Monitoring and Evaluation Updates for John Day/The Dalles Dam Mitigation Programs at Spring Creek and Little White Salmon National Fish Hatcheries - FY 2023 Annual Report

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Abstract - The John Day/The Dalles Dam Mitigation (JDTD) program provides mitigation for the escapement of 30,000 adult fall Chinook salmon (*Oncorhynchus tshawytscha*) due to the loss of spawning habitat and production caused by construction of the John Day and The Dalles Dams in the Columbia River. The program is funded by the U.S. Army Corps of Engineers (USACE) and operates with a total adult production (TAP) goal of 107,000 adults to replace the loss of 30,000 spawning adults (which include all adults harvested in saltwater and freshwater, returns to the hatchery, strays to other facilities, and any adults observed on the spawning grounds). Working towards this TAP goal, juvenile fall Chinook are reared and released from numerous state, tribal, and federally-operated hatcheries. Spring Creek and Little White Salmon National Fish Hatcheries (NFHs) annually contribute to the TAP goal of the JDTD program through the coordinated rearing and release of juvenile tule and upriver bright fall Chinook. In the past ten years, Spring Creek NFH has annually released a mean of 10.7 million juvenile tules into the Columbia River. Over the past 10 brood years, the program has contributed a mean of 87,322 adult tules (including 66,120 for harvest) annually to the JDTD program TAP goal. Since 2014, Little White Salmon NFH has annually released a mean of 4.4 M juvenile upriver brights into the Little White Salmon River. Over the past 10 brood years, the program at Little White Salmon NFH contributed a mean of 34,133 adult upriver brights (including 17,594 for harvest) annually to the JDTD program TAP goal. Congressional mandated mass marking of juveniles prior to release from both Spring Creek and Little White Salmon NFHs has been conducted to allow selective harvest of hatchery-reared individuals and protection of wild fish stocks. Additionally, coded-wire and PIT tagging of juveniles at both facilities has provided knowledge on timing of juvenile migration, downstream survival, number of adult returns to the facilities by brood year, smolt-to-adult survival rates, and tracking of fish straying. Additional monitoring and evaluation projects for both facilities are ongoing or currently being developed to determine the success and longevity of the programs in meeting their mitigation goals as well as ESA compliance through Biological Opinions as part of the JDTD program.

Disclaimer:

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Introduction

Extensive hydropower development on the Columbia River during the 20th century altered habitats and led to rapid declines of wild salmonid populations in the mainstem (Fraley et al. 1989; Bottom et al. 2005). A prominent change in hydromorphology within the Columbia River Gorge occurred in 1957 due to the completion of The Dalles Dam which was constructed by the U.S. Army Corps of Engineers (USACE) for hydropower generation and navigation. The impoundment created by The Dalles Dam flooded the town of Celilo and submerged Celilo Falls, a productive fishing site which was utilized by several native tribes on the Columbia River. In 1971, the John Day Dam was completed approximately 40 kilometers upstream of The Dalles (Figure 1), leading to further loss of spawning habitat and decreased production of fall Chinook salmon (*Oncorhynchus tshawytscha*) in the mainstem of the Columbia River.

To offset the inundation of spawning habitat and reduced fall Chinook salmon production due to construction of the John Day and The Dalles Dams, Congress authorized the John Day/The Dalles Dam Mitigation (JDTD) program. Mitigation included financial settlements to the Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of Warm Springs Reservation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe for the submergence of Celilo Falls, and the development of hatchery programs to compensate for the loss of spawning adult Chinook in the mainstem. Using historical data on adult returns and smolt-to-adult survival rates, the USACE negotiated with *U.S. v Oregon* parties in 2013 to provide mitigation for the escapement of 30,000 adult Chinook salmon as part of the JDTD program. To meet the escapement goal, hatchery programs collectively operate with a total adult production (TAP) goal of 107,000 adults which includes all adults harvested in saltwater and freshwater, returns to the hatchery, strays to other facilities, and any adults observed on spawning grounds. The goal is to have 25% of the TAP composed of tule (or early-run) fall Chinook which begin migrating from the Pacific Ocean in August to spawn from late September to November (PFMC 2011). The other 75% of the TAP goal consists of upriver bright (URB; or late-run) fall Chinook which begin migrating up the Columbia River in August, but spawn from mid-October to December. The 25% tule and 75% URB split was an “In Kind / In Place” goal set when considering the impact that both The Dalles and John Day Dams had on spawning and rearing habitat as well as upstream and downstream fisheries. Collectively, the TAP goal is to be achieved through the coordinated rearing and release of juvenile tule and URB fall Chinook from numerous existing (and planned) state, tribal, and federally-operated facilities.

Spring Creek National Fish Hatchery (NFH) and Little White Salmon NFH (Figure 1) are two federally-operated facilities with fall Chinook production programs that are part of the JDTD program. At Spring Creek NFH, juvenile tules are annually released from the hatchery directly into the mainstem of the Columbia River in April and May. For the production program at Little White Salmon NFH, a proportion of juvenile URBs are annually reared and released from the facility into the Little White Salmon River in June and July. Additionally, as part of the JDTD program, the facility transfers URB juveniles to the Yakima River-Prosser Hatchery program, and URB eggs to the state-operated Bonneville Hatchery to support the Umatilla and Yakima River programs. Juvenile fish released as part of the JDTD program provide locally adapted adult broodstock as well as harvest opportunities for sport, commercial, and tribal fishermen, contributing to the TAP goal and mitigation agreements negotiated by *U.S. v Oregon* parties and USACE.

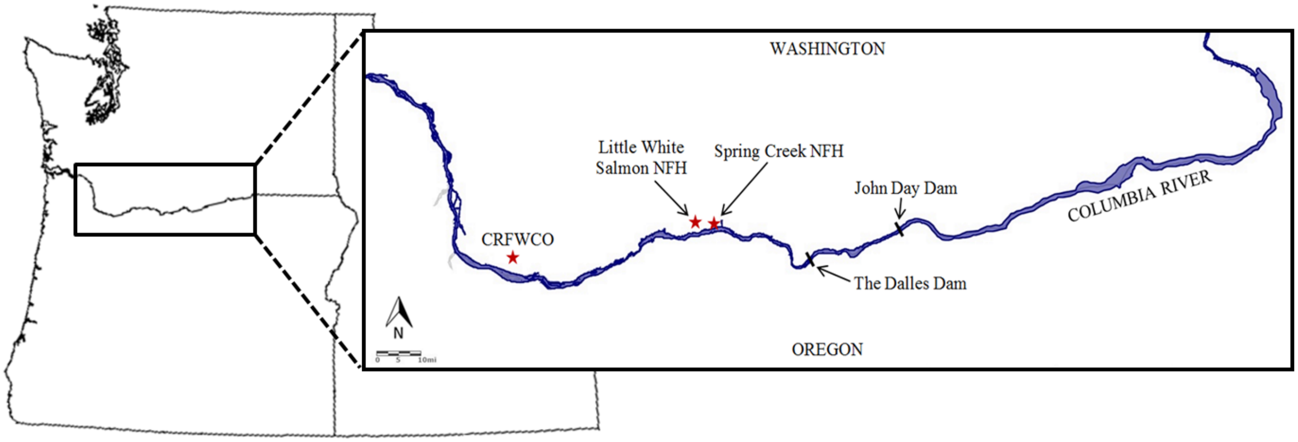

Figure 1. Spring Creek and Little White Salmon NFHs are located on the Washington side of the Columbia River downstream of the John Day and The Dalles Dams. Monitoring and evaluation of the fall Chinook production programs at these facilities is conducted by staff at the Columbia River Fish and Wildlife Conservation Office (CRFWCO) located in Vancouver, Washington.

Juvenile fish reared at Spring Creek and Little White Salmon NFHs are mass marked by removal (clipping) of the adipose fin due to a congressional mandate (February 20, 2003, Public Law 108-7) implemented in release year 2005 requiring all production fish from federal funded facilities intended for harvest to be externally marked. Absence of an adipose fin delineates hatchery-reared fish from wild stocks allowing for selective harvest of adult returns in both saltwater and freshwater fisheries. In addition to an adipose fin-mark, a proportion of the juveniles are marked with coded-wire tags (CWT) in the snout prior to release. CWT marking allows researchers to estimate smolt-to-adult survival, determine age structure of adult returns, and evaluate the contribution of the annual juvenile release to the TAP goal by tracking the number of adults recovered during harvest, at the spawning grounds, and as returns to the hatchery. Data is utilized by staff at the facilities and the Columbia River Fish and Wildlife Conservation Office (CRFWCO) for monitoring and evaluating the effectiveness of the production programs in meeting overall mitigation agreements, and for limiting the effects of production programs on fish stocks listed under the U.S. Endangered Species Act (ESA). Fish that have CWTs but are not adipose fin-marked are referred to as double-index tagged (or DIT) fish and are utilized by harvest managers as a proxy for determining the impacts of catch-and-release fisheries on wild fish.

For fiscal year (FY) 2023, the U.S. Fish and Wildlife Service (USFWS) requested funding from the USACE in the amount of $5,351,228 to support the JDTD programs at Spring Creek and Little White Salmon NFHs. Funds supported costs associated with juvenile production, mass marking, tagging, facility operations, and monitoring and evaluation efforts at the CRFWCO to allow for best management practices as outlined in the National Marine Fisheries Service (2007) and (2017) Biological Opinions. The purpose of this report is to provide an annual update summarizing results of the monitoring and evaluation programs conducted over the past ten years, discuss whether facilities are meeting objectives outlined in their Hatchery and Genetic Management Plans (HGMPs), and identify any special studies or notable trends with the fall Chinook production programs at Spring Creek and Little White Salmon NFHs that are supported by JDTD funds.

For previous Columbia River Fish and Wildlife Program Office reports, please see:
https://www.fws.gov/office/columbia-river-fish-and-wildlife-conservation/reports

Spring Creek NFH: Tule Program

Spring Creek NFH (Figure 2) was established in 1901 and is located at river kilometer (rkm) 269 of the Columbia River near the towns of Underwood and White Salmon, WA. The tule fall Chinook program at the facility contributes to fulfilling tribal trust mandated responsibilities and mitigation requirements for recreational and commercial fisheries. Previous financial support to produce tule fall Chinook and monitoring and evaluation studies at the facility have been provided by funds from the Mitchell Act (administered by NMFS), USFWS (mass marking), and from the USACE as part of the JDTD program. The USACE has been providing 100% of the funding for the tule program since FY 2015 (brood year 2014). Broodstock for the tule program originated from the White Salmon River located approximately 1.5 kilometers upstream of the hatchery. The lower Columbia River White Salmon River tule stock is listed as threatened under the ESA (70 FR 37160), but the hatchery produced fish from Spring Creek NFH are exempt from take prohibitions because they are surplus to the conservation needs of the ESU and are mass marked so they can be differentiated from natural origin fish (NMFS 2007). Presently, 100% of the adults used for broodstock at Spring Creek NFH are provided by hatchery-reared, adult returns to the facility as a segregated program.

Figure 2. Aerial photograph of Spring Creek NFH located along the Columbia River. U.S. Fish and Wildlife Service stock photograph by Cheri Anderson.

On-Station Juvenile Production

a) Egg-to-Smolt Survival

Survival objectives during the early life stages are important monitoring and evaluation metrics for determining whether the hatchery is equipped to meet mitigation goals being funded by the USACE. These survival objectives include:

1. 95% or higher survival from the egg to eye up stage
2. 90% survival from the egg to fry stage; and
3. 97% survival from fry to smolt stage

Mortality can occur during each of these life stages due to disease, injury, predation, starvation, deformities, genetic anomalies, and hatchery equipment malfunction. Throughout the rearing cycle, the hatchery has a maximum Flow Index ≤ 1.5 and Density Index ≤ 0.3 to minimize disease risk (USFWS 2004a). Hatchery staff monitor these objectives to make sure facilities are meeting their production levels and determine whether alternative rearing and release practices are needed to improve on-station survival.

b) Juvenile Mass Marking, Tagging, and Release Data

Historically, Spring Creek NFH released 15.1M juvenile tule into the Columbia River in March, April, and May. Beginning in release year (RY) 2009, reprogramming at the facility changed the production level goal to 10.5M tule released in April and May, since RY 2020 the May release has been moved to a late April release. For Brood Years (BYs) 20 - 23, the Pacific Salmon Treaty funded an increase of up to two million juveniles for Southern Resident Killer Whale (SRKW) production. Any fish produced above 10.5M (*U.S. v Oregon* obligation) are credited to SRKW production. The actual number of juvenile tule released annually has varied with a mean of 10,670,542 since release year 2014 (Table 1). The facility has mean juvenile size goals of 90-120 fish/lb for the April release and 60-80 fish/lb for the May release as outlined in the hatchery's Hatchery and Genetics Management Plan (USFWS 2004a). Ninety-two percent (~10M) of the annual production is mass marked with an adipose fin-mark (AD) only. The remaining fish are tagged with CWTs with ~405K being AD and tagged with CWTs, and ~405K being tagged with CWTs only (DIT fish). The CWT marking and tagging goals comply with the minimum suggested 200,000 per release group level recommended for sub-yearling fall Chinook by the Coast-wide CWT Database Expert Panel for Pacific Salmon Commission. The numbers of juveniles that have been mass marked and tagged since release year 2014 are presented below (Table 1).

Table 1. Annual release dates, marking and tagging information, number of juveniles released, and mean size at release in April and May for juvenile tule fall Chinook released from Spring Creek NFH. Brood year is one year before release year. Data retrieved from CRiS SR80s file: 12/11/2023.

Release Year	Release Dates	River Temp. (°C)	AD + CWT	CWT Only (DIT)	AD Only	No Mark/No CWT*	Total Released	Mean Size (Fish/lb)	Annual Total Release
2014	11-Apr	8.9	205,922	205,548	5,757,948	0	6,169,418	122	10,754,482
	6-May	11.1	199,060	198,350	4,186,873	781	4,585,064	88	
2015	13-Apr	9.2	201,918	196,759	5,975,115	5,370	6,379,162	148	10,415,634
	27-Apr	10.6	190,848	191,210	3,654,414	0	4,036,472	105	
2016	11-Apr	-	203,461	201,944	5,941,689	2,278	6,349,372	112	10,167,948
	9-May	8.9	194,817	197,566	3,425,802	391	3,818,576	90	
2017	10-Apr	8.9	204,714	204,431	6,168,828	393	6,578,366	126	10,775,114
	8-May	11.3	195,800	194,472	3,802,122	4,354	4,196,748	84	
2018	9-Apr	4.4	203,899	201,850	6,266,724	2,907	6,675,380	135	10,737,862
	7-May	7.0	197,100	197,321	3,666,549	1,512	4,062,482	87	
2019	8-Apr	7.7	204,668	204,551	6,228,055	218,575	6,855,849	223	11,226,628
	6-May	8.3	197,627	197,565	3,975,216	371	4,370,779	152	
2020**	10-Apr	-	153,161	152,451	4,391,178	2,199,589	6,896,379	99	11,184,169
	13-Apr	-	149,020	147,850	2,028,753	1,962,167	4,287,790	104	
2021†	12-Apr	5.0	163,427	164,049	6,219,089	321	6,546,886	95	11,188,509
	20-Apr	6.7	196,581	196,643	4,247,245	1,154	4,641,623	83	
2022**†‡	14-Mar	-	150,585	116,714	2,011,145	8,287,850	10,566,294	204	10,576,764
	28-Apr	8.4	-	-	-	-	10,470	-	
2023	11-Apr	7.8	254,504	255,546	6,157,662	600	6,668,312	113	9,678,312
	20-Apr	8.9	149,906	149,328	2,710,189	577	3,010,000	95	
Mean	**Group 1 April**	**7.4**	**199,519**	**198,570**	**5,900,699**	**270,004**	**6,568,792**	**130.3**	**10,670,542**
	Group 2 Late Apr/May	**9.1**	**185,640**	**185,589**	**3,521,907**	**219,034**	**4,112,170**	**98.7**	

* Fish with No Mark/No CWT include unmarked releases and double index tagged (DIT) fish that shed their coded-wire tag prior to release.

**An increased number of No Mark/No CWT fish were released in 2020 when marking was suspended due to COVID-19 and in 2022 when fish were released early due to bacterial gill disease.

† All RY 2021 and 2022 juveniles produced above 10.5M for are credited to SRKW production.

‡ Fish released in 2022 were not included in the group means. March was an early release; April was an isolated population that was part of a study.

Off-Station Survival

a) PIT Tagging Program: Juvenile Migration Time

Approximately 15,000 juveniles are annually tagged by crews from the USFWS with Passive Integrated Transponder (PIT) tags prior to release from Spring Creek NFH (Table 2). PIT tagging juveniles provides real-time data as fish migrate to the Pacific Ocean and is accessible from the regional database called the Columbia Basin PIT Tag Information System (PTAGIS). PIT tag detections at fish ladders, hydropower dams, bird colonies, and the Columbia River estuary are utilized by staff at the CRFWCO to estimate juvenile migration time and survival through the Columbia River Basin. This information was also used to inform spill timing and duration need at Bonneville Dam for juvenile tule released early from Spring Creek NFH in 2022. Additionally, PIT tagged fish provide adult return run time information, estimation of straying rates, and knowledge on ecological interactions with ESA listed stocks in the Columbia River.

PIT tagged juvenile tule released from Spring Creek NFH are typically detected at Bonneville Dam located 35 kilometers downstream from the facility as they migrate to the Pacific Ocean. The detection rate of PIT tagged fish at Bonneville Dam is a function of a) migration survival from release to the dam, and b) the detection efficiency of the PIT antenna arrays at the dam. Detection efficiency at Bonneville Dam varies between and within years due to flow levels and dam operations (e.g., amount of spill, number of operating turbines, etc.). Travel times and detection rates to Bonneville Dam are estimated annually (Table 2). The average detection rate at Bonneville Dam of PIT tagged tule fall Chinook juveniles from Spring Creek NFH is approximately 5.8%, with an average median travel time from the hatchery to the dam of 2 days.

Due to the low detection rate of Spring Creek PIT tagged juveniles downstream of Bonneville Dam, at bird colony recovery sites, and at the estuary trawl survey site (NOAA), juvenile survival estimates cannot be accurately calculated.

Table 2. The number of PIT tagged juvenile tule released from Spring Creek NFH and juvenile travel time (days) to Bonneville Dam (BONN). Data retrieved from PTAGIS: 12/11/2023.

Release Year	# PIT Tagged*	# Detected at BONN	% Detected	Mean	Median	Range	75th	90th
2014	14,866	757	5.1	2	1	(0.5 - 37)	1.5	2.0
2015	14,929	847	5.7	3	2	(1 - 55)	2.5	3.5
2016	14,954	779	5.2	1	1	(0.5 - 10)	1.5	1.5
2017	14,918	513	3.4	1	1	(0.5 - 12)	1.0	1.0
2018	14,907	619	4.2	1	1	(0.5 - 54)	1.5	1.5
2019	15,225	1,519	10.0	1	1	(0.5 - 47)	1.5	2.0
2020†	-	-	-	-	-	-	-	-
2021	14,979	1,064	7.1	4	3	(2 - 56)	3.5	5.0
2022‡	-	-	-	-	-	-	-	-
2023	14,962	906	6.1	5	3	(1 - 53)	5.0	7.0
Mean	**14,968**	**876**	**5.8**	**2.2**	**2**	**(0.5 - 56)**	**2**	**3**

* Number PIT tagged is adjusted for shed tags and pre-release mortality.
† PIT tagging operations were cancelled in 2020 due to COVID-19, outmigration timing for Brood Year 2019 (Release Year 2020) could not be determined.
‡ In spring 2022, juveniles were released early due to bacterial gill disease and were not PIT tagged; outmigration timing for Brood Year 2021 (Release Year 2022) could not be determined.

Adult Returns

a) Harvest Data and Smolt-to-Adult Survival

CWT recoveries, collected by federal, state, and tribal agencies and maintained in the Regional Mark Information System (RMIS) database are used to estimate adult returns to hatcheries in the Columbia River Basin, harvested adults, and adults recovered on the spawning grounds in all watersheds (Table 3). Based on CWT recoveries from brood years for brood years 2007 - 2016, the facility has a mean smolt-to-adult survival rate of 0.76% (Table 3) which exceeds the program's goal of a 10-year-average of 0.5% smolt-to-adult survival rate outlined in the facility's HGMP (USFWS 2004a). The tule program has contributed an average 87,322 adults for the past ten Brood Years 2007 - 2016 with the highest number of returns from the April (Group 1) juvenile release group (Table 4). Off-station CWT recoveries for harvest and spawning grounds beyond Brood Year 2016 may be incomplete due to a lag in RMIS reporting.

Table 3. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery and expansion data for tule fall Chinook released from Spring Creek NFH. The smolt-to-adult survival estimate is the total number of adults (from expanded CWT recoveries) divided by juvenile fish released for that brood year, multiplied by 100 for a percentage, and rounded to the nearest hundredth. Data downloaded from RMIS TS1-Rec Report on 1/3/2024.

Brood Year	Hatchery Returns*	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total Adults†	Smolt-to-Adult Survival (%)
2007	55,022	69,779	41,277	520	166,599	1.12
2008	19,087	30,011	18,246	175	68,046	0.6
2009	20,376	30,740	21,032	151	72,512	0.67
2010	12,711	29,611	15,900	28	58,339	0.54
2011	18,558	67,380	35,806	355	122,226	1.1
2012	34,518	99,768	57,775	1,060	193,256	1.72
2013	8,842	18,898	7,791	90	35,621	0.33
2014	13,712	32,243	25,001	189	71,723	0.69
2015	13,939	18,203	14,650	150	47,801	0.47
2016	8,933	20,145	6,938	704	37,095	0.34
2017**	14,412	34,864	10,883	406	60,786	0.57
2018**	16,011	29,175	15,351	339	61,338	0.55
Mean**	**20,570**	**41,678**	**24,442**	**342**	**87,322**	**0.76**

* Hatchery returns are returns to Spring Creek NFH.
† Total Adults include other recovery locations not listed, such as strays to other hatcheries.
Due to delays in reporting to RMIS, CWT recoveries may be adjusted every year for accuracy.
** Mean calculated for Brood Years 2007 – 2016, Brood Years 2017 - 2018 may be incomplete due to a lag in RMIS reporting and are not included in the 10-year mean.

Table 4. Mean smolt-to-adult survival rates based on CWT expansion by April (Group 1) and Late April/May (Group 2) juvenile release groups. Brood Year 2007 does not include the March release. Data retrieved from RMIS 1/12/2024.

Brood Year	Release Year	Release Date	Release Group	Mean Size (Fish/lb)	Mean Smolt-to-Adult Survival (%)
2007	2008	10-Apr	1	79.81	1.49
		2-May	2	65.43	1.58
2008	2009	13-Apr	1	149.73	0.61
		1-May	2	90.87	0.58
2009	2010	12-Apr	1	111.84	0.85
		10-May	2	76.26	0.44
2010	2011	12-Apr	1	110.63	0.6
		4-May	2	88.59	0.45
2011	2012	13-Apr	1	122.64	0.94
		30-Apr	2	99.46	1.3
2012	2013	11-Apr	1	100.96	1.87
		2-May	2	79.17	1.49
2013	2014	11-Apr	1	138.7	0.47
		6-May	2	102.34	0.15
2014	2015	13-Apr	1	143.3	0.74
		27-Apr	2	105.36	0.62
2015	2016	11-Apr	1	115.8	0.55
		9-May	2	87.32	0.34
2016	2017	10-Apr	1	125.15	0.38
		8-May	2	85.25	0.3
2017*	2018	9-Apr	1	156.73	0.63
		7-May	2	88.26	0.44
2018*	2019	8-Apr	1	132.9	0.52
		6-May	2	88.7	0.6
Mean*			**1**	**119.86**	**0.85**
			2	**88.00**	**0.73**

* Mean calculated for Brood Years 2007 – 2016, Brood Years 2017 - 2018 may be incomplete due to a lag in RMIS reporting and are not included in the 10-year mean.

An average 630 CWTs have been recovered each year at Spring Creek NFH since 2014 (Table 5). The Spring Creek NFH tule fall Chinook program accounts for 99.8 percent of all recoveries; tule fall Chinook from other programs include Little White Salmon NFH (0.1%), Bonneville Hatchery (0.1%), and Coleman NFH (<0.1%).

Table 5. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Spring Creek NFH 2014 - 2023. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from CRiS CWT Recovery Reports: 1/17/2024.

Return Year	CWT Recoveries	Hatchery Origin	% of CWT Total Return
2014	484	Spring Creek NFH	100
2015	452	Spring Creek NFH	98
	8	L White Salmon NFH	2
2016	646	Spring Creek NFH	99.4
	3	Bonneville Hatchery	0.5
	1	Coleman NFH	0.2
2017	529	Spring Creek NFH	99.8
	1	Bonneville Hatchery	0.2
2018	655	Spring Creek NFH	100
2019	719	Spring Creek NFH	100
2020	630	Spring Creek NFH	100
2021	719	Spring Creek NFH	99.7
	2	Bonneville Hatchery	0.3
2022	856	Spring Creek NFH	100
2023	598	Spring Creek NFH	100
Mean	**630**		

b) Age Structure

Age structure of returning adult fish is used in pre-season forecast models and to evaluate brood year productivity. The estimated age structure can also identify potential changes and trends in age composition over time due to ecological or anthropogenic factors. Adult returns to Spring Creek NFH are sampled by hatchery personnel and the USFWS marking and biosampling crew from CRFWCO (Table 6: brood year; Table 7: return year). A subsample of adults (500 minimum) are aged by the biosampling crew using scales and CWT sampling, and the age ratios are applied to the total number of adults to estimate the overall age structure of the adult returns. The majority (~62%) of adult tule (24,707 of 40,017) return to Spring Creek NFH at Age-3, but 29% return at Age-2 (11,636 of 40,017) as precocially mature males/females. Approximately 9% of adults return at Age-4 (3,631 of 40,017) and less than 1% return at Age-5 (43 of 40,017). The facility has produced an annual mean of 40,017 adult returns to Spring Creek NFH for return years 2014 - 2023 (Table 7).

Table 6. Estimated age structure of adult tule fall Chinook returns to Spring Creek NFH by *brood year*. Data retrieved from CRiS Age Composition reports run on: 12/12/2023.

Brood Year	Age-2	Age-3	Age-4	Age-5	Total # Adults
2009	4,049	20,890	3,178	119	28,236
2010	1,867	12,615	3,433	66	17,981
2011	2,827	18,221	5,203	124	26,375
2012	10,028	36,152	3,865	0	50,045
2013	2,738	4,823	487	0	8,048
2014	8,566	11,327	352	0	20,245
2015	6,101	10,045	1,047	0	17,193
2016	5,018	6,290	486	0	11,794
2017	7,695	9,938	3,657	0	21,290
2018	7,259	20,775	2,060	117	30,211
2019*	28,740	83,202	15,724	NA	NA
2020*	26,292	46,296	NA	NA	NA
2021*	13,924	NA	NA	NA	NA
Mean	**9,623**	**23,381**	**3,590**	**43**	**23,142**

*Brood Years 2019 - 2021 are incomplete because fish have not yet returned as adults.

Table 7. Total number of adult tule fall Chinook returns to Spring Creek NFH and estimated age structure by *return year*. Data retrieved from CRiS Age Composition reports run on: 12/12/2023.

Return Year	Age-2	Age-3	Age-4	Age-5	Total # Adults
2014	10,028	18,221	3,433	119	31,801
2015	2,738	36,152	5,203	66	44,159
2016	8,566	4,823	3,865	124	17,378
2017	6,101	11,327	487	0	17,915
2018	5,018	10,045	352	0	15,415
2019	7,695	6,290	1,047	0	15,032
2020	7,259	9,938	486	0	17,683
2021	28,740	20,775	3,657	0	53,172
2022	26,292	83,202	2,060	0	111,554
2023	13,924	46,296	15,724	117	76,061
Mean	**11,636**	**24,707**	**3,631**	**43**	**40,017**

c) Bonneville Dam Detections

Since Return Year 2014, adult tule fall Chinook (≥ Age 2) PIT tagged and released from Spring Creek NFH returned to Bonneville Dam as early as Jul-31 and as late as Sep-29 with the average median Sep-04 (Table 8). An average 72% of the Spring Creek NFH tule fall Chinook adults that pass upstream through Bonneville Dam's adult ladders return to Spring Creek NFH (based on expanded PIT tag detections, not including return years with BY19 and BY21 fish).

In 2020, no fish from BY19 were PIT tagged due to COVID-19 restrictions and in 2022, no representative fish from BY21 were PIT tagged because juveniles were released early due to bacterial gill disease. Fish from these brood years (return years 2021 - 2023) are not included in the mean Bonneville Expansion or the Hatchery Return/Bonneville Expansion % (Table 8).

Table 8. Median Bonneville Dam passage date of adult tule fall Chinook PIT tagged and released from Spring Creek NFH (≥ Age 2). Confidence limits do not include detections of five fish or fewer per age group to reduce the variability and increase the accuracy of the estimate. Data retrieved from PTAGIS: 1/17/2024.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion	95% CI	Hat. Return	Hat. Return/Bonn. Expansion (%)
2014	Sep-08	Aug-24	Sep-25	59	44,216	(29,839 - 72,542)	31,801	72
2015	Sep-10	Aug-20	Sep-29	80	60,056	(46,584 - 82,881)	44,159	74
2016	Sep-03	Aug-08	Sep-26	32	23,861	(13,499 - 48,477)	17,378	73
2017	Sep-08	Aug-23	Sep-20	22	16,131	(8,730 - 31,296)	17,915	111
2018	Sep-01	Aug-21	Sep-13	29	20,131	(11,743 - 35,638)	15,415	77
2019	Sep-06	Jul-31	Sep-23	40	28,814	(18,134 - 46,370)	15,032	52
2020	Sep-02	Aug-02	Sep-18	51	36,977	(24,892 - 55,896)	17,683	48
2021*	Aug-31	Aug-22	Sep-19	39	28,656	(19,319 - 47,117)	53,172	186
2022*	Sep-06	Aug-24	Sep-15	33	24,655	(16,093 - 42,899)	111,554	452
2023*^	Sep-01	Aug-14	Sep-29	95	78,538	(59,132 - 107,439)	76,061	97
Mean*^	**Sep-04**	**Aug-15**	**Sep-21**	**48**	**36,204**		**40,017**	**72**

The expanded returns to Bonneville do not include brood years *2019 or ^2021.

d) Hatchery Ladder Detections

Since Return Year 2014, tule fall Chinook adults (≥ Age 2) PIT tagged and released from Spring Creek NFH returned to the Spring Creek NFH Ladder as early as Aug-23 and as late as Oct-02 with the average median Sep-08 (Table 9). An average 19 PIT tagged fish are detected in the Hatchery ladder each year. When expanded, the number of detections underestimate the actual return by approximately 200% (range 101% – 596%) and are not a reliable way to estimate the actual number of fish returning to the hatchery (Table 9). Fish from brood years 2019 and 2021 (return years 2021 - 2023) are not included in the mean Ladder Expansion or the Hatchery Return /Ladder Expansion % in Table 9.

Table 9. Median detection date of adult tule fall Chinook PIT tagged and released from Spring Creek NFH at the Spring Creek NFH Adult Ladder (≥ Age 2). Confidence limits do not include detections of five fish or fewer per age group to reduce the variability and increase the accuracy of the estimate. Data retrieved from PTAGIS: 11/6/2023.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Ladder Expansion	95% CI	Hat. Return	Hat. Return /Ladder Expansion (%)
2014	Sep-10	Aug-31	Oct-01	24	18,015	(9,839 - 34,036)	31,801	177
2015	Sep-13	Sep-04	Oct-02	22	16,526	(10,341 - 25,523)	44,159	267
2016	Sep-06	Aug-23	Sep-20	11	7,861	(1,924 - 11,402)	17,378	221
2017	Aug-31	Aug-30	Sep-11	5	3,435	(NA - NA)	17,915	522
2018	Sep-08	Aug-29	Sep-14	16	10,964	(5,676 - 17,407)	15,415	141
2019	Sep-13	Aug-27	Sep-22	14	10,056	(4,441 - 24,342)	15,032	149
2020	Sep-08	Aug-31	Sep-25	24	17,428	(2,926 - 12,174)	17,683	101
2021*	Sep-08	Aug-30	Sep-19	19	13,959	(7,268 - 20,635)	53,172	381
2022*	Sep-08	Aug-30	Sep-23	25	18,710	(12,083 - 28,044)	111,554**	596
2023*^	Sep-09	Aug-30	Sep-23	34	28,103	(17,588 - 49,189)	76,061	271
Mean*^	**Sep-08**	**Aug-29**	**Sep-22**	**19**	**14,506**		**40,017**	**225**

The Ladder Expansion and Hat. Return /Ladder Expansion % do not include brood years 2019* or 2021^.
** Large returns exceeded potential take estimate of 75,512 (NMNFS 2007, page 210)

Additional Monitoring and Evaluation Projects

a) Escapement of Hatchery Fish to Spawning Grounds

Coded-wire tag recovery data stored in the RMIS database allows for the estimation of the number of adults that were released from Spring Creek NFH as juveniles and observed on spawning grounds in nearby watersheds (Table 3) including the White Salmon River (Pastor 2004). Biologists at the Washington Department of Fish and Wildlife (WDFW) have been monitoring the abundance, age structure, and CWT recovery of adult tule in the White Salmon basin since 1965. Beginning in 2010, the monitoring program was expanded to include estimates for the number of hatchery-origin (for all facilities including Spring Creek NFH) versus natural-origin (wild) spawners present on the spawning grounds in the White Salmon River.

Annual spawning ground surveys conducted in the White Salmon River begin in August and end near mid-December once spawning has been completed. Included in the surveys are identification of run types (spring, tule, or URB Chinook), and escapement estimates for both hatchery-origin and natural-origin spawners (Figure 3). Escapement estimates include the number of live and dead spawners observed from Husum Falls (at rkm 12.5) to the confluence of the Columbia River during the annual surveys. Hatchery-origin individuals are identified by the lack of an adipose fin and/or the presence of a CWT (J. Wilson, WDFW, 2018 memorandum to interested parties, Washington Department of Fish and Wildlife, on the 2017 White Salmon Chinook survey methods and results). Data from the spawning surveys is accessible on the Salmon Conservation Reporting Engine (SCoRE) website operated by WDFW. Preliminary 2022 and 2023 data will not be available until spring 2024.

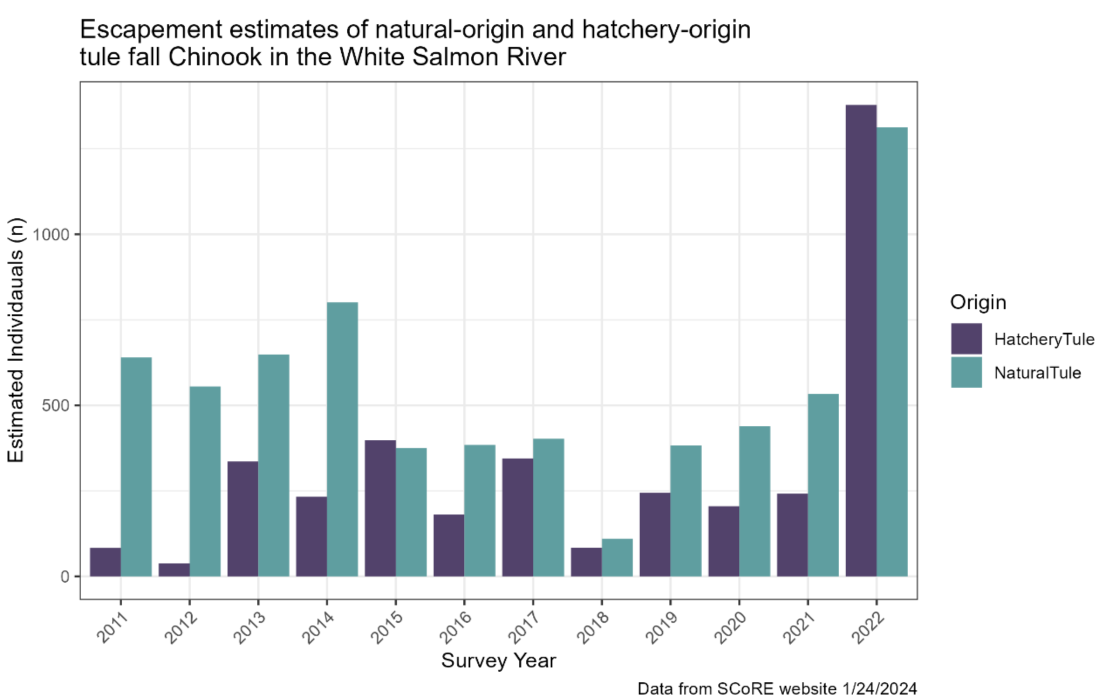

Figure 3. Annual escapement estimates of natural-origin and hatchery-origin tule fall Chinook spawning in the White Salmon River during annual spawning surveys (2011 - 2022)

As part of the JDTD program, data downloaded from SCoRE is used to estimate the proportion of hatchery-origin spawners (pHOS) for tule fall Chinook on the White Salmon River. These estimates can include hatchery fish released from Spring Creek NFH or other hatchery programs. Based on escapement estimates of natural and hatchery-origin tule for spawning ground surveys from 2011 to 2022, pHOS estimates ranged from 6% to 51% with a mean pHOS of 33% (Figure 4). It appears that the proportion of hatchery origin spawners in the White Salmon River was increasing after 2012 and reached a high of 51% in 2015 before decreasing in recent years. Reasons for this apparent increase and decrease are not known and may warrant further study. Based on adult return data from Spring Creek NFH, there is a positive correlation between the number of hatchery-origin tule on the White Salmon River spawning grounds and the number of total adult returns to the facility from 2011 - 2022 is (Pearson's) r = 0.89.

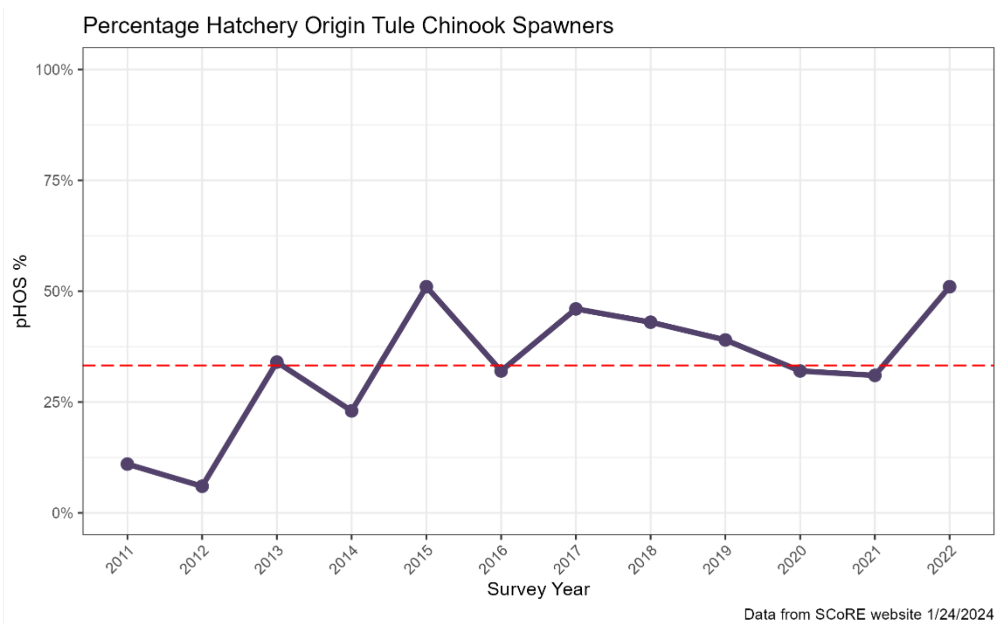

Figure 4. Estimated proportion of tule fall Chinook hatchery origin spawners (pHOS) in the White Salmon River (2011 - 2022). Dotted line is the mean (33 %).

b) Noise Mechanosensory Study

A research project was conducted at Spring Creek NFH analyzing the effect that anthropogenic noise has on the mechanosensory development of juvenile Chinook Salmon. This experiment specifically measured the development of lateral line neuromasts, inner ear hair cell density, otolith composition, and rheotactic response of fish exposed to varying levels of noise. These measures are indicators of hearing threshold and swimming efficiency in salmonids and may affect overall fitness. Spring Creek NFH provided 12,000 fertilized Chinook eggs for this study. The experimental population was initially split between heath tray enclosures and newer redd box enclosures to investigate whether initial rearing habitat had an effect on fry development. This led to a nested experimental design featuring two rearing habitats (redd box and heath tray) and three noise treatments (quiet, ambient, and a loud white noise treatment). Ultimately this design produced 6 experimental treatments with 3 replicates each. All specimens were reared on station and those not used in experiments were released by Spring Creek NFH staff. Fish were housed in Spring Creek NFH's incubation room throughout experimental treatments and never came into proximity of the production population. Prior to release, 10,470 pre-smolt fry not used for sampling were PIT tagged for future tracking. This experimental population was distinct and separate from the production population at Spring Creek NFH. To date analyses on the collected dataset are still being conducted but 2-year-old adults from this study have returned to the Columbia River Basin. At the conclusion of the study, once fish return as adults, a standalone report will be written.

Little White Salmon NFH: URB Program

Little White Salmon (LWS) NFH (Figure 5) was established in 1898 and is located on the Little White Salmon River just upstream of Drano Lake, a small body of water that converges with the Columbia River at rkm 261. The facility began rearing Upriver Bright (URB) fall Chinook in 1982 for the Mitchell Act program and to partially fulfill mitigation agreements for the JDTD program. The USACE currently provides funding for the annual production and mass marking of juvenile URBs into the Little White Salmon River, transfer of URB fingerlings to the Yakama Nation for the Yakima River-Prosser hatchery program, and transfer of URB eggs to the Bonneville Hatchery operated by the Oregon Department of Fish and Wildlife to support the Umatilla/Yakima River programs. The facility is also supported by funds from the Mitchell Act (administered by the NMFS) for egg transfers to Willard NFH and to the Yakama Nation Klickitat Hatchery URB Program, as well as the rearing and release of spring-run Chinook salmon from Little White Salmon NFH (Dammerman et al. 2017). The facility has a broodstock need of 9,300 adults to meet all program requests including USACE, Mitchell Act, and Bonneville Power Administration funded programs. The nearly 4,000 adults used as broodstock for the JDTD URB program are adult returns of hatchery-reared URB to the facility.

Figure 5. Aerial photograph of Little White Salmon NFH located on the Little White Salmon River. U.S. Fish and Wildlife Service stock photograph by Speros Doulos.

On-Station Juvenile Production

a) Production Goals

The Little White Salmon NFH URB program has on-station JDM releases, on-station SRKW releases (BY19-20 only), Willard Mitchell Act URB broodstock collection, transfers juveniles and/or eggs for the Prosser/Umatilla programs, and transfers juveniles/eggs for the Klickitat program. Table 10 summarizes the production goals for each program (not the actual releases or transfers for each year). For Brood Years 2019 and 2020, Little White Salmon NFH reared an extra ~450k URBs and Willard an extra ~200k URBs for SRKW production.

Table 10. Broodstock target collected at Little White Salmon NFH for URB Fall Chinook programs 2019 - 2023.

Brood Year	Funding	Program	Broodstock need 1:1 Males:Females	Target Green Egg Take
2019-2020	MA/COE	LWS NFH/ Prosser	1,000	1,900,000
	COE	LWS NFH	2,556	4,900,000
	MA	Willard NFH	1,186	2,250,000
2019-2022	PST	Klickitat Hatchery	3,324	6,300,000
	MA			
2019-2020	COE	Bonneville/Prosser	166	300,000
	NOAA	SRKW- Willard NFH	130	247,500
	NOAA	SRKW- Little White Salmon NFH	256	490,000
2021-2023	MA/COE	LWS NFH/ Prosser	652	1,840,000
2021-2023	COE	LWS NFH	2,556	4,900,000
	MA	Willard NFH	1,186	2,250,000
2023	MA	Klickitat Hatchery	2,105	4,000,000
2021-2023	COE	Bonneville/Prosser	166	300,000

b) Egg-to-Smolt Survival

The survival objectives for the facility are the same as Spring Creek NFH. Hatchery staff at Little White Salmon NFH monitor these objectives to make sure the facilities are meeting their production goals, and design alternative rearing and release practices to improve on-station survival as needed. Throughout the rearing cycle, the hatchery has a maximum Flow Index ≤ 1.5 and Density Index < 0.25 to minimize disease risk (USFWS 2004b)

c) Juvenile Mass Marking, Tagging, and Release Data

The original goal for the facility was to release 2.0M juvenile URBs into the Little White Salmon River (NMFS 2007); however, production expanded in RY09 (BY08) to a release goal of 4.5M juvenile URBs (NMFS 2017). For BYs 19 and 20, the Pacific Salmon Treaty funded an increase of up to 450,000 juvenile upriver bright fall Chinook for SRKW production. Any fish produced above 4.5M (*U.S. v Oregon* obligation) for these brood years are credited to SRKW production. Juveniles are released from the facility in late June to mid-July. The actual number of juvenile

URBs released from the facility is recorded by hatchery personnel and has varied for the past ten years (Table 11). Little White Salmon NFH has a mean juvenile size goal of 70-90 fish/lb at the time of release as outlined in the facility's HGMP (USFWS 2004b, 2015). Since release year 2014, the facility has annually released an average 4,393,858 juveniles with a mean size of 83.3 fish/lb. Ninety percent (~4M) of the annual production released into the Little White Salmon River is AD only. Approximately 5% are AD and CWT, and the remaining 5% are CWT only (DIT fish). The actual numbers of juveniles that have been mass marked and tagged by USFWS crews over the past 10 years are presented below (Table 11).

Table 11. Annual release dates, marking and tagging information, total number of juveniles released, and mean juvenile size for URB fall Chinook released from Little White Salmon NFH. Brood year is one year before release year. Data retrieved from CRiS SR80s File: 12/18/2023.

Release Year	Release Dates	River Temp (°C)	AD + CWT	CWT Only (DIT)	AD Only	No Mark/No CWT*	Total Released	Mean Size (Fish/lb)
2014	1-Jul, 2-Jul	7.2	267,804	99,702	4,038,588	298	4,406,392	86
2015	2-Jul	9.8	188,763	186,398	3,583,770	13,595	3,972,526	82
2016	11-Jul	7.6	196,105	196,772	3,565,052	3,186	3,961,115	85
2017	5-Jul	6.8	197,829	198,487	4,297,331	1,381	4,695,028	77
2018	11-Jul	9.0	189,005	186,872	3,475,401	13,093 (419,000) †	3,864,371 (419,000)†	78
2019	9-Jul	9.0	104,346	98,088	2,961,342	3,545	3,167,321	81
	15-Jul	9.1	97,123	96,545	1,120,176	3,490	1,317,334	90
2020‡	14-Jul	7.3	198,573	199,339	2,225,542	2,149,865§	4,773,319	85
2021‡	29-Jun	7.7	169,522	169,256	4,610,216	1,006	4,950,000	79
2022	5-Jul	7.2	196,833	198,706	4,038,267	1,621	4,435,427	89
2023	6-Jul	7.4	199,062	198,037	3,996,931	1,720	4,395,750	87
Mean		**7.9**	**200,496**	**182,820**	**3,791,262**	**219,280**	**4,393,858**	**83.3**

* Fish with No Mark/No CWT (DIT) include unmarked releases and are double index tagged fish that shed their coded-wire tag prior to release.
† Approximately 419,000 unmarked fish accidentally released on 4/18/2018 due to a loose screen. These fish are not included in totals.
‡ All juveniles produced above 4.5M for are credited to SRKW production in release years 2020 and 2021
§ In 2020 marking and tagging operations were suspended due to COVID-19. Only a portion of fish released were marked.

d) Transfer Data

The facility also transfers 1.7M URB juveniles and/or eggs to the Yakima River-Prosser Hatchery program for the Yakama Nation in late March to late April (Table 12). The transferred URB juveniles are marked prior to release with ~1.5M being adipose fin-marked only, and ~200K juveniles being adipose marked and CWT tagged with a half-length tag due to small size at marking. In 2018 and 2021, a portion (500K and 600K, respectively) of the 1.7M fish transferred to Prosser Hatchery were transferred as eggs. Of the 1.7M fish transferred in 2022 and 2023, 600K eggs were provided by Priest Rapids and/or Ringold Hatchery. The current transfer request for the Yakima River-Prosser Hatchery program is 1.1M sub-yearlings from Little White Salmon NFH and 600K eggs from either Little White Salmon NFH or Priest Rapids Hatchery. The actual number of URB juveniles that have been transferred to the Prosser program since 2014 are presented in Table 12. Little White Salmon NFH also transfers between 1.55M and 2.48M (depending on program needs and requests) URB eggs to Bonneville Hatchery operated by the Oregon Department of Fish and Wildlife to support the Umatilla and Yakima River yearling programs. In 2019, no fish or eggs were transferred due to low adult returns to Little White Salmon NFH in 2018. To fulfill full production at Little White Salmon NFH for BY 2018, approximately one million eggs were received from Priest Rapids Hatchery. Egg and juvenile production may change in the future depending on survival and program broodstock needs. In 2020 marking and tagging operations were suspended due to COVID-19, no fish were marked or CWT tagged before their transfer to Prosser Hatchery. In July 2021, an excess ~160K marked and untagged BY20 fingerlings were transferred to the Klickitat Tribal Hatchery for release into the Klickitat River due to excess overproduction at Little White Salmon NFH.

Table 12. Annual transfer dates and total number of juveniles transferred *to* the Prosser program from Little White Salmon NFH. Data retrieved from CRiS: 12/18/2023.

Transfer Year	Transfer Dates	Transfer Location	Total Transferred
2014	4/9, 4/15, 4/22, 4/30	Prosser	1,549,626
2015	4/6, 4/13, 4/15, 4/21, 4/28	Prosser	1,700,649
2016	3/30,4/5,4/11,4,14/4,18	Prosser	1,650,070
2017	4/4, 4/10, 4/13, 4/19, 4/21	Prosser	1,701,850
2018	4/16, 4/18, 4/23, 5/2	Prosser	1,203,675
2018	Fall	Prosser	500,000
2019	No Transfers		-
2020	3/31, 4/1, 4/6, 4/7, 4/9, 4/10	Prosser	1,701,568
2021	3/25, 3/31, 4/6, 4/13	Prosser	1,100,069
2021	7/14	Klickitat Tribal Hatchery	161,633
2022	3/28, 4/12, 4/18, 4/21	Prosser	1,100,000
2023	3/29, 4/5, 4/11, 4/21	Prosser	1,107,571
Annual Mean			**1,497,412**

Off-Station Juvenile Survival

a) PIT Tagging Program

PIT tagging juveniles provides real-time data as fish migrate to the Pacific Ocean and is accessible from PTAGIS. PIT tag detections at fish ladders, hydropower dams, bird colonies, and the Columbia River estuary are utilized by staff at CRFWCO to estimate juvenile migration time and survival through the Columbia River Basin. Additionally, PIT tagged fish provide adult return run time information, in-season run forecasts, estimation of straying rates, and knowledge on ecological interactions with ESA listed stocks in the Columbia River. Tagged juvenile URBs from Little White Salmon NFH are typically detected at BONN, approximately 30 kilometers downstream from the confluence of the Little White Salmon and Columbia Rivers. The detection rate of PIT tagged fish at BONN is a function of a) migration survival from release to BONN, and b) the detection efficiency of the PIT antenna arrays at the dam. Detection efficiency at BONN varies between and within years due to flow levels and dam operations (e.g., amount of spill, number of turbines in operation, etc.).

b) Migration Timing

PIT tagging of the juvenile production began with BY07 with 25,000 juvenile URBs being PIT tagged annually to monitor juvenile migration through the Columbia River basin. Beginning with BY12, the number of juveniles that were PIT tagged was decreased to 15,000 (Table 13). The average detection rate at Bonneville Dam of PIT tagged URB juveniles from Little White Salmon is approximately 13.1%, with an average median travel time from the hatchery to the dam of 11 days. A few PIT tagged juveniles take a substantially longer time to migrate downstream each year, with the longest migration time per year ranging from 39 to 78 days.

Table 13. The number of PIT tagged juvenile URB fall Chinook released from Little White Salmon NFH and juvenile travel time (days) to Bonneville Dam (BONN). Data retrieved from PTAGIS: 12/18/2023.

Release Year	Release Date	# PIT Tagged*	# Detected at BONN	% Detected	Mean	Median	Range	75th	90th
2014	2-Jul	14,925	1,785	12.0	19	17	(1.5 - 78)	26	36
2015	2-Jul	14,958	1,194	8.0	12	10	(1.5 - 44)	13	16
2016	11-Jul	14,823	1,647	11.1	12	11	(2 - 50)	13	16
2017	5-Jul	14,438	1,854	12.8	12	10	(1 - 47)	14	21
2018	11-Jul	14,840	2,467	16.6	11	10	(0.5 - 45)	12	16
2019	9, 15-Jul	14,775	1,950	13.2	14	13	(1.5 - 45)	17	21
2020	14-Jul	14,848	2,481	16.7	11	10	(1 - 77)	13	19
2021	29-Jun	14,982	2,561	17.1	12	12	(1.5 - 57)	15	16
2022	5-Jul	15,234	1,508	9.9	12	11	(1 - 52)	14	19
2023	5-Jul	14,858	2,065	13.9	11	10	(1.5 - 39)	13	16
Mean		**14,868**	**1,951**	**13.1**	**13**	**11**	**(0.5 - 78)**	**15**	**20**

* Number tagged is adjusted for shed tags and pre-release mortality

c) Juvenile Survival

PIT tag detection histories are used to estimate the apparent juvenile survival from hatchery release downstream to Bonneville Dam for Little White Salmon NFH URBs. A PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged fish to estimate the detection probability at Bonneville Dam and estimate the apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0. As a note, the term "apparent survival" is used to indicate that a tagged fish that is alive, but never migrates past Bonneville Dam, is considered a "mortality" in the model.

For the juvenile survival analysis, a PIT tagged juvenile could be encountered on three occasions: 1) at release, 2) passing downstream at Bonneville Dam, and 3) encountered after passing downstream of Bonneville Dam. Encounter histories for each PIT tagged juvenile released in a particular release were developed based on the following criteria:

- **Released**: All PIT tags in the tagging file query
- **Passing downstream at Bonneville Dam**: Tagged fish detected passing downstream of Bonneville Dam on the following PIT antenna arrays:
  - Juvenile Bypass: B2J PIT antenna site
  - Corner Collector: BCC PIT antenna site
  - Adult Ladders: PIT antennas within the adult ladders. Juvenile fish can pass downstream through the adult ladders; however mini-jacks (mature fish in year of release) can also move upstream through the ladders during the year of release. Based on the configuration of antenna sites, the directionality of ladder detections was used to separate out juvenile fish passing downstream from upstream moving mini-jacks.

- After passing downstream of Bonneville Dam:
  - Lower river trawl and pile dike sites (TWX, PD5 through PD8 interrogation sites)
  - Lower river bird colony recoveries on East Sand Island, Rice Island, Miller Sands Island, Pier 3 boat yard, and Troutdale Transmission Towers (ESANIS, RICEIS, MLRSNI, PIER3, and TTOWER mortality sites). The assumption is that the PIT tagged fish were predated on downstream of Bonneville Dam.
  - Adult ladder detections at Bonneville Dam, including mini-jack detections. The assumption is that mini-jacks at Bonneville and subsequent adult returns must have passed downstream of Bonneville Dam as juveniles.

Estimated apparent juvenile survival of the Little White Salmon NFH URBs for brood years 2012-2021 (release years 2013-2022) ranged from 0.44 to 0.88 with a mean of 0.61 (Table 14; Fig. 6). Due to the limited time and number of fish detections downstream, survival is not reported for the current release year. The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years. This is due to the addition of adult returns to the detection histories (as "downstream of Bonneville" detections), which in turn decreases the variance. Since recent years do not have adult returns, or at least not the full age complement of adult returns, the more recent estimates have larger variances. In subsequent years, as more adults from a brood year return, the variance of the estimates should decrease.

Table 14. Little White Salmon NFH Upriver Bright Fall Chinook apparent juvenile survival from release to Bonneville Dam. Estimates are median survival, and lower and upper credible intervals. The Markov chain Monte Carlo Bayesian parameter estimation method in MARK was used to estimate the variance of the estimated survival. Note: Due to the limited time and number of fish detections downstream, survival is not reported for the most recent release year. Data retrieved from PTAGIS: 12/13/2023.

Brood Year	Release Year	Median Survival	95% Lower	95% Upper
2012	2013	0.70	0.63	0.77
2013	2014	0.59	0.51	0.70
2014	2015	0.51	0.40	0.64
2015	2016	0.59	0.48	0.72
2016	2017	0.55	0.46	0.66
2017	2018	0.65	0.57	0.80
2018	2019	0.44	0.38	0.53
2019	2020	0.59	0.48	0.71
2020	2021	0.60	0.46	0.81
2021	2022	0.88	0.72	1.00
Mean		**0.61**	**0.51**	**0.73**

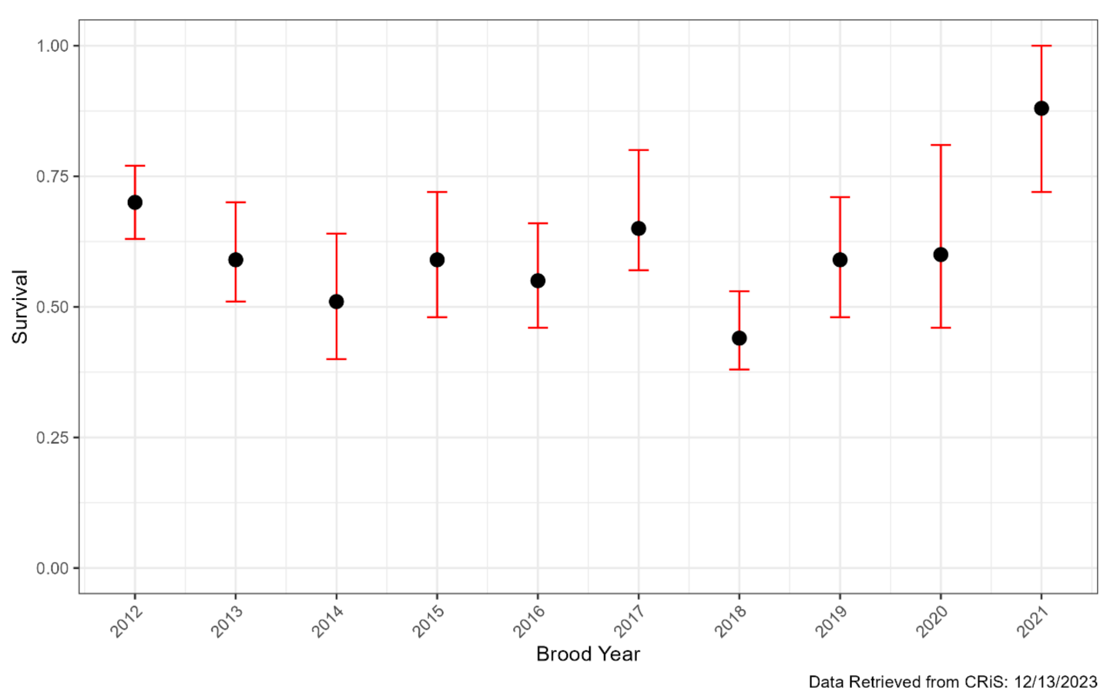

Figure 6. Little White Salmon NFH Upriver Bright Fall Chinook apparent juvenile survival from release to Bonneville Dam, (2012 - 2021). Note: Due to the limited time and number of fish detections downstream, survival is not reported for the most recent release year. Error bars are lower and upper 95% credible intervals.

Adult Returns

a) Harvest Data and Smolt-to-Adult Survival

CWT recoveries maintained in RMIS are used to estimate adult returns to hatcheries in the Columbia River basin, harvested adults, and adults recovered on the spawning grounds in all watersheds [Table 15; Pastor (2004); Pastor (2016)]. The mean smolt-to-adult survival rate is 0.84 for brood years 2007-2016 (Table 15), which has contributed a mean of 34,133 (43% of the overall TAP target of 80,250) adults annually to freshwater and ocean recoveries for brood years 2007 - 2016. Off-station CWT recoveries for harvest and spawning grounds beyond BY2016 may be incomplete due to a lag in RMIS reporting.

The Yakima River-Prosser Hatchery program has a mean smolt-to-adult survival of 0.10% (based on brood years 2001-2015) contributing an additional 1,700 adult URB fall Chinook towards the TAP goal. Release and adult recoveries for the Prosser Hatchery are monitored by the Yakama Nation.

Table 15. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery data for URB fall Chinook released from Little White Salmon NFH. The smolt-to-adult survival estimate is the total number of adults (from expanded CWT recoveries) divided by juvenile fish released for that brood year, multiplied by 100 for a percentage, and rounded to the nearest hundredth. Data downloaded from RMIS TS1-Rec Report on 1/3/2024.

Brood Year	Hatchery Returns*	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults†	Smolt-to-Adult Survival (%)
2007	14,689	6,418	5,243	1,241	27,591	1.38
2008	7,983	5,317	5,120	1,813	20,233	0.43
2009	19,289	16,154	14,902	11,909	62,254	1.37
2010	30,192	29,100	28,460	12,129	100,591	2.25
2011	4,502	4,071	3,216	3,270	15,059	0.33
2012	10,633	11,622	9,885	4,797	36,967	0.84
2013	2,571	4,234	1,981	779	9,565	0.22
2014	606	748	202	30	1,586	0.04
2015	11,871	6,886	4,405	7,824	31,093	0.78
2016	14,137	10,698	7,275	4,282	36,392	0.78
2017§	5,368	4,503	6,386	3,028	19,285	0.50
2018§	6,588	4,802	6,008	3,110	20,534	0.46
Mean§	**11,647**	**9,525**	**8,069**	**4,807**	**34,133**	**0.84**

* Hatchery returns are returns to Little White Salmon NFH.
† Total Adults includes other recovery locations not listed, such as strays to other hatcheries.
‡ Due to delays in reporting to RMIS, CWT recoveries may be adjusted every year for accuracy
§ Mean calculated for Brood Years 2007-2016, Brood Years 2017 - 2018 may be incomplete due to a lag in RMIS reporting and are not included in the 10-year mean.

An average 664 CWTs have been recovered each year at Little White Salmon NFH since 2014 (Table 16). The Little White Salmon NFH URB fall Chinook program accounts for 92.2 percent of all recoveries; URB fall Chinook from other programs include Willard NFH (7%) and Bonneville Hatchery (0.5%); other hatchery programs account for 0.3%.

Table 16. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Little White NFH 2014 - 2023. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. Data retrieved from CRiS CWT Recovery Reports: 1/25/2024.

Return Year	CWT Recoveries	Hatchery Origin	% of Total CWT Return
2014	538	L White Salmon NFH	95.7
	21	Bonneville Hatchery	3.7
	2	Lyons Ferry Hatchery	0.4
	1	Nez Perce Hatchery	0.2
2015	346	L White Salmon NFH	98
	6	Bonneville Hatchery	1.7
	1	Lyons Ferry Hatchery	0.3
2016	535	L White Salmon NFH	100
2017	262	L White Salmon NFH	91
	26	Willard NFH@Little White	9
2018	492	L White Salmon NFH	100
2019	1,315	L White Salmon NFH	99.7
	1	Klickitat Hatchery	0.1
	1	Willard NFH@Little White	0.1
	2	Willard NFH@Drano	0.2
2020	871	L White Salmon NFH	90.4
	76	Willard NFH@Little White	7.9
	12	Willard NFH@Drano	1.2
	1	Lyons Ferry Hatchery	0.1
	3	Nez Perce Hatchery	0.3
2021	562	L White Salmon NFH	89.3
	36	Willard NFH	5.7
	22	Willard NFH@Drano	3.5
	2	Bonneville Hatchery	0.3
	3	Nez Perce Hatchery	0.5
	2	Lyons Ferry Hatchery	0.3
	2	Washougal Hatchery	0.3
2022	552	L White Salmon NFH	79
	139	Willard NFH	19.9
	7	Bonneville Hatchery	1
	1	Nez Perce Hatchery	0.1
2023	643	L White Salmon NFH	81
	52	Willard NFH	7
	99	Willard NFH@ Little White	12
	1	Nez Perce Hatchery	0.1
	1	Lyons Ferry Hatchery	0.1
Annual Mean	**664**		

b) Age Structure

Age structure of returning adult fish is used in pre-season forecast models and to evaluate brood year productivity. The estimated age structure can also identify potential changes and trends in age composition over time due to ecological or anthropogenic factors. Adult returns to Little White Salmon NFH are sampled annually by hatchery personnel and the USFWS marking and biosampling crew from the CRFWCO. A subsample of adults (minimum of 500) are aged annually by the biosampling crew using scales and CWT sampling and the age ratios are then applied to the total number of adults to estimate the overall age structure of the adult returns (Table 17: brood year; Table 18: return year). The facility has produced a mean 11,556 adult returns to the hatchery each year between 2014 and 2023 (Table 18). The majority (63%) of adult URBs return to the facility at Age-4 (7,256 of 11,556), and 23% return at Age-3 (2,634 of 11,556). Approximately 2% (238 of 11,556) mature precocially returning as jacks or jills at Age-2. Approximately 12% of adults return at Age-5 (1,410 of 11,556) and less than 1% of adults return at Age-6 (19 of 11,556).

Table 17. Estimated age structure of adult URB fall Chinook returns to Little White Salmon NFH by *brood year*. Data retrieved from CRiS Age Composition Reports on 12/18/2023.

Brood Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2007	1,156	5,675	6,863	1,229	73	14,996
2008	1,021	2,990	2,770	1,501	0	8,282
2009	612	4,551	18,377	2,363	13	25,916
2010	587	15,644	17,023	2,956	75	36,285
2011	374	1,480	3,568	1,713	39	7,174
2012	658	5,558	5,675	2,000	23	13,914
2013	65	759	3,384	638	0	4,846
2014	0	300	1,179	185	0	1,664
2015	101	2,282	8,194	1,374	0	11,951
2016	676	5,861	10,812	735	25	18,109
2017	246	2,444	6,946	1,193	13	10,842
2018*	354	3,000	6,594	943	NA	NA
2019*	35	2,348	9,180	NA	NA	NA
2020*	215	2,306	NA	NA	NA	NA
2021*	25	NA	NA	NA	NA	NA
Mean	**408**	**3,943**	**7,736**	**1,402**	**24**	**13,998**

* The full age complement of adult returns for these brood years have not been recovered yet.

Table 18. Total number of adult URB fall Chinook returns to Little White Salmon NFH and estimated age structure by *return year*. Data retrieved from CRiS Age Composition Report on 12/18/2023.

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2014	658	1,480	17,023	2,363	0	21,524
2015	65	5,558	3,568	2,956	13	12,160
2016	0	759	5,675	1,713	75	8,222
2017	101	300	3,384	2,000	39	5,824
2018	676	2,282	1,179	638	23	4,798
2019	246	5,861	8,194	185	0	14,486
2020	354	2,444	10,812	1,374	0	14,984
2021	35	3,000	6,946	735	0	10,716
2022	215	2,348	6,594	1,193	25	10,375
2023	25	2,306	9,180	943	13	12,467
Mean	**238**	**2,634**	**7,256**	**1,410**	**19**	**11,556**

c) Bonneville Dam Detections

Since Return Year 2014, URB fall Chinook adults (Ages 2 - 6) PIT tagged and released from Little White Salmon NFH returned to Bonneville Dam as early as Jul-07 and as late as Nov-08 with the average median Sep-08 (Table 19). On average, 45% of URB fall Chinook adults released from Little White Salmon NFH are counted returning to the Little White Salmon NFH after passing upstream through Bonneville Dam's adult ladders (based on expansion of PIT tags).

Table 19. Median Bonneville Dam passage date of URB Fall Chinook adults PIT tagged and released from Little White NFH (Ages 2 - 6). Data retrieved from PTAGIS 12/18/2023.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion	95% CI	Hat. Return	Hat. Return/Bonn. Expansion (%)
2014	Sep-10	Aug-17	Oct-15	375	70,175	(58,673 - 86,198)	21,524	31
2015	Sep-11	Aug-15	Oct-22	302	66,095	(54,249 - 81,529)	12,160	18
2016	Sep-04	Jul-29	Sep-22	92	24,941	(17,816 - 38,159)	8,222	33
2017	Sep-12	Aug-24	Oct-12	62	18,174	(11,725 - 25,210)	5,824	32
2018	Sep-11	Aug-20	Oct-13	41	11,581	(6,472 - 24,149)	4,798	41
2019	Sep-13	Aug-22	Nov-05	83	23,703	(16,608 - 31,836)	14,486	61
2020	Sep-08	Jul-16	Oct-07	84	25,507	(17,138 - 36,442)	14,984	59
2021	Sep-02	Jul-07	Oct-01	81	24,119	(16,925 - 36,654)	10,716	44
2022	Sep-06	Aug-13	Oct-08	74	22,533	(15,140 - 33,904)	10,375	46
2023	Sep-08	Aug-22	Nov-08	49	15,539	(9,480 - 22,102)	12,467	80
Mean	**Sep-08**	**Aug-09**	**Oct-12**	**124**	**30,237**		**11,556**	**45**

d) Hatchery Ladder Detections

Since Return Year 2014, URB fall Chinook adults (Ages 2 - 6) PIT tagged and released from Little White Salmon NFH returned to the Little White Salmon NFH Ladder as early as Sep-24 and as late as Nov-16 with the average median passage date on Oct-18 (Table 20). Upriver bright fall Chinook released from Willard NFH also return to Little White Salmon NFH for spawning. Since Return Year 2018, a mean 11,556 URB fall Chinook adults (Ages 2 - 6) reared and PIT tagged at Willard NFH returned to the Little White Salmon NFH Ladder as early as Sep-30 and as late as Nov-08 with the average median Oct-21. The total number of URB fall Chinook adults reared at Willard NFH that return to the Little White Salmon NFH is unknown because not all returning fish have CWTs to indicate their hatchery of origin. All adult returns, regardless of their origin, are included in the Little White Salmon NFH hatchery count (Table 20).

Table 20. Median detection date of adult upriver bright fall Chinook PIT tagged and released from Little White Salmon NFH (LW) and Willard NFH (WI) at the Little White Salmon NFH Adult Ladder (Ages 2 - 6). Data retrieved from PTAGIS 12/18/2023.

Return Year	Mark Site	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Ladder Expansion	95% CI	Hat. Return	Hat. Return /Ladder Expansion (%)
2014	LW	Oct-23	Sep-24	Nov-05	101	18,712	(12,985 - 25,402)	21,524	115
2015	LW	Oct-27	Oct-09	Nov-08	81	17,529	(12,068 - 26,644)	12,160	69
2016	LW	Oct-16	Sep-27	Nov-05	39	10,286	(6,166 - 19,076)	8,222	80
2017	LW	Oct-20	Oct-17	Oct-26	15	4,403	(2,071 - 10,490)	5,824	132
2018	LW	Oct-24	Sep-29	Nov-14	24	6,670	(2,840 - 7,793)	4,798	72
	WI	Oct-25	Oct-20	Oct-30	3	362	-	-	-
2019	LW	Oct-22	Oct-07	Nov-16	34	9,951	(5,800 - 16,503)	14,486	146
	WI	Oct-27	Oct-20	Nov-03	2	230	-	-	-
2020	LW	Oct-23	Sep-30	Oct-05	33	10,295	(5,608 - 16,234)	14,984	146
	WI	Oct-12	Sep-30	Oct-30	6	789	-	-	-
2021	LW	Oct-22	Oct-15	Nov-14	32	9,540	(5,157 - 15,480)	10,716	112
	WI	Oct-24	Oct-19	Nov-08	10	857	-	-	NA
2022	LW	Oct-12	Oct-04	Oct-18	12	3,636	(652 - 4,670)	10,375	285
	WI	Oct-10	Oct-09	Oct-10	3	269	-	-	-
2023	LW	Oct-23	Oct-05	Nov-01	18	5,751	(2,447 - 7,844)	12,467	129
	WI	Oct-18	Oct-08	Nov-03	10	1,439	(393 - 2,322)	-	-
Mean	**LW**	**Oct-21**	**Oct-04**	**Nov-01**	**39**	**9,677**	-	**11,556**	**119**
	WI	**Oct-19**	**Oct-12**	**Oct-29**	**7**	**658**	-	-	-

Additional Monitoring and Evaluation Projects

a) Other Fish Counted and Handled at Little White Salmon NFH

The Little White Salmon NFH ladder is opened in mid-September with the goal to remain open throughout the entire URB fall Chinook salmon return to collect adult URB broodstock (if the brood pond reaches capacity, the ladder is closed until an adequate number of fish can be processed before the ladder is re-opened). Salmon and other non-target species volitionally enter and leave the fish ladder located immediately below the hatchery barrier dam before reaching the Little White Salmon NFH spawning facility. Tule fall Chinook salmon, coho salmon, chum salmon, sockeye salmon and steelhead that volunteer into the trap are sorted and those that are not adipose fin-marked or tagged with a CWT are assumed to be natural-origin and released back into the Little White Salmon River below the ladder (Table 21).

In recent years, coho salmon have returned in high numbers. In 2021, detections of PIT tagged coho confirmed that coho salmon re-entered the fish ladder multiple times after being released (Baker 2021). The majority of the coho detected by the PIT antennas were reared at Willard NFH and released at other acclimation ponds or hatcheries in the mid-Columbia River. For the 2022 fall Chinook salmon return, Parentage-Based Tagging (PBT) was used to determine potential hatchery origin of unmarked, untagged coho salmon collected at the Little White Salmon NFH. The results of a post-season PBT analysis suggested that nearly all (90 percent) of unmarked, untagged coho salmon encountered at the Little White Salmon NFH in 2022 were hatchery-origin fish (Baker et al. 2023). The majority of unmarked, untagged coho salmon genetically assigned to rearing facilities at Willard NFH (42.6 percent) followed by Eagle Creek NFH (30.5 percent), Dworshak NFH (9.9 percent), and Bonneville Hatchery (4.7 percent). Only 52 unmarked, untagged coho salmon (2 percent of the total coho salmon encountered) could not be assigned to a hatchery using the PBT baseline data available from FishGen (Baker et al. 2023). While these 52 coho salmon might have been natural-origin fish, it's also possible that they came from a hatchery or brood year not included in the PBT baseline data. The results of the PBT analysis has helped managers make more informed decisions when planning for future returns on how to handle unmarked, untagged coho salmon. In 2023, the hatchery evaluation team for Little White Salmon NFH made the decision in coordination with NMFS to remove all encountered coho salmon during the URB fall Chinook salmon return.

Table 21. Counts of non-production target fish removed and returned to river (), at the Little White Salmon NFH 2014 – 2023. Totals include both hatchery and wild fish. Data retrieved from CRiS Fish Removal files 12/31/2023.

Year	Coho	Fall Chinook	Sockeye	Chum	Rainbow Trout	Steelhead Trout
2014	615	3520	0	0	0	1
2015	77	1872	26	0	0	4
2016	156	472	2	0	4	6
2017	265	116	0	0	3 (1)	1 (6)
2018	139	80	1	0	0	1 (10)
2019	749	308	0	1	0	0 (4)
2020	1,065	426	0	0	0	0
2021	174 (2,488*)	618	0 (3)	0 (2)	0	1 (35)
2022	1984 (470*)	786	0	0	0 (1)	0 (8)
2023	677	309	0	0	0	2 (1)
Mean	**590**	**851**	**3**	**0**	**1**	**8**

* In 2021 and 2022, unmarked coho were returned to the river. Returned to river fish were encountered multiple times and are included in the total, the actual number of unique fish encountered is not known.

b) Escapement of Hatchery Fish to the White Salmon River Spawning Grounds and Impacts on Tule Populations

The White Salmon River is a tributary of the Columbia River located approximately 9 river kilometers upstream from Little White Salmon NFH. The White Salmon River supports a natural population of tule fall Chinook Salmon that are part of the Lower Columbia River Chinook Salmon ESU listed as threatened under the Endangered Species Act. Hatchery origin upriver bright fall Chinook from the Little White Salmon NFH program are known to stray into the White Salmon River, potentially negatively impacting the listed tule population (NMFS 2017). The URB hatchery stocks in the Columbia River Basin were derived from fall Chinook stocks that spawned above the historic Celilo Falls area and are not considered to be part of the Lower Columbia River Chinook Salmon ESU. Monitoring of the abundance of adult URBs in the White Salmon River basin has been conducted since 1989 (J. Wilson, WDFW, 2018 memorandum to interested parties, Washington Department of Fish and Wildlife, on the 2017 White Salmon Chinook survey methods and results), and spawning ground surveys conducted by the Washington Department of Fish and Wildlife since 2010 have included the identification of hatchery-origin (for all facilities, including Little White Salmon NFH) and natural-origin adult URB and tule fall Chinook in the White Salmon River (SCoRE Website) (Table 22; Fig. 7).

Due to COVID-19 health and saftey restrictions in 2020, approximately 45% of Little White Salmon NFH origin Brood Year 2019 fish were released unmarked. These unmarked fish will impact the WDFW White Salmon River spawning ground stray estimates in upcoming years. Natural-origin URBs may be overestimated, especially in 2023 when Brood Year 2019 fish returned as Age-4 adults.

Table 22. Estimated number of hatchery origin and natural origin upriver bright (URB) fall Chinook Salmon in the White Salmon River. Data is from WDFW spawning surveys (SCoRE website and personal communication 1/24/2024).

Year	Hatchery URB	Natural URB
2010	1,093	841
2011*	-	-
2012	361	743
2013	2,135	1,221
2014	3,208	1,636
2015	6,944	1,741
2016	1,508	621
2017	753	487
2018	1,446	991
2019	7,177	2,058
2020	2,264	1,382
2021**	3,531	2,472
2022**	4,982†	1,911†
Mean	**2,950**	**1,342**

* Escapement estimates in 2011 were unavailable due to the breach of Condit Dam.
** Approximately 45% of Brood Year 2019 Little White Salmon NFH origin fish were released unmarked.
† Draft estimate subject to change.

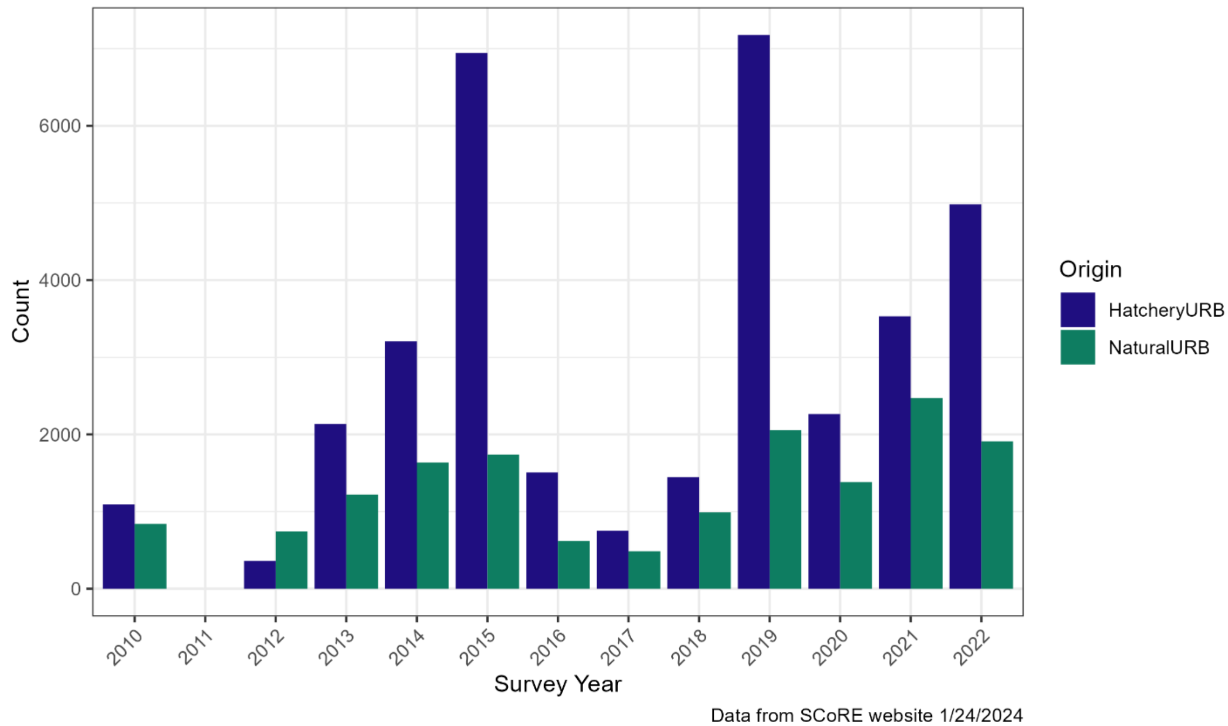

Figure 7. Escapement estimates of hatchery-origin and natural-origin upriver bright (URB) fall Chinook in the White Salmon River during annual spawning surveys (2010 - 2022). Escapement estimates in 2011 were unavailable due to the breach of Condit Dam.

It is likely that the natural-origin URBs spawning in the White Salmon River are predominately progeny of hatchery URBs that strayed and naturally spawned in the White Salmon River in previous years. Historically, natural URB populations primarily spawned in the Middle and Upper Columbia River areas, and limited spawning in areas of the lower Columbia River, including the White Salmon River. Between 2010 and 2022 the mean percentage of hatchery-origin spawners in the White Salmon River URB spawning population was 64%, with a range of 33% to 80% (Fig. 8). There appears to be little correlation between the number of hatchery-origin URBs on the spawning grounds of the White Salmon River and either the number of hatchery fish collected at Little White Salmon NFH (Pearson's r = 0.12) or the estimated total number of Little White Salmon URBs (based on PIT tag expansions) passing Bonneville Dam (Pearson's r = 0.26) each year. Return years 2015 and 2019 saw large numbers of hatchery-origin strays in the White Salmon River but relatively lower counts at Little White Salmon NFH (Table 23). The preliminary 2023 estimates of the number of hatchery-origin URBs spawning in the White Salmon River will not be available until spring 2024.

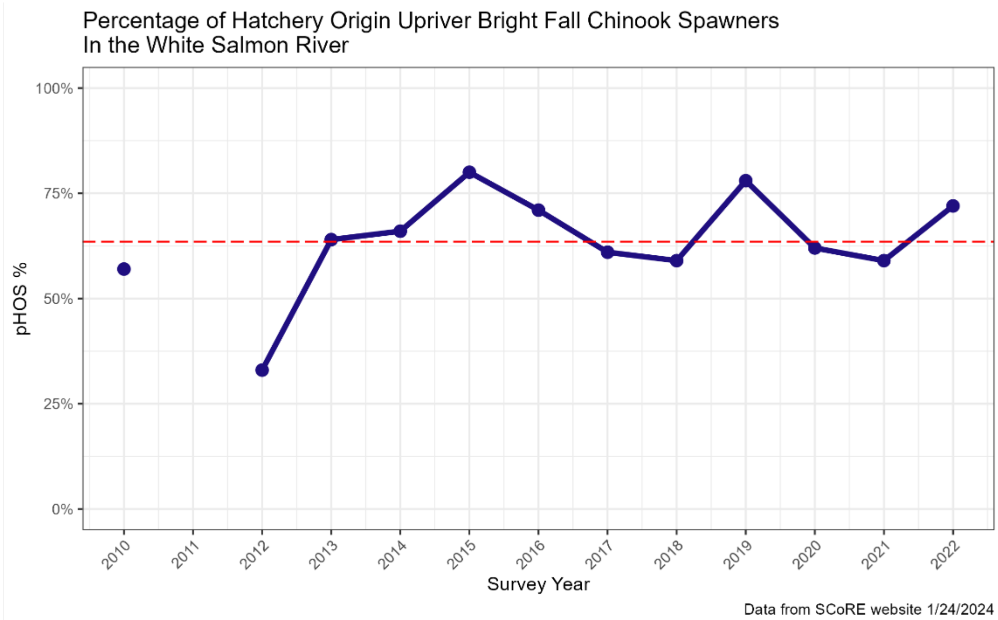

Figure 8. Estimated proportion of upriver bright (URB) fall Chinook hatchery origin spawners (pHOS) in the White Salmon River (2010 - 2022). Dotted line is the mean (63%).

Table 23. Number of hatchery upriver bright fall Chinook Salmon collected at Little White Salmon NFH and the estimated number of hatchery upriver bright fall Chinook spawning in the White Salmon River (2013-2022). Hatchery counts are from the CRiS database, WDFW estimates of all URBs (not just the LWSNFH contribution) are from the SCORE website and personal communication. Data retrieved from SCoRE website 1/24/2024.

Year	Hatchery Count	WDFW Estimate (all URBs)
2013	35,969	2,135
2014	21,524	3,208
2015	12,160	6,944
2016	8,222	1,508
2017	5,824	753
2018	4,798	1,446
2019	14,513	7,117
2020	14,992	2,264
2021	10,716	3,531
2022	10,375	4,982*

* Draft estimate subject to change.

Coded-wire tag recoveries from hatchery fish in the White Salmon River, collected during WDFW's spawning surveys, are used to estimate the total number of URB hatchery strays from an individual hatchery program. Coded-wire tags from adult returns expected to return to Little

White Salmon NFH (i.e., Little White Salmon NFH program releases and releases from the Mitchell Act Willard NFH program) represented 94%-100% of the annual total coded-wire tag recoveries in the White Salmon River (recovery years 2013-2022), with the Little White Salmon NFH component averaging 88% and Willard NFH component averaging 10% of the total annual recoveries. The total number of coded-wire tags recovered on the spawning grounds each year ranged from 133 to 1,241. Expansions of coded-wire tag recoveries to account for a) the tagging rate at juvenile release, and b) the sampling rate during the spawning surveys, can be used to estimate the total number of hatchery fish from the Little White Salmon NFH programs that are spawning in the White Salmon River (Table 24). In all years (2013-2022), except 2016 and 2017, the WDFW estimates of the total number of hatchery URBs on the spawning grounds were within the 80% confidence intervals of the total estimated number of URBs from the Little White Salmon and Willard NFH programs (Figure 9).

Table 24. Estimated number of hatchery upriver bright fall Chinook Salmon on the spawning grounds of the White Salmon River from the Little White Salmon and Willard NFH programs, and the total number of hatchery URBs estimated on the spawning ground from WDFW surveys. Coded-wire tag estimates are based on coded-wire tag recoveries and expansions for tagging rate and sampling rate. Eighty percent confidence intervals shown in parentheses are calculated based on proportions (i.e., tagging rate). Data from RMIS, WDFW SCORE website, and personal communication 1/24/2024.

Year	Little White Salmon NFH	Willard NFH	WDFW Estimate
2013	2,150 (1,275 – 4,240)	0	2,135
2014	3,233 (2,410 – 4,571)	0	3,208
2015	5,679 (3,999 – 8,834)	180 (118 – 289)	6,944
2016	703 (491 – 1,177)	0	1,508
2017	89 (89 – 99)	430 (331 – 573)	753
2018	1,023 (706 – 1,596)	263 (180 – 411)	1,446
2019	5,187 (3,651 – 7,723)	25 (25 – 31)	7,117
2020	1,864 (941 – 4,657)	28 (16 – 69)	2,264
2021	2,126 (1,483 – 3,237)	590 (405 – 906)	3,531
2022	2,452 (1,438 – 4,737)	379 (226 – 727)	4,982*

* Draft estimate subject to change.

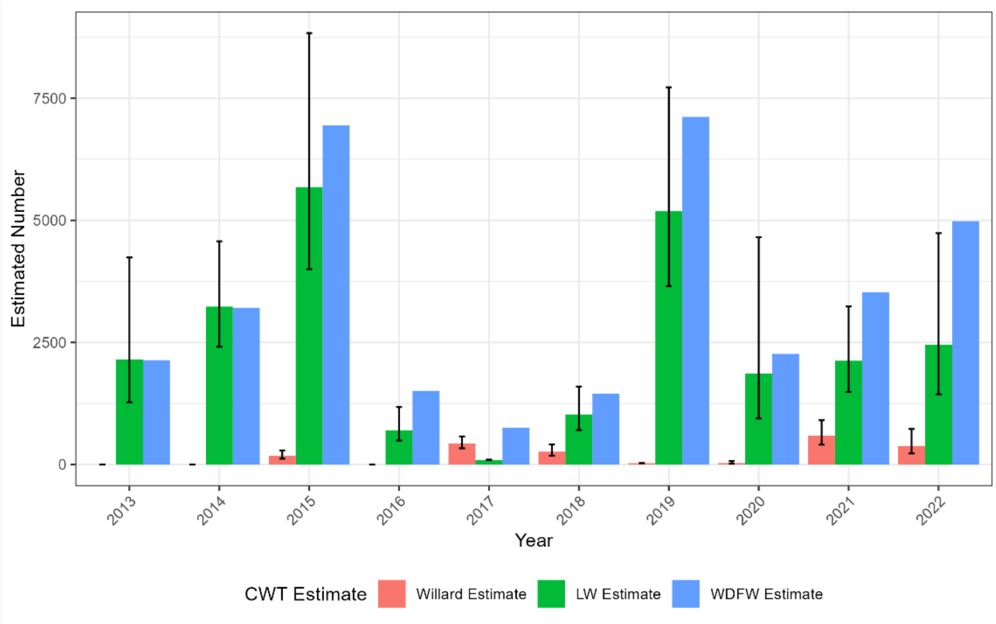

Figure 9. Estimated number of hatchery upriver bright fall Chinook from the Little White and Willard NFH programs, based on coded-wire tag expansions for tagging rate and sampling rate, and the total number of estimated hatchery Upriver Bright Fall Chinook spawning in the White Salmon River (WDFW estimate). Confidence intervals for the coded-wire tag estimates are based on the proportions of fish tagged versus total release. Coded wire tag data from RMIS 12/8/22. WDFW data 2013-2022 from SCORE website and personal communication.

A variety of environmental and anthropogenic factors have been proposed to explain the incidence of hatchery-origin strays entering the White Salmon River, though the exact causes are not well known (Silver et al. 2021). Interactions between hatchery-origin URB strays and native tule fall Chinook are believed to lead to a loss in productivity of the native tule population (e.g., through hybridization and redd superimposition) (NMFS 2017). As part of the Terms and Conditions (T&C) in the Biological Opinion for upriver bright fall Chinook increased production at Little White Salmon NFH (NMFS 2017; T&C 2b), the USFWS is to manage the abundance of hatchery-origin URB fall Chinook that spawn naturally in the White Salmon River so that the abundance does not exceed 3,000 adults, based on a 3-year moving average. Several different methods have been previously discussed for assessing whether the 3,000 hatchery adults from the Little White Salmon NFH URB program threshold has been exceeded, including WDFW point estimates, expanded coded-wire tag recoveries, and assuming 90% of hatchery fish from WDFW estimates are from the Little White Salmon River NFH (Silver et al. 2021). Depending on the approach used results in slightly different estimates of URBs from Little White Salmon NFH on the spawning grounds. Using the WDFW estimates of total hatchery spawners (and the assumed percentage of Little White Salmon NFH's component of the total strays based on proportion of Little White Salmon NFH CWT s recovered), the 3-year average for 2020 – 2022 was 3,592. Using the expanded coded-wire tag recoveries of URBs from the Little White Salmon NFH results in a 3-year average of 2,147. Using a percentage of the hatchery fish from WDFS estimates varies depending on the percentage used. The previously used 90% of the WDFW estimate assumed to be URBs from Little White Salmon NFH based on the average proportion of coded wire tag recoveries from 2013-2019 results in a 3-year average of 3,233. If the individual return year proportions of URBs from Little White Salmon NFH based on coded wire tag recoveries is applied to the WDFW estimates, the 3-year average would be 2,984. Exceedance of this T&C in 2020 triggered a review by the USFWS, in cooperation with NMFS, to see what happened and what actions could be taken to address this exceedance. Based on the review, the exceedance was caused by a high level of Little White Salmon NFH URB fall Chinook salmon that strayed into the White Salmon River in 2019, which was believed to be an anomaly. A few factors outside the Little White Salmon NFH URB hatchery releases and adult trap operations may have contributed the high stray rate in 2019 including hatchery returns higher than forecasted and reduced harvest combined with low Bonneville Pool levels. For return years 2021 - 2023, the Little White Salmon NFH executed several actions to manage hatchery URB fall Chinook salmon straying including maximizing adult ladder operation to collect adults, surplussing adult fish earlier in the run, and coordinating with BPA and USACE to maintain a minimum Bonneville Dam forebay pool level of 74 feet during the URB run. Continued exceedance of the T&C beyond estimates including the anomaly year in 2019 may require additional management actions to reduce straying and those actions will be discussed during reconsultation that needs to be initiated by August 2024 (NMFS 2017).

In 2022, a pilot feasibility study was conducted to assess superimposition of tule redds by URB fall Chinook salmon within the first river mile of the White Salmon River (Baker and Hand, 2023, available at: https://www.fws.gov/media/impacts-redd-superimposition-spawning-success-listed-tule-fall-chinook-salmon-white-salmon-0). Redd locations were documented weekly throughout the spawning season from September – November and the degree of overlap and level of disturbance to tule redds were evaluated. Redd locations and associated GPS coordinates were recorded using a tablet computer with ArcGIS Field Maps and an Arrow RTK GNSS Receiver resulting in centimeter-level location accuracy. A polygon was created around clearly defined redds by walking around the outside perimeter of the redd. Tule redds identified in September through the first week of October were monitored for superimposition during the URB spawning run (i.e., mid-October through the last week of November). Superimposition was determined in the field by visual inspection of identified tule redds to evaluate whether the redd was excavated on top of by a URB fall Chinook, including documenting fish presence and observations of digging or guarding of the new redd. Only redds having significant overlap and substantial scouring and deposition were considered superimposed. Across all four reaches surveyed in 2022, a surprisingly high incidence (71 percent) of tule redds were superimposed by URBs, with approximately 88 percent of all tule redds surveyed disturbed in some way (Baker and Hand, 2023).

In 2023, weekly ground surveys following the same methodology as in 2022 were supplemented with aerial surveys using an unmanned aerial vehicle (i.e., drone) to provide high-resolution georeferenced imagery of spawning grounds (Baker et al., 2024, available at: https://www.fws.gov/media/assessing-superimposition-listed-tule-fall-chinook-salmon-redds-using-aerial-and-ground). A Parrot Anafi aircraft was used for all aerial missions containing a 21 megapixel camera with 4K resolution, 180o gimbal tilt, 3-axis hybrid image stabilization, and 2.8x lossless digital zoom. Four independent observers reviewed and identified redds from weekly imagery to distinguish superimposed redds. Imagery of the same survey locations from sequential flights were sometimes overlayed or viewed simultaneously, side by side, if needed, to determine weekly changes in the spatial pattern of redd locations. This aided in the identification of newly constructed redds that overlapped with previously constructed tule redds during the monitoring period (i.e., week of October 9 through week of November 22). Observers were able to review the georeferenced images multiple times, zooming in and panning as needed, to allow redds to be quantified more clearly. Results based on imagery from drone surveys and counts from ground-based surveys were compared to evaluate methodologies and estimate aerial observer error. Comparisons of aerial and ground surveys were made to evaluate method accuracy and compare advantages and disadvantages of each method (Baker et al., 2024).

To understand the impacts of hybridization between hatchery-origin URB strays and the listed tule fall Chinook salmon population in the White Salmon River, genetic samples were analyzed from adult carcasses collected by WDFW during annual spawning ground surveys of the White Salmon River from 2013 – 2021 (Mussmann et al., 2023, available at: https://www.fws.gov/media/genetic-evaluation-fall-chinook-salmon-carcasses-collected-during-annual-spawning-ground). Previous genetic studies focused on out-migrating juveniles to measure levels of hybridization (Smith and Engle, 2011; Smith et al., 2021). The most recent study evaluated whether hatchery-origin tule x URB hybrids are straying to the White Salmon River at an elevated rate and thereby increasing hybridization rates on spawning grounds. The number of hybrids returning to spawning grounds was quantified and the concordance of genotypic sample classifications with phenotypic carcass identifications was also investigated. A parentage-based tagging approach (Steele et al. 2019) was used to determine the percent of carcasses that were misclassified as wild-origin spawners due to the non-detection of visible hatchery marks or tags and quantify the proportion of hatchery-origin strays assigned to hybrid classes. A total of 967 field-identified tule (n = 622) and URB (n = 345) carcass samples collected in the White Salmon River from 2013 through 2021 were genotyped using a 344-locus GTseq panel. Analyses revealed a greater proportion of hybrids among natural-origin spawners (30%) compared to hatchery-origin spawners (11%). The overall annual proportion of hybrid spawners was 31.1%, with a greater annual mean proportion of hybrids found among field-identified tule carcasses (38.1%) relative to URBs (15.7%) (Mussmann et al., 2023). A large proportion of tule carcasses were tule backcrosses (27%), which were typically recovered from spawning grounds in late October. Just three tule carcasses were hatchery-origin, but parentage-based tagging analysis combined with hatchery-marking data indicated that 30.1% of URB carcasses originated from fish spawned at Little White Salmon NFH, rather than the 11.8% inferred from physical hatchery markings. However, the proportion of hybrids among Little White Salmon NFH strays (8.2%) matched prior estimates for Little White Salmon NFH broodstock (8.4%). Overall, a greater proportion of hybrid spawners in the White Salmon River are wild-origin rather than hatchery-origin. Most of these returning hybrids display run timing intermediate to the main tule and URB spawning runs. This overlap in run timing with non-hybridized fish is expected to result in continued production of wild-origin hybrids.

c) Monitoring Studies of URB Movement

A previous assessment of ladder operations at the Little White Salmon NFH suggested an increase in straying due to ladder closures, with most movement away from the hatchery occurring from late October to early November (Engle et al. 2006). In this previous study a total of 253 adult URBs were tagged with radio transmitters in 2004 and 35 adult URBs were tagged in 2005 with 45 and 28 recoveries in each year, respectively. Inferences of increased straying due to ladder closures were made based on the proportion of tag recoveries at adjacent tributaries (e.g., White Salmon River recoveries were 31 percent of recoveries in 2004 versus 4 percent in 2005) and differences in ladder operation among years (i.e., the ladder was open for only 2.75 hrs over seven days in 2004 versus 557 hrs over 33 days in 2005) (Engle et al. 2006). Based on these results, leaving the ladder open throughout the URB return was believed to remove more URBs from the Little White Salmon River and prevent those adults from straying to the White Salmon River.

A re-evaluation of CWT recoveries obtained from the RMIS database, however, revealed that the proportion of strays were higher in 2005 when the ladder remained open for most of the URB return then in 2004 when the ladder was closed. Due to delayed reporting of recoveries in the RMIS database these data were not available at the time of Engle et al.'s study. The percent of hatchery-origin strays recovered in the White Salmon River was 30.8 percent of the total estimated CWT freshwater return in 2005 versus 18.9 percent of the total estimated CWT freshwater return in 2004. These results are somewhat contradictory to those presented by Engle et al. 2006 study of radio tagged fish and suggest that additional monitoring studies of URB movement may be warranted to help identify factors contributing to straying.

In 2023, an investigation of the timing and movement of returning adult URBs in the Little White Salmon River and potential straying into the White Salmon River continued using submersible PIT antennas placed at strategic locations. Two PIT antennas were located adjacent to the Little White Salmon NFH's nursery building in the Little White Salmon River (upstream antenna: 45.7193, -121.6430; downstream antenna: 45.7186, -121.6437). Two additional PIT antennas were placed in the lower section of the White Salmon River (upstream antenna: 45.7360, -121.5224; downstream antenna: 45.7342, -121.5223). At each location a six-foot diameter submersible PIT antenna (Biomark, Boise, Idaho) was weighed down and positioned resting on the bottom substrate. Fish with a PIT tag were detected if they swam overtop within approximately three feet of the antenna. Data from the antennas were downloaded monthly by retrieving the device and downloading the data via Bluetooth. Battery packs were also switched out at this time to allow for extended field operation over the entire URB return.

A total of 34 unique PIT tags were detected over 80 days (September 14 through December 3, 2023) at the antennas in the Little White Salmon River near the Little White Salmon NFH (Table 25). Several species were detected during this period including hatchery fall Chinook salmon, spring Chinook salmon, coho salmon, and summer steelhead (Table 25). Fourteen URBs were detected at the submersible antennas; nine from the Little White Salmon NFH and five from Willard NFH (Table 25). Ten of the 14 URBs detected at the submersible antennas were also detected at the Little White Salmon NFH fish ladder (Table 25). Additionally, 12 Chinook salmon (unknown run) tagged at Bonneville dam were also detected. Ten of these 12 Chinook salmon were later recorded at the Little White Salmon NFH fish ladder. Based on the run timing of these Chinook salmon crossing Bonneville dam between August 30 and October 6, it is likely that these fish were fall Chinook salmon, possibly URBs reared at Little White Salmon or Willard NFHs. Three hatchery coho salmon detected at the antennas were reared at Willard NFH and released at the Chewuch Acclimation Pond. Two hatchery summer steelhead and one steelhead tagged at Bonneville were also detected in the Little White Salmon River. A total of 23 of the 34 fish detected at the submersible antennas were also detected at the Little White Salmon NFH fish ladder (Table 25).

A total of 18 unique PIT tags were detected over 66 days (September 8 through November 11, 2023) at the antennas in the lower section of the White Salmon River (Table 26). Several species were detected during this period including hatchery fall Chinook salmon (tule and URBs), summer Chinook salmon, coho salmon, and summer steelhead (Table 26). Four URBs were detected at the submersible antennas; two of these URBs were reared at the Little White Salmon NFH and two were reared at Willard NFH (Table 26). Two additional adult fall Chinook salmon tagged at Lyle Falls, Klickitat River and seven adult Chinook salmon tagged at Bonneville dam were also detected. There was one hatchery tule fall Chinook salmon from Spring Creek NFH that was detected. One summer Chinook salmon from Ford Hatchery and one coho salmon tagged at Lyle Falls was also detected at the antennas. Only one fish detected at the antennas in the White Salmon River was also detected by the antennas in the Little White Salmon River. This fish was an adult steelhead tagged and released at the Bonneville Dam Adult Fish Facility on 9/18/2023.

Table 25. Number of Detections at Submersible PIT Antennas in the Little White Salmon River by Species, Run, Rearing and Mark/Release Locations

Species Run Rear Name	Number of Detections	Mark Location[a]	Release Location[a]	Number of Detections at LWS Ladder
Hat. Spring Chinook	1	LWSH	LWSH	0
Chinook (unknown run)	12	BONAFF	BONAFF	10
Hat. Fall Chinook (URB)	9	LWSH	LWSH	5
Hat. Fall Chinook (URB)	2	WILL	WILL	2
Hat. Fall Chinook (URB)	3	WILL	LWSH	3
Hat. Coho	3	WILL	CHEWUP	3
Hat. Coho	1	TWITRP	TWISPR	0
Steelhead (unknown run)	1	BONAFF	BONAFF	0
Hat. Summer Steelhead	1	TUCR	TUCR	0
Hat. Summer Steelhead	1	DWOR	CLWRSF	0
Total	**34**	**6 locations**	**7 locations**	**23**

[a] Codes for Mark/Release Locations: BONAFF-Bonneville Dam; CHEWUP - Chewuch Acclimation Pond; CLWRSF - South Fork Clearwater River; DWOR - Dworshak National Fish Hatchery; LWSH - Little White Salmon National Fish Hatchery; TUCR - Tucannon River; TWISPR - Twisp River; TWITRP - Twisp River rotary smolt trap; WILL - Willard National Fish Hatchery

Table 26. Number of Detections at Submersible PIT Antennas in the White Salmon River by Species, Run, Rearing and Mark/Release Locations

Species Run Rear Name	Number of Detections	Mark Location[a]	Release Location[a]	Number of Detections in Little White Salmon River
Hat. Fall Chinook (URB)	2	LWSH	LWSH	0
Hat. Fall Chinook (URB)	1	WILL	LWSH	0
Hat. Fall Chinook (URB)	1	WILL	WILL	0
Fall Chinook	2	LYLFAT	LYLFAT	0
Chinook (unknown run)	7	BONAFF	BONAFF	0
Hat. Fall Chinook (Tule)	1	SPRC	SPRC	0
Hat. Summer Chinook	1	FORDH	KETFAL	0
Coho (unknown run)	1	LYLFAT	LYLFAT	0
Steelhead (unknown run)	1	BONAFF	BONAFF	1
Summer Steelhead	1	LYLFAT	LYLFAT	0
Total	**18**	**6 locations**	**6 locations**	**1**

[a] Codes for Mark/Release Locations: BONAFF-Bonneville Dam; FORDH - Ford Hatchery; KETFAL - Kettle Falls; LWSH - Little White Salmon National Fish Hatchery; LYLFAT - Lyle Falls Adult Fish Trap, Klickitat River; SPRC - Spring Creek National Fish Hatchery; WILL - Willard National Fish Hatchery

In 2024, the investigation of the timing and movement of returning adult URBs in and out of the Little White Salmon River and straying into the White Salmon River will continue using submersible PIT antennas placed at strategic locations. Detection data of adult URB movement in the Little White Salmon and White Salmon Rivers collected will be used to assess factors that may be leading to straying.

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