam	Linear regression using forecast to Bonneville Dam as predictor.	Fish Passage Center
Forecast to Rock Island Dam	Linear regression using forecast to Priest Rapids Dam as predictor.	Fish Passage Center
Forecast to Rocky Reach Dam	Linear regression using forecast to Rock Island Dam as predictor.	Fish Passage Center
Forecast to Wells Dam	Linear regression using forecast to Rocky Reach Dam as predictor.	Fish Passage Center
Forecast of LNFH-origin SCS to Icicle Creek	Linear regression using Rock Island Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of natural-origin SCS to Entiat River	Linear regression using Rocky Reach Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006
Forecast of WNFH-origin SCS to Methow River	Linear regression using with Wells Dam counts as predictor.	Fish Passage Center, Cooper et al. 2006

Brood Year Survival Model- The Brood Year Survival model uses historical age compositions and survivals to predict future adult returns, and only applies to hatchery-origin returns (Table A6). This model begins with the juvenile releases from each of the 3 years prior to the year being forecasted. Each juvenile release is divided into predicted adult return age composition, based on historical data. Then, a Smolt-to-Adult Return (SAR) is applied, based on historical data. The calculation is made as follows:

$$((N^{Y-1}*P^{age\ 3})+(N^{Y-2}*P^{age\ 4})+(N^{Y-3}*P^{age\ 5}))*S$$

where: *N* is the historical number of juveniles released.
Y is the year of the adult return forecast.
P is the historical mean proportion of age class of historical adult returns.
S is the historical SAR.

From this forecasted total adult return, adult returns to Rock Island Dam and Icicle Creek can be made using historical return data and linear regressions.

Table B6. Variables, methods, and source of data for the Brood Year Survival adult return forecasting model.

Variable	Methods	Source of data
Proportion of age class returning.	Mean age composition is applied to previous 3 years' release numbers, resulting in a proportion of each group that will return this year in a given age class.	Cooper et al. 2006
Forecasted total adult return	A SAR is applied to the sum of the age class returns. The result is a total adult return forecast.	RMIS, Cooper et al. 2006
Forecast to Rock Island Dam	Linear regression using forecasted total adult return as predictor.	Cooper et al. 2006, Fish Passage Center.
Forecast of LNFH-origin SCS to Icicle Creek	Linear regression using forecasted total adult return as predictor.	Cooper et al. 2006

Appendix C: Return Year 2009 Outside-of-Icicle-Creek-Basin Coded Wire Tag Recoveries.

Table C1. Return Year 2009 outside-of-Icicle Creek-basin coded wire tag recoveries.

Return Year	Brood Year	CWT	Recovery Location Name	Estimated N Based on Sample Rate	Expanded N Based on Mark Rate	Age
2009	2004	052575	LTL WHITE SALMON NFH	1	4	5
2009	2004	051584	NASON CR 45.0888	4	4	5
2009	2005	051575	ENTIAT R 46.0042	4	7	4
2009	2005	052676	NASON CR 45.0888	4	10	4
2008	2003	051789	ENTIAT NFH	1	2	5
2008	2004	051177	DRYD DAM+TUM FCF+CHI	1	2	4
2008	2004	051584	DRYD DAM+TUM FCF+CHI	4	4	4
2008	2004	052575	DRYD DAM+TUM FCF+CHI	1	4	4
2008	2004	054861	DRYD DAM+TUM FCF+CHI	1	4	4
2008	2004	052576	METHOW R 48.0002	2	9	4
2008	2004	051584	NASON CR 45.0888	5	4	4
2008	2004	052576	NASON CR 45.0888	2	10	4
2008	2004	054861	NASON CR 45.0888	2	8	4
2008	2004	052575	WENATCHEE R 45.0030	3	12	4
2007	2001	050789	DWORSHAK NAT. HATCH	1	1	6
2007	2001	050790	LTL WHITE SALMON NFH	1	2	6
2007	2004	052576	LTL WHITE SALMON NFH	1	4	3
2006	2001	050789	METHOW R 48.0002	2	3	5
2006	2002	051493	ENTIAT NFH	1	2	4
2006	2002	051494	ENTIAT NFH	1	2	4
2006	2002	054851	ENTIAT NFH	1	2	4
2006	2002	054851	WARM SPRINGS NFH	2	3	4
2006	2002	050795	WINTHROP NFH	1	1	4
2006	2002	051493	CHEWUCH R 48.0728	2	4	4
2006	2002	054943	CHEWUCH R 48.0728	2	4	4
2006	2002	051493	ENTIAT R 46.0042	4	5	4
2006	2002	054945	ENTIAT R 46.0042	4	6	4
2005	2000	054414	WARM SPRINGS NFH	3	24	5
2005	2000	054415	WARM SPRINGS NFH	5	39	5
2005	2001	050790	ENTIAT NFH	2	4	4
2005	2001	050791	TUMWATER DAM FCF	1	3	4
2005	2001	050792	ENTIAT R 46.0042	7	12	4
2005	2001	050792	METHOW R 48.0002	4	7	4
2005	2001	050793	NASON CR 45.0888	2	2	4
2005	2001	054530	NASON CR 45.0888	2	2	4
2004	1999	054429	WARM SPRINGS NFH	2	14	5
2004	1999	054911	KLICKITAT R 30.0002	8	48	5

2004	2000	054307	DRYD DAM+TUM FCF+CHI	3	9	4
2004	2000	054415	DRYD DAM+TUM FCF+CHI	3	24	4
2004	2000	054436	DRYD DAM+TUM FCF+CHI	2	6	4
2004	2000	054438	DRYD DAM+TUM FCF+CHI	1	2	4
2004	2000	054415	ENTIAT NFH	1	8	4
2004	2000	054415	ROUND BUTTE TRAP	1	8	4
2004	2000	054414	NASON CR 45.0888	3	22	4
2004	2000	054437	NASON CR 45.0888	3	11	4
2004	2000	054438	NASON CR 45.0888	3	7	4
2004	2000	054440	NASON CR 45.0888	3	7	4
2004	2000	054440	WENATCHEE R 45.0030	5	12	4
2003	1998	054257	DRYD DAM+TUM FCF+CHI	1	8	5
2003	1998	054246	CHIWAWA R 45.0759	4	36	5
2003	1998	054257	CHIWAWA R 45.0759	4	32	5
2003	1998	054257	NASON CR 45.0888	2	17	5
2003	1998	054245	WENATCHEE R 45.0030	5	43	5
2003	1999	054912	DRYD DAM+TUM FCF+CHI	1	7	4
2003	1999	054911	ENTIAT NFH	1	6	4
2003	1999	054429	WENATCHEE R 45.0030	5	41	4
2003	2000	054440	NASON CR 45.0888	2	5	3
2002	1997	053928	NASON CR 45.0888	2	20	5
2002	1998	054258	ENTIAT NFH	1	9	4
2002	1998	054257	LTL WENATCHEE 450985	3	22	4
2002	1998	054245	NASON CR 45.0888	2	16	4
2002	1998	054246	NASON CR 45.0888	2	17	4
2002	1998	054257	NASON CR 45.0888	2	15	4
2002	1998	054259	NASON CR 45.0888	2	20	4
2002	1998	054246	WENATCHEE R 45.0030	6	48	4
2002	1998	054257	WENATCHEE R 45.0030	5	41	4
2002	1998	054258	WENATCHEE R 45.0030	3	26	4
2002	1998	054259	WENATCHEE R 45.0030	6	58	4
2001	1996	053919	CHIWAWA +CHICKAMIN	2	45	5
2001	1996	053919	LTL WENATCHEE 450985	2	34	5
2001	1996	053850	NASON CR 45.0888	2	2	5
2001	1996	053918	WENATCHEE R 45.0030	2	2	5
2001	1997	053734	DRYDEN DAM FCF	1	8	4
2001	1997	053852	CHIWAWA +CHICKAMIN	2	19	4
2001	1997	053734	NASON CR 45.0888	6	48	4
2001	1997	053852	NASON CR 45.0888	2	13	4
2001	1997	053853	NASON CR 45.0888	2	13	4
2001	1997	053928	NASON CR 45.0888	5	45	4
2001	1997	054255	NASON CR 45.0888	5	42	4
2001	1997	053734	WENATCHEE R 45.0030	10	75	4
2001	1997	053928	WENATCHEE R 45.0030	12	113	4
2001	1997	054255	WENATCHEE R 45.0030	4	34	4

2001	1997	053734	WHITE+NAPEEQUA+PANTHER	2	16	4
2000	1994	053640	LTL WHITE SALMON NFH	1	1	6
2000	1996	052831	WELLS W LADDE+METHOW	1	1	4
2000	1996	053916	WELLS W LADDE+METHOW	1	1	4
2000	1996	053925	WELLS W LADDE+METHOW	2	26	4
2000	1996	055014	WELLS W LADDE+METHOW	1	2	4
2000	1996	053848	WINTHROP NFH	1	9	4
2000	1996	053916	NASON CR 45.0888	3	3	4
1999	1994	053511	ENTIAT NFH	1	11	5
1999	1995	053920	WELLS W LADDER TRAP	1	2	4

Appendix D: Methods for Calculating a Smolt-to-Adult Return Ratio at the Leavenworth National Fish Hatchery.

Method for Calculating a Smolt-to-Adult Return Ratio

at the Leavenworth National Fish Hatchery

by

Matt Hall

Hatchery Evaluation Program

Mid-Columbia River Fisheries Resource Office

U.S. Fish and Wildlife Service

Introduction

A Smolt-to-Adult Return (SAR) is a measure of how many adult fish are produced from a cohort of juveniles. For hatcheries, it is the ratio of adult returns to juveniles released, commonly expressed as a percent (%), for the entire population produced in a single Brood Year. For example, if a release of 1,500,000 juveniles results in the return of 10,000 adults, the SAR would be 0.7% ((10,000/1,500,000)*100).

Hatcheries can calculate the number of juveniles that they release by tracking egg takes and rearing mortalities, or by using an automated counter. Calculating the number of adult fish produced from those juvenile releases is a much more complex task. Returning adults have to be accounted for in harvest fisheries, spawning ground escapement, and straying to other hatcheries, among other places. To ensure that its adult fish are identified, the Leavenworth National Fish Hatchery (LNFH) implants Coded Wire Tags (CWT's) into a portion of its juvenile population. These tags have an identification code unique to the LNFH. When an adult fish is captured and killed, such as in harvest fisheries, or recovered as a carcass on a spawning ground, the CWT can be retrieved and the origin of the fish can be determined.

RMIS

When a group of juvenile fish is tagged with a CWT, the tagging entity submits the tag code and the number of fish tagged to the Regional Mark Information System (RMIS). Subsequently, if/when an adult fish is lethally sampled, either for scientific or commercial purposes, and is found to have a CWT, the tag code and associated data are also reported to RMIS. The RMIS database houses CWT recovery data from throughout western North America and the northern Pacific Ocean. Its online interface allows users to query the database using a variety of selection criteria, and provides fisheries managers with survival and contribution data.

Observed and Estimated CWT Recoveries-When the RMIS database is queried for CWT recoveries, both "Observed" and "Estimated" recoveries are provided (Figure D1). The Observed number of recoveries is the actual number of CWT recovered from a sampling event. If every fish is sampled, the Observed number is the actual number of CWT'd adult fish returning to that specific sampling event. However, in most cases only a portion of the adult fish is checked for CWT's. In this case, an Estimated number is calculated by dividing the Observed number by a sampling rate. The sampling rate is provided by the reporting agency when they submit CWT data to RMIS.

TAGCODE	YEAR	AGCY	FC	SITE NAME	OBS'D	EST'D	MEAS'D	AVG MM
051584	2007	FWS	50	LEAVENWORTH HATCHERY	10	26	10	511
051584	2008	ADFG	10	AK M 1 NW 113-45	1	3		
051584	2008	FWS	50	LEAVENWORTH HATCHERY	168	170	168	797
051584	2008	ODFW	21	ABOVE BNVILLE NET	22	100	22	762
051584	2008	ODFW	21	COL R ZONE 4 NET	4	9	4	745
051584	2008	ODFW	21	COL R ZONE 5 NET 45	9	20	9	765
051584	2008	ODFW	21	COL R ZONE 5 NET ARE	17	36	17	749
051584	2008	ODFW	44	COL R OR SPORT SEC 1	4	15	4	788
051584	2008	ODFW	44	COL R OR SPORT SEC 2	12	44	12	769
051584	2008	ODFW	44	COL R OR SPORT SEC 3	14	49	14	752
051584	2008	ODFW	44	COL R OR SPORT SEC 5	1	4	1	720
051584	2008	ODFW	44	COL R OR SPORT SEC 8	2	7	2	740
051584	2008	ODFW	44	COL R WA SPORT SEC 2	4	15	4	800
051584	2008	ODFW	44	COL R WA SPORT SEC 3	10	33	10	782
051584	2008	ODFW	44	COL R WA SPORT SEC 9	1	3	1	940
051584	2008	ODFW	44	COL R WN SPORT SEC 1	2	7	2	785
051584	2008	ODFW	46	THE DALLES POOL UPPE	5	5	5	788
051584	2008	ODFW	55	BVILLE POOL UM TRIBE	2	2	2	805
051584	2008	ODFW	61	CORBETT TEST	2	2	2	788
051584	2008	WDFW	24	DRANO LK (SKAM)	1	0	1	740
051584	2008	WDFW	50	DRYD DAM+TUM FCF+CHI	4	4	4	855
051584	2008	WDFW	54	ICICLE CR 45.0474	2	7	2	770
051584	2008	WDFW	54	NASON CR 45.0888	2	5	2	760
051584	2009	FWS	50	LEAVENWORTH HATCHERY	41	41	41	902
051584	2009	ODFW	21	COL R ZONE 5 NET 45	2	4	2	813
051584	2009	ODFW	21	COL R ZONE 5 NET ARE	4	8	4	911
051584	2009	ODFW	44	COL R OR SPORT SEC 2	2	8	2	875
051584	2009	ODFW	44	COL R OR SPORT SEC 3	1	4	1	1020
051584	2009	ODFW	44	COL R OR SPORT SEC 9	1	4	1	850
051584	2009	ODFW	44	COL R WA SPORT SEC 3	1	4	1	900
051584	2009	WDFW	46	ICICLE CR 45.0474	1	4	1	940
051584	2009	WDFW	54	NASON CR 45.0888	1	4	1	900

Figure D1. An example RMIS query output showing Tag Code, Recovery Year, Recovery Locations ("SITE NAME"), Observed recoveries ("OBS'D"), and Estimated recoveries ("EST'D"), and other information.

RMIS SAR-Because both the number of CWT'd juveniles released and the number of CWT's recovered from adults are reported to RMIS, an SAR can be calculated (Figure D2). The calculation relies on accurate reporting by harvest managers and monitoring agencies. If CWT recoveries go unreported, the RMIS calculated SAR will be lower than the actual SAR. It is far more likely that CWT recoveries are *under reported* (i.e. not reported) than *over reported* (i.e. report recoveries that did not happen).

```
12:56:30 07/22/2013                    Regional Mark Information System                          PAGE 1
REPORT: SA1                              SPECIES SURVIVAL ANALYSIS
                                            SPECIES: Chin

Tagcode      BrYr Date Rel  Release Location....  Hatchery Location...  #CWT.... LossRt  #Non-CWT.  Total Rel  #Obs. #Est.... % Surv
050794       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY    105632      0      95519     201151     45    72.52   0.07
050795       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY    109344      0      51200     160544     86   156.03   0.14
050897       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     54701      0      59061     113762     20    38.71   0.07
050898       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     59630      0      57837     117467     46    84.84   0.14
050899       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     57734      0      52758     110492     65   118.54   0.21
051493       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY    104742      0      58519     163261     60   114.47   0.11
051494       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY    104896      0      56794     161690     66   110.54   0.11
054851       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     31640      0      26098      57738     30    52.79   0.17
054943       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     48349      0      35739      84088     34    68.79   0.14
054944       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     47959      0      35279      83238     20    34.38   0.07
054945       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     49748      0      34406      84154     19    37.21   0.07
054946       2002 20040419  ICICLE CR    45.0474  LEAVENWORTH HATCHERY     47627      0      36888      84515     25    42.01   0.09

Release Group Percent Survival: (%.Surv) = (Total(Estimated.Number))(100) / (Number.Released.CWT)
This report is sorted by:  1) Species Name; 2) Brood Year; 3) Tag Code.
```

Figure D2. An example RMIS query output showing an SAR ("% Surv") for juveniles released from the LNFH from Brood Year 2002.

LNFH SAR-The LNFH does not rely solely on RMIS to calculate its SAR because LNFH-origin CWT recoveries are known to be missing from the database. For example, there are no (0) recoveries of CWT's reported to RMIS from the Icicle Creek Tribal harvest, however in most years this fishery is known to be the largest termination point for LNFH-origin spring Chinook outside of the LNFH hatchery. Because data is known to be missing from the RMIS database, the LNFH uses data from a variety of sources to calculate an SAR, and uses RMIS data only when no other data is available.

The LNFH divides its CWT recoveries into 5 recovery areas: 1) LNFH hatchery returns, 2) Icicle Creek Tribal harvest, 3) Icicle Creek non-Tribal harvest, 4) Icicle Creek spawning escapment, and 5) out-of-basin recoveries. These recovery areas cover all of the locations where LNFH-origin adult fish could be lethally intercepted, with the majority occurring in the first 4 areas (few LNFH-origin adults are terminally intercepted outside of the Icicle Creek basin). Because of the intense management of spring Chinook salmon in the Icicle Creek basin, fish in recovery areas 1-4 are extensively monitored through harvest creels, spawning ground surveys, and hatchery sampling. These monitoring efforts produce return estimates, or in some cases, such as at hatcheries, actual adult return counts. Using this "local' return data to calculate an SAR is preferable to using CWT recoveries reported to RMIS because often only small numbers of CWT's are recovered, and in some cases, no CWT's are reported (Table D1).

Table D1. LNFH SAR data source possibilities.

	LNFH Hatchery Return	**Icicle Creek Tribal Harvest**	**Icicle Creek non-Tribal Harvest**	**Icicle Creek Spawning Escapement**	**Out-of-Basin Recoveries**
CWT-Derived SAR	RMIS	RMIS	RMIS	RMIS	RMIS
Locally-Derived SAR	Local Data	Local Data	Local Data	Local Data	RMIS

LNFH SAR Calculations-To calculate an SAR using locally-derived data, the age composition of LNFH adult returns is applied to the creel estimate of the Icicle Creek Tribal and non-Tribal harvests and the

Icicle Creek spawning escapement estimate (where age-6 spring Chinook salmon returned, these fish were added to the age-5 classes). This provides the Brood Year contribution to recovery areas 1-4. For the fifth recovery area (out-of-basin recoveries), the RMIS-reported CWT recovery data is expanded by the CWT mark rate, providing an estimated adult return to that recovery area. Combining all of these adult return estimates, and dividing by the total number released in each Brood Year results in a SAR. An example of a locally-derived SAR, using Brood Year 2002 data, is given in Table D2.

Table D2. Brood Year 2002 SAR calculations.

Brood Year	Recovery Year	Total Return to LNFH	Age 3 Returns Attributed to Brood Year 2002	Age 4 Returns Attributed to Brood Year 2002	Age 5 Returns Attributed to Brood Year 2002	Proportion Attributed to Brood Year 2002
2002	2005	2560	64	2351	145	0.03
	2006	1957	14	1626	317	0.83
	2007	1708	355	980	373	0.22

Recovery Year	Icicle Creek Tribal Harvest Estimate[1]	# Attributed to Brood Year 2002	Icicle Creek non-Tribal Harvest Estimate[2]	# Attributed to Brood Year 2002	Icicle Escapement Estimate[3]	# Attributed to Brood Year 2002
2005	1063*.03	27	103*.03	3	0*.03	0
2006	588*.83	489	529*.83	440	66*.83	55
2007	751*.22	164	115*.22	25	21*.22	5

Recovery Year	Total # Attributed to Brood Year 2002	Expanded Out-of-Basin CWT-Derived Estimate[4]	Total Brood Year 2002 Adult Return Estimate	Brood Year 2002 Total Release	Locally-Derived SAR (%)	CWT-Derived SAR (%)
2005	94 (64+27+3+0)	0	3648	1,422,100	0.26	0.11
2006	2610 (1626+489+440+55)	244				
2007	567 (373+164+25+5)	133				

[1]Icicle Creek Tribal harvest estimate provided by the Yakama Nation and the Colville Confederated Tribes.
[2]Icicle Creek non-Tribal harvest estimate is provided by the Washington Department of Fish and Wildlife.
[3]Icicle Creek escapement estimate is provided by the Chelan County Public Utility District.
[4]Out of basin CWT estimate provided by RMIS. Mark expansion for Brood Year 2002 provided by the LNFH.

Locally-derived and CWT-derived SAR's for the Brood Years 1995-2002 are given in Table D3. When locally-derived SAR's are compared to CWT-derived SAR's, the SAR with locally-derived data is 1.48 times that of the CWT-derived SAR (Figure D3). This relationship demonstrates the effect of under-reporting (or not reporting) CWT recoveries, and the shortcomings of relying solely on RMIS for SAR calculations. Reflecting more accurate data, the locally-derived SAR is used in all LNFH reporting.

Table D3. LNFH SAR calculation comparisons.

	2002	2001	2000	1999	1998	1997	1996	1995
Locally-Derived SAR	0.26%	0.38%	0.32%	0.15%	1.30%	1.30%	0.64%	0.17%
CWT-Derived SAR	0.11%	0.26%	0.40%	0.11%	0.90%	0.80%	0.36%	0.13%

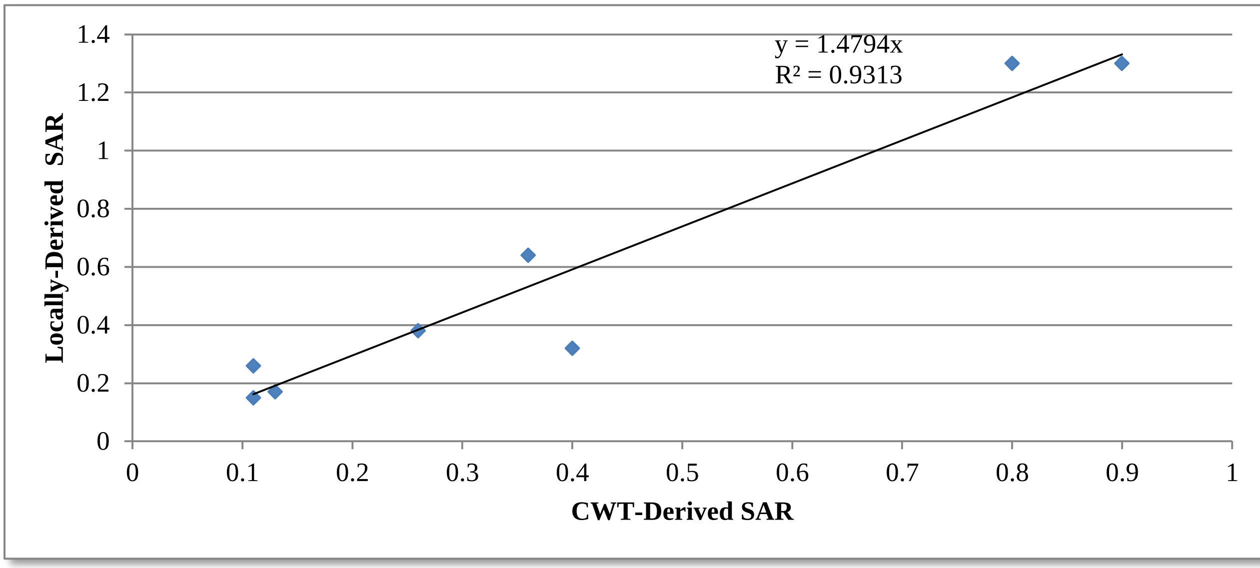

Figure D3. Relationship between two methods of calculating the LNFH SAR.

Appendix E: Brood Year 2002 Outside-of-Icicle-Creek-Basin Coded Wire Tag Recoveries.

Table E1. Brood Year 2002 outside-of-Icicle Creek-basin coded wire tag recoveries.

Brood Year	Recovery Year	CWT Code	RMIS Fishery Description	RMIS SITE NAME	Estimated N Based on Sample Rate	Expanded N Based on Mark Rate
2002	2006	050794	Treaty Ceremonial	BONNEVILLE POOL CERE	1	2
2002	2006	050795	Treaty Ceremonial	BONNEVILLE POOL CERE	3	4
2002	2006	050898	Treaty Ceremonial	BONNEVILLE POOL CERE	1	2
2002	2006	050899	Treaty Ceremonial	BONNEVILLE POOL CERE	1	2
2002	2006	051494	Treaty Ceremonial	BONNEVILLE POOL CERE	4	6
2002	2006	054945	Treaty Ceremonial	BONNEVILLE POOL CERE	1	2
2002	2007	050795	Treaty Ceremonial	BONNEVILLE POOL CERE	2	3
2002	2007	051493	Treaty Ceremonial	BONNEVILLE POOL CERE	4	6
2002	2006	051493	Spawning Ground	CHEWUCH R 48.0728	2	3
2002	2006	054943	Spawning Ground	CHEWUCH R 48.0728	2	3
2002	2006	054943	Columbia River Sport	COL R OR SPORT SEC 3	4	7
2002	2007	050794	Columbia River Sport	COL R OR SPORT SEC 4	4	8
2002	2007	050795	Columbia River Sport	COL R OR SPORT SEC 4	4	6
2002	2006	050795	Columbia River Sport	COL R OR SPORT SEC 9	17	25
2002	2006	050899	Columbia River Sport	COL R OR SPORT SEC 9	12	23
2002	2006	050794	Columbia River Sport	COL R OR SPT SEC 10	4	8
2002	2006	051493	Columbia River Sport	COL R OR SPT SEC 10	9	14
2002	2006	051494	Columbia River Sport	COL R OR SPT SEC 10	4	6
2002	2006	050795	Columbia River Sport	COL R WA SEC 10	9	13
2002	2006	050897	Columbia River Sport	COL R WA SEC 10	4	8
2002	2006	050898	Columbia River Sport	COL R WA SEC 10	4	8
2002	2006	050899	Columbia River Sport	COL R WA SEC 10	4	8
2002	2006	054851	Columbia River Sport	COL R WA SEC 10	4	7
2002	2006	054944	Columbia River Sport	COL R WA SEC 10	4	7
2002	2006	050899	Columbia River Sport	COL R WA SEC 4	4	8
2002	2006	051493	Columbia River Sport	COL R WA SEC 4	4	6
2002	2007	050899	Columbia River Sport	COL R WA SEC 4	4	8
2002	2007	054945	Columbia River Sport	COL R WA SEC 4	4	7
2002	2006	054851	Columbia River Sport	COL R WA SEC 6	4	7
2002	2007	050795	Columbia River Sport	COL R WA SEC 6	4	6
2002	2006	050897	Columbia River Sport	COL R WA SPORT SEC 8	4	8
2002	2006	051493	Columbia River Sport	COL R WA SPORT SEC 8	8	12
2002	2007	051493	Columbia River Sport	COL R WA SPORT SEC 8	4	6
2002	2007	050898	Columbia River Gillnet	COL R ZONE 1 NET	2	4
2002	2007	050795	Columbia River Gillnet	COL R ZONE 2 NET	9	13
2002	2007	050899	Columbia River Gillnet	COL R ZONE 2 NET	4	8
2002	2007	051493	Columbia River Gillnet	COL R ZONE 2 NET	4	6

2002	2007	051494	Columbia River Gillnet	COL R ZONE 2 NET	5	8
2002	2007	054851	Columbia River Gillnet	COL R ZONE 2 NET	2	4
2002	2007	054943	Columbia River Gillnet	COL R ZONE 2 NET	4	7
2002	2007	054944	Columbia River Gillnet	COL R ZONE 2 NET	3	5
2002	2007	054945	Columbia River Gillnet	COL R ZONE 2 NET	4	7
2002	2007	054946	Columbia River Gillnet	COL R ZONE 2 NET	4	7
2002	2007	050795	Columbia River Gillnet	COL R ZONE 3 NET	2	3
2002	2007	050899	Columbia River Gillnet	COL R ZONE 3 NET	2	4
2002	2007	054851	Columbia River Gillnet	COL R ZONE 3 NET	2	4
2002	2007	054945	Columbia River Gillnet	COL R ZONE 4 NET	2	3
2002	2006	054944	Columbia River Gillnet	COL R ZONE 5 NET ARE	1	2
2002	2006	051493	Hatchery	ENTIAT NFH	1	2
2002	2006	051494	Hatchery	ENTIAT NFH	1	2
2002	2006	054851	Hatchery	ENTIAT NFH	1	2
2002	2006	051493	Spawning Ground	ENTIAT R 46.0042	5	8
2002	2006	054945	Spawning Ground	ENTIAT R 46.0042	6	10
2002	2006	050794	Ocean Troll (non-treaty)	MARINE AREA 3	2	4
2002	2006	050795	Ocean Troll (non-treaty)	SWTR 023-000	5	7
2002	2006	050795	Freshwater Sport	THE DALLES POOL UPR	1	1
2002	2006	054851	Hatchery	WARM SPRINGS NFH	2	4
2002	2006	050795	Hatchery	WINTHROP NFH	1	1
2002	2006	054943	Columbia River Gillnet	YOUNGS BAY NET AREA	1	2

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