Monitoring and Evaluation Updates for John Day/The Dalles Dam Mitigation Programs at Spring Creek and Little White Salmon National Fish Hatcheries - FY 2021 Annual Report

Brook Silver, Todd Gilmore, Steven Lazzini, Justin Baker, David Hand, Jesse Rivera, and Jeremy Voeltz

Columbia River Fish and Wildlife Conservation Office 1211 SE Cardinal Court, Suite 100 Vancouver, WA 98683

Prepared for The U.S. Army Corps of Engineers, P.O. Box 2946, Portland, OR 97208

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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 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 10.9 million juvenile tules into the Columbia River. Over the past 10 brood years, the program has contributed a mean of 91,645 adult tules (including 68,349 for harvest) annually to the JDTD program TAP goal. Since 2012, 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 28,284 adult upriver brights (including 14,809 for harvest) 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.

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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. Slackwater 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. Approximately, 25% of the TAP goal is 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" 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.

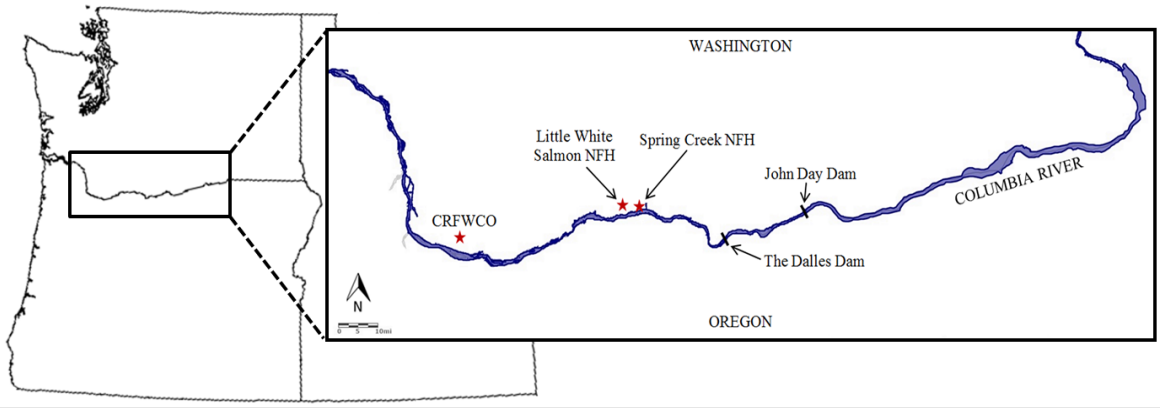

Figure 1. Spring Creek and Little White Salmon NFHs are located on the Washington side of the Columbia River downstream of the John Day and The Dalles Dams. Monitoring and evaluation of the fall Chinook production programs at these facilities is conducted by staff at the Columbia River Fish and Wildlife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

A significant proportion of the 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 12, 2003 Congressional Record, Sec. 138) implemented in release year 2005 requiring all production fish from federal facilities (except those explicitly reared for conservation) 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-clip, 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-clipped 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) 2021, the U.S. Fish and Wildlife Service (USFWS) requested funding from the USACE in the amount of $5,176,343 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/CRFWCO/CRFPO_pubs.cfm

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 for the production of 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). Presently, 100% of the adults used for broodstock at Spring Creek NFH are provided by hatchery-reared, adult returns to the facility.

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

Traditionally, Spring Creek NFH released 15.1M juvenile tule into the Columbia River in March, April, and May. Beginning in release year 2009, reprogramming at the facility changed the production level goal to 10.5M tule released in April and May. For BYs 20 and 21, the Pacific Salmon Treaty funded an increase of up to two million juveniles for Southern Resident Killer Whale (SRKW) production. A proposal for additional BY22 funding will be determined in the Spring of 2022. Any fish produced above 10.5M (*U.S. v Oregon* obligation) for are credited to SRKW production. The actual number of juvenile tule released annually has varied with a mean of 10,877,174 since release year 2012 (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 HGMP (USFWS 2004a). Ninety-two percent (~10M) of the annual production is mass marked with an adipose fin-clip (AD) only. The remaining fish are marked with CWTs with ~405K being AD and marked with CWTs, and ~405K being marked with CWTs only (DIT fish). The CWT marking 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 actual numbers of juveniles that have been mass marked and tagged since release year 2012 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. Data retrieved from CRiS 10/6/2021.

Release Year	Release Dates	River °C at Release	AD + CWT	CWT (DIT)	AD Only	No Mark/CWT*	Mean Size (Fish/lb)	Group Release #	Annual Release
2012	11,13-Apr	8.0	205,066	203,460	5,862,141	1,115	124	6,271,782	11,078,704
	30-Apr	9.2	208,147	199,232	4,399,138	405	98	4,806,922	
2013	11-Apr	7.7	196,681	203,834	6,040,240	820	99	6,441,575	11,242,686
	2-May	10.6	200,696	199,892	4,398,952	1,571	79	4,801,111	
2014	11-Apr	8.9	205,922	205,548	5,757,948	0	122	6,169,418	10,754,482
	6-May	11.1	199,060	198,350	4,186,873	781	88	4,585,064	
2015	13-Apr	9.2	201,918	196,759	5,975,115	5,370	148	6,379,162	10,415,634
	27-Apr	10.6	190,848	191,210	3,654,414	0	105	4,036,472	
2016	11-Apr	-	203,461	201,944	5,941,689	2,278	112	6,349,372	10,167,948
	9-May	8.9	194,817	197,566	3,425,802	391	90	3,818,576	
2017	10-Apr	8.9	204,714	204,431	6,168,828	393	126	6,578,366	10,775,114
	8-May	11.3	195,800	194,472	3,802,122	4,354	84	4,196,748	
2018	9-Apr	4.4	203,899	201,850	6,266,724	2,907	135	6,675,380	10,737,862
	7-May	7.0	197,100	197,321	3,666,549	1,512	87	4,062,482	
2019	8-Apr	7.7	204,668	204,551	6,228,055	218,575	223	6,855,849	11,226,628
	6-May	8.3	197,627	197,565	3,975,216	371	152	4,370,779	
2020	10-Apr	-	153,161	152,451	4,391,178	2,199,589	99	6,896,379	11,184,169
	13-Apr	-	149,020	147,850	2,028,753	1,962,167	104	4,287,790	
2021†	12-Apr	5.0	163,427	164,049	6,219,089	321	95	6,546,886	11,188,509
	20-Apr	6.1	196,581	196,643	4,247,245	1,154	83	4,641,623	
Mean	**April**	**7.3**	**190,710**	**190,281**	**5,427,250**	**366,224**	**122.5**	**6,516,417**	**10,877,174**
	Late Apr/May	**9.6**	**198,012**	**196,951**	**3,938,633**	**1,173**	**97.9**	**4,360,757**	

***** Fish with No Mark/CWT include unmarked releases and double index tagged fish that shed their coded-wire tag prior to release. In 2020 marking was suspended due to COVID-19 which resulted in the increased number of No Mark/CWT fish released.

†All juveniles produced above 10.5M for are credited to SRKW production

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. 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 mean detection rate at Bonneville Dam of PIT tagged tule fall Chinook juveniles from Spring Creek NFH is approximately 5.6%, with an average median travel time from the hatchery to the dam of 1 day.

Due the low detection rate of Spring Creek PIT tagged juveniles downstream of Bonneville Dam, no juvenile survival estimates can be 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 CRiS 10/6/2021.

Release Year	# PIT Tagged*	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2012	14,750	655	4.4	1	(0.5 – 24)	1	1.0	1.5
2013	14,940	825	5.5	2	(0.5 – 38)	1	2.0	3.0
2014	14,866	757	5.1	2	(0.5 – 37)	1	1.5	2.0
2015	14,929	847	5.7	3	(1 – 55)	2	2.5	3.5
2016	14,954	779	5.2	1	(0.5 – 10)	1	1.5	1.5
2017	14,918	513	3.4	1	(0.5 – 12)	1	1.0	1.0
2018	14,907	619	4.2	1	(0.5 – 54)	1	1.5	1.5
2019	15,225	1,519	10.0	1	(0.5 – 47)	1	1.5	2.0
2020†	-	-	-	-	-	-	-	-
2021	14,979	1,064	7.1	4	(2 – 56)	3	3.5	5.0
Mean	14,941	842	5.6	1.8	(0.5 - 54)	1	2	2

*Number 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.

Adult Returns

a) Harvest Data and Smolt-to-Adult Survival

CWT recoveries, collected by federal, state, and tribal agencies and maintained in the 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; Pastor (2004); Pastor (2016)]. Based on CWT recoveries from brood years 1990 to 2004, Spring Creek NFH was estimated to have a mean smolt-to-adult survival rate of 0.47%. *U.S. v. Oregon* parties utilized this rate to set the juvenile production goal, and estimated that the facility would contribute an estimated 49,592 adult Chinook, on average, towards the TAP goal of 107,000 with 28,000 adults supplied for harvest. However, for brood years 2005-2014, 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). Additionally, the tule program has contributed a mean of 91,645 adults for the past ten years with the highest number of returns from the April juvenile release group.

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 from RMIS for tule fall Chinook released from Spring Creek NFH. RMIS data queried on 12/6/2021 and CRiS stock assessment reports run on 12/6/2021.

Brood Year	Hatchery Returns*	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total Adults†	Smolt-to-Adult Survival (%)
2005	36,300	43,025	19,361	140	98,826	0.65
2006	11,121	12,497	4,415	0	28,033	0.18
2007	55,022	69,779	41,303	520	166,624	1.12
2008	19,087	30,011	18,772	175	68,045	0.60
2009	20,376	30,740	21,244	151	72,511	0.67
2010	12,711	29,761	15,984	28	58,484	0.54
2011	18,558	67,380	35,933	355	122,226	1.10
2012	34,518	99,768	57,910	1,060	193,256	1.72
2013	8,842	18,898	7,904	90	35,734	0.33
2014	13,712	32,243	26,563	189	72,707	0.70
Mean	**23,025**	**43,410**	**24,939**	**271**	**91,645**	**0.76**

* Hatchery returns are returns to Spring Creek 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.

An average 606 CWTs have been recovered each year at Spring Creek NFH since 2012 (Table 4). 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 the Coleman NFH (<0.1%).

Table 4. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Spring Creek NFH 2012 - 20201. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from RMIS: 12/9/2021.

Return Year	CWT Recoveries	Hatchery Origin	% of CWT Total Return
2012	517	Spring Creek NFH	100
2013	699	Spring Creek NFH	100
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
Mean	**606**		

b) Age Structure

Adult returns to Spring Creek NFH are estimated by hatchery personnel and the USFWS marking and biosampling crew from CRFWCO (Table 5: brood year; Table 6: 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 of adult tule (~58%) return to Spring Creek NFH at Age-3, but 31% return at Age-2 as precocially mature males/females. Approximately 10% of adults return at Age-4 and less than 1% return at Age-5. The facility has produced an annual mean of 25,834 adult returns to Spring Creek NFH for return years 2012-2021.

Table 5. 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 12/6/2021.

Brood Year	Age-2	Age-3	Age-4	Age-5	Total # Adults
2007	11,988	43,835	2,108	50	57,981
2008	4,856	14,618	4,328	29	23,831
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	NA	-
2018*	7,259	20,775	NA	NA	-
2019*	28,740	NA	NA	NA	-
Mean	**7,826**	**17,461**	**2,559**	**39**	**26,173**

* Denotes incomplete brood years given that adults have either not yet returned to the hatchery or have not been aged

Table 6. 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 12/6/2021.

Return Year	Age-2	Age-3	Age-4	Age-5	Total # Adults
2012	1,867	20,890	4,328	50	27,135
2013	2,827	12,615	3,178	29	18,649
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
Mean	**8,084**	**15,108**	**2,604**	**39**	**25,834**

c) Bonneville Dam Detections

Since Return Year 2012, tule fall Chinook adults (≥ 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 7). On average, 88% of tule fall Chinook adults released from Spring NFH passing upstream through Bonneville Dam's adult ladders (based on expansion of PIT tags) are counted returning to Spring Creek NFH. No fish from BY 19 were PIT tagged due to COVID-19 restrictions in 2020. Fish from this brood year (jacks) are not included in the expanded returns in 2021.

Table 7. Median Bonneville Dam passage date of adult tule fall Chinook PIT tagged and released from Spring Creek NFH (≥ Age 2). Data retrieved from PTAGIS 12/6/2021.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion	95% CI	Hat. Return	Hat. Return/ Bonn. Expansion (%)
2012	Sep-06	Aug-12	Sep-16	34	24,477	(17,521 – 35,337)	27,135	111
2013	Sep-05	Aug-15	Sep-26	33	24,132	(13,121 – 38,590)	18,649	77
2014	Sep-08	Aug-24	Sep-25	59	44,216	(29,839 – 72, 541)	31,801	72
2015	Sep-10	Aug-20	Sep-29	80	60,056	(46,583 – 82,880)	44,159	74
2016	Sep-03	Aug-08	Sep-26	32	23,861	(13,498 – 48,476)	17,378	73
2017	Sep-08	Aug-23	Sep-20	22	16,131	(8,729 – 31,296)	17,915	111
2018	Sep-01	Aug-21	Sep-13	29	20,131	(11,743 – 35,637)	15,415	77
2019	Sep-06	Jul-31	Sep-23	40	28,814	(18,133 – 46,369)	15,032	52
2020	Sep-02	Aug-02	Sep-18	51	36,977	(24,891 – 55,895)	17,683	48
2021	Aug-31	Aug-22	Sep-19	39	28,656	(19,318 – 47,116)	53,172	186
Mean	**Sep-04**	**Aug-14**	**Sep-21**	**42**	**30,746**		**25,834**	**88**

d) Hatchery Ladder Detections

Since Return Year 2012, 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 8).

Table 8. 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). Data retrieved from PTAGIS 12/6/2021.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Ladder Expansion	95% CI	Hat. Return	Hat. Return/ Ladder Expansion (%)
2012	Sep-08	Aug-30	Sep-16	17	12,239	(7,647 – 21,003)	27,135	222
2013	Sep-10	Sep-04	Sep-24	12	8,774	(3,956 – 15,159)	18,649	213
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
Mean	**Sep-08**	**Aug-30**	**Sep-21**	**16**	**11,926**		**25,834**	**239**

*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

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 2021 data will not be available until January 2022 (K. Dammerman, WDFW, personal communication).

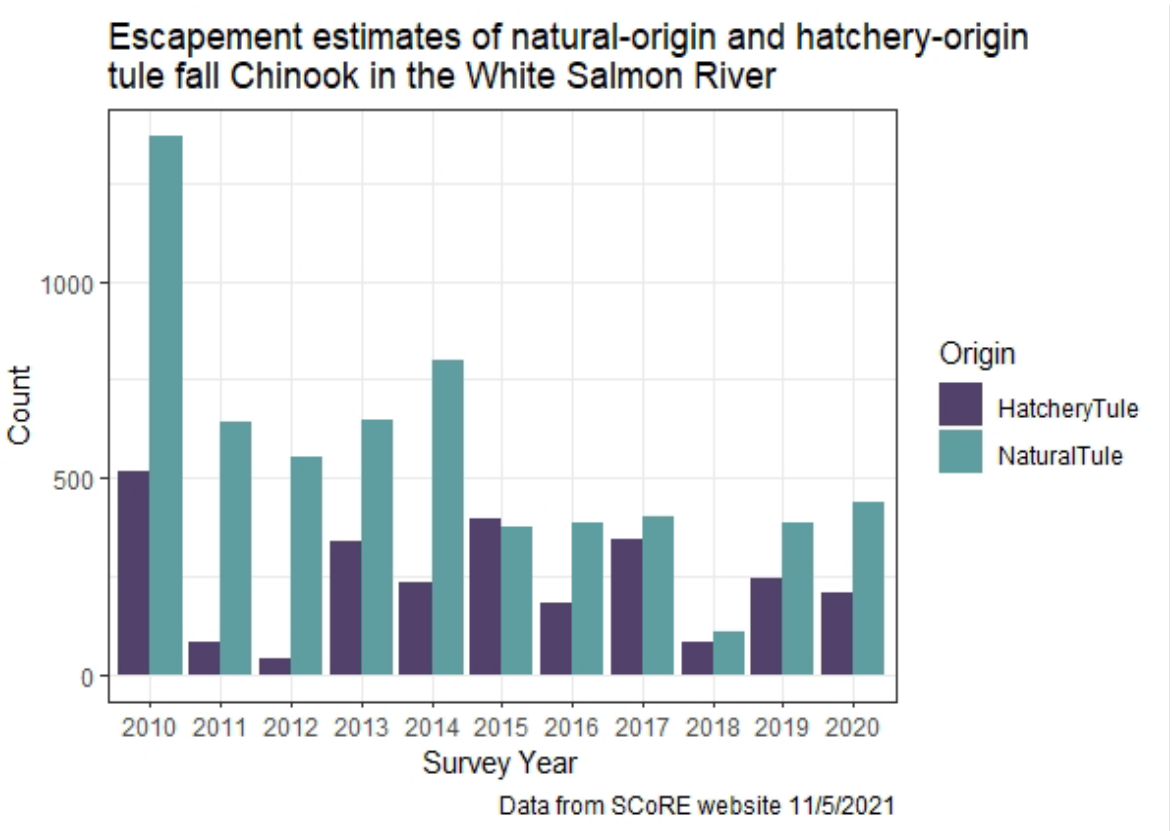

Figure 3. Annual escapement estimates of natural-origin and hatchery-origin tule fall Chinook spawning in the White Salmon River during annual spawning surveys (2010 - 2020)

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 2010 to 2020, pHOS estimates ranged from 6 to 51% with a mean pHOS of 31% (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 2010 - 2020 is (Pearson's) r = 0.62.

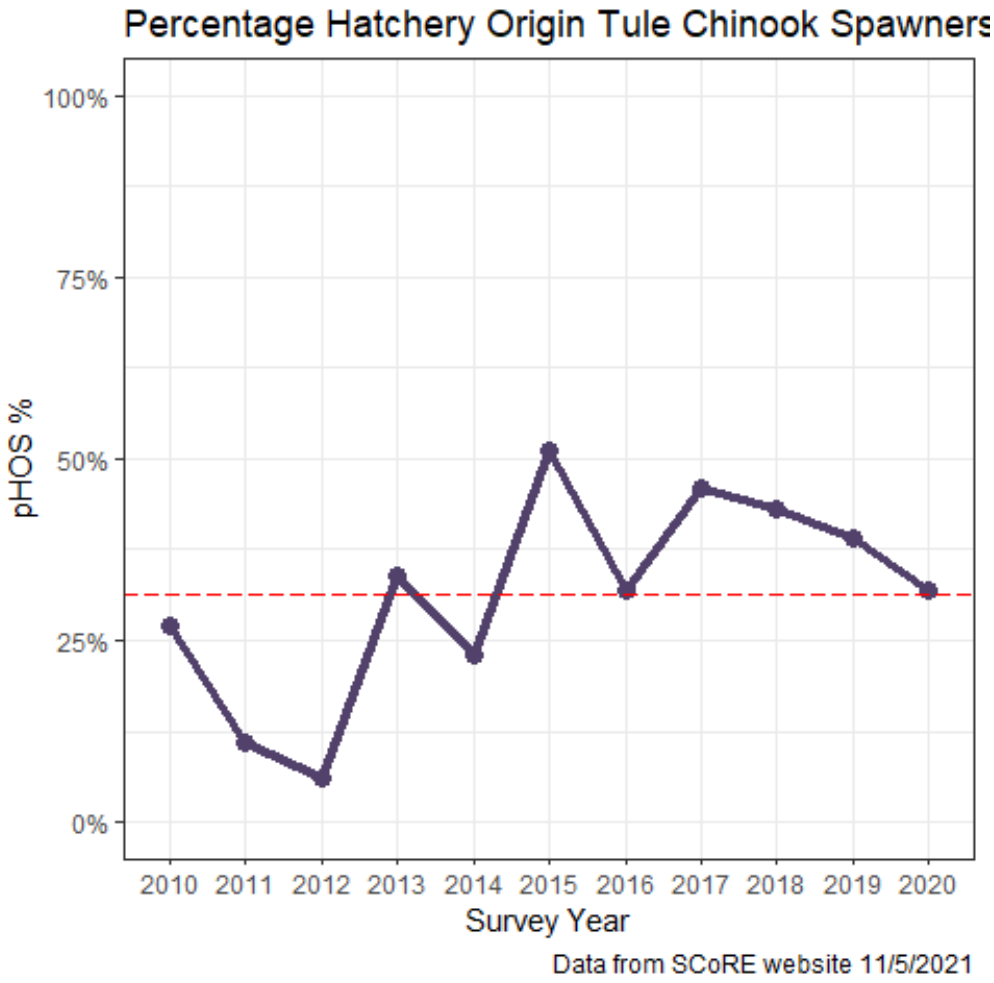

Figure 4. Estimated proportion of tule fall Chinook hatchery origin spawners (pHOS) in the White Salmon River (2010 - 2020). Dotted line is the mean (31 %).

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 and 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 LWS NFH URB program has on-station JDM releases, on-station SRKW releases, Willard Mitchell Act URB broodstock collection, egg transfers for the Prosser/Umatilla programs, and transfers juveniles/eggs for the Klickitat program. The Prosser program at LWS consists of a 1.1M juvenile transfer and a 600k egg transfer for a total of 1.7M. However, the egg transfer may be filled elsewhere depending on brood stock availability at LWS and other URB facilities (i.e., Priest Rapids provided eggs in BY21). Table 9 summarizes the production goals for each program (not the actual releases or transfers for each year). For Brood Years 2019 and 2020, LWS NFH reared an extra ~450k URBs and Willard an extra ~220k URBs.

Table 9. Broodstock Target collected at Little White Salmon NFH for URB Fall Chinook programs 2019 - 2021.

Brood Year	Funding	Program	Total Broodstock need (1:1, M:F)	Target Green Egg Take	Target Release Number	Lifestage
2019	MA/COE	LWS NFH/ Prosser	652	1,240,000	1,700,000	0+
	COE	LWS NFH	2,556	4,900,000	4,500,000	0+
	MA	Willard NFH	1,186	2,250,000	2,000,000	0+
	PST	Klickitat Hatchery	3,324	6,300,000	1,000,000	0+
	MA	Klickitat Hatchery			4,000,000	0+
	COE	Bonneville/Prosser	166	300,000	210,000	1+
	NOAA	SRKW- Willard NFH	130	247,500	220,000	0+
	NOAA	SRKW- Little White Salmon NFH	256	490,000	450,000	0+
2020	MA/COE	LWS NFH/ Prosser	652	1,240,000	1,700,000	0+
	COE	LWS NFH	2,556	4,900,000	4,500,000	0+
	MA	Willard NFH	1,186	2,250,000	2,000,000	0+
	PST	Klickitat Hatchery	3,324	6,300,000	1,000,000	0+
	MA	Klickitat Hatchery			4,000,000	0+
	COE	Bonneville/Prosser	166	300,000	210,000	1+
	NOAA	SRKW- Willard NFH	130	247,500	200,000	0+
	NOAA	SRKW- Little White Salmon NFH	256	490,000	450,000	0+
2021	MA/COE	LWS NFH/ Prosser	652	1,240,000	1,100,000	0+
	MA/COE	LWS NFH/ Prosser		600,000	NA	Eggs
	COE	LWS NFH	2,556	4,900,000	4,500,000	0+
	MA	Willard NFH	1,186	2,250,000	2,000,000	0+
	PST	Klickitat Hatchery	3,324	6,300,000	1,000,000	0+
	MA	Klickitat Hatchery			4,000,000	0+
	COE	Bonneville/Prosser	166	300,000	210,000	1+

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 RY 2009 (brood year 2008) 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) 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 9). 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 2012, the facility has annually released an average 4,409,841 juveniles with a mean size of 81.1 fish/lb. Eighty-eight percent (~3.9M) of the annual production released into the Little White Salmon River is AD only. Approximately 7% 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 10).

Table 10. 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. Data retrieved from CRiS 11/15/2021.

Release Year	Release Dates	Water Temp. at Release (°C)	AD + CWT	CWT (DIT)	AD Only	No Mark/CWT*	Total Released	Mean Size (Fish/lb)
2012	26-Jun, 3-Jul	6.1	565,914	194,722	3,803,310	5,483	4,569,429	87.00
2013	2-Jul	8.3	360,089	198,443	3,862,277	769	4,421,578	66.00
2014	1-Jul, 2-Jul	7.2	267,804	99,702	4,038,588	298	4,406,392	86.00
2015	2-Jul	9.8	188,763	186,398	3,583,770	13,595	3,972,526	82.00
2016	11-Jul	7.6	196,105	196,772	3,565,052	3,186	3,961,115	85.00
2017	5-Jul	6.8	197,829	198,487	4,297,331	1,381	4,695,028	77.00
2018	11-Jul	9.0	189,005	186,872	3,475,401	13,093†	3,864,37 †	78.00
2019	9-Jul	9.0	104,346	98,088	2,961,342	3,545	3,167,321	81.00
2019	15-Jul	7.3	97,123	96,545	1,120,176	3,490	1,317,334	90.00
2020	14-Jul	7.7	198,573	199,339	2,225,542	2,149,865	4,773,319	85.00
2021‡	29-Jun	-	169,522	169,256	4,610,605	617	4,950,000	79.23
Mean		**7.9**	**253,507**	**182,462**	**3,754,339**	**219,532**	**4,409,841**	**81.1**

* Fish with No Mark/CWT 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

d) Transfer Data

The facility also transfers 1.7M URB juveniles to the Yakima River-Prosser Hatchery program for the Yakama Nation in late March to late April (Table 11). The transferred URB juveniles are marked prior to release with ~1.5M being adipose fin-clipped only, and ~200K juveniles being adipose fin-clipped and CWTed 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. Ten percent of these fish were marked and CWTed, the rest were marked by the CRFWCO marking program at Prosser Hatchery. The Yakima River-Prosser Hatchery program is moving towards taking eyed eggs with the entire 1.7M. The actual number of URB juveniles that have been marked, tagged, and transferred to the Prosser program since 2012 are presented in Table 11. 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 programs. In 2019, no fish or eggs were transferred due to low adult returns to Little White Salmon 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 CWTed before their transfer to Prosser Hatchery. In July 2021, an excess ~160 K marked and untagged BY 2020 fingerlings were transferred to the Klickitat Tribal Hatchery for release into the Klickitat River due to excess overproduction at LWNFH.

Table 11. Annual transfer dates and total number of juveniles transferred *to* the Prosser program from Little White Salmon NFH. Data retrieved from CRiS 12/15/2021.

Transfer Year	Transfer Dates	Transfer Location	Total Transferred
2012	4/2, 4/9, 4/13, 4/23	Prosser	1,507,117
2013	4/4, 4/8, 4/15, 4/18	Prosser	1,551,115
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
	Fall	Prosser	500,000 eggs
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
	7/14	Klickitat Tribal Hatchery	161,633
	Fall	Prosser	600,000 eggs
Annual Mean			**1,536,375**

* In 2020, marking and tagging was suspended due to COVID-19

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 brood year 2007 with 25,000 juvenile URBs being PIT tagged annually to monitor juvenile migration through the Columbia River basin. Beginning in brood year 2012, the number of juveniles that were PIT tagged was decreased to 15,000 (Table 12). The mean detection rate at Bonneville Dam of PIT tagged URB juveniles from Little White Salmon is approximately 12.7%, with an average median travel time from the hatchery to the dam of 12 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 44 to 252 days.

Table 12. 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 10/6/2021.

Release Year	Release Dates	# PIT Tagged*	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2012	3-Jul	24,947	1,439	5.8	16	(0.5 - 127)	10	19	37
2013	2-Jul	14,959	1,977	13.2	15	(0.5 - 252)	12	20	26
2013	2-Jul	14,925	1,787	12.0	19	(1.5 - 138)	17	26	36
2015	2-Jul	14,958	1,194	8.0	12	(1.5 - 44)	10	13	16
2016	11-Jul	14,823	1,647	11.1	12	(2 - 50)	11	13	16
2017	5-Jul	14,438	1,855	12.8	12	(1 - 121)	11	14	21
2018	11-Jul	14,840	2,468	16.6	11	(0.5 - 106)	10	12	16
2019	7/9, 7/15	14,775	1,950	13.2	14	(1.5 - 45)	13	17	21
2020	14-Jul	14,862	2,481	16.7	11	(1 - 77)	10	13	19
2021	29-Jun	14,982	2,561	17.1	12	(1.5 - 57)	12	15	16
Mean		**15,851**	**1,936**	**12.7**	**13**		**12**	**16**	**22**

*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 in order 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 subsequent to 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 likely juvenile downstream fish from upstream moving mini-jacks.

- **Subsequent to passing downstream of Bonneville Dam**:
  - Lower river trawl (TWX and PD7 interrogation sites)
  - Lower river bird colony recoveries on East Sand Island, Rice Island and Miller Sands Island (ESANIS, RICEIS, and MLRSNI 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 2011-2020 (release years 2012-2021) ranged from 0.43 to 0.71 (Table 13; Fig. 6). The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years. This is because adult returns are added into 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 a larger variances. In subsequent years, as more adults from a brood year return, the variance of the estimates should decrease.

Table 13. 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. Data retrieved from PTAGIS: 11/19/2021.

Brood Year	Release Year	Median Survival	95% Lower	95% Upper
2011	2012	0.67	0.53	0.82
2012	2013	0.71	0.63	0.77
2013	2014	0.59	0.49	0.70
2014	2015	0.51	0.41	0.64
2015	2016	0.61	0.47	0.76
2016	2017	0.56	0.45	0.68
2017	2018	0.65	0.56	0.76
2018	2019	0.43	0.35	0.51
2019	2020	0.52	0.43	0.63
2020	2021	0.48	0.37	0.62
Mean		**0.57**	**0.47**	**0.69**

Note: survival estimates vary greatly for the current year due to the limited time after release and number of fish detections downstream.

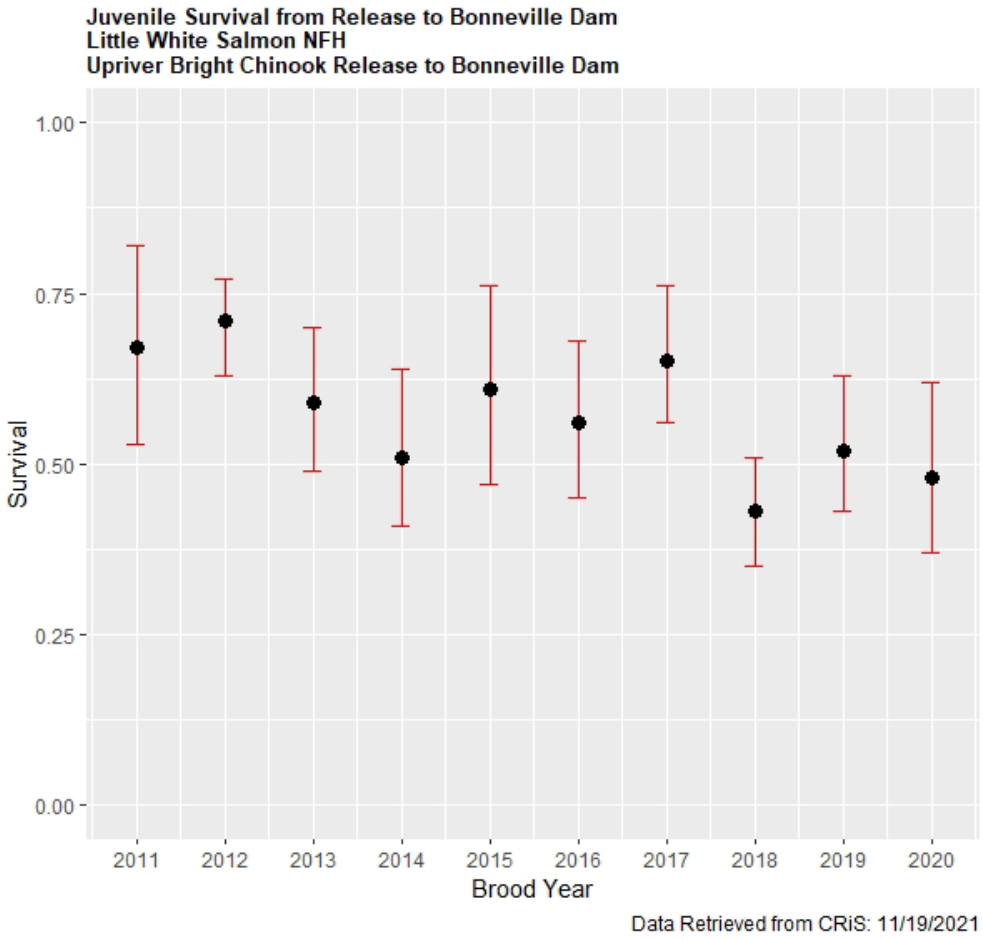

Figure 6. Little White Salmon NFH Upriver Bright Fall Chinook apparent juvenile survival from release to Bonneville Dam, (2011 - 2020). Error bars are lower and upper credible intervals. Note: survival estimates vary greatly for the current year due to the limited time after release and number of fish detections downstream.

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 14; Pastor (2004); Pastor (2016)]. Based on a mean smolt-to-adult survival rate of 0.32% estimated for brood years 1990 to 2004, the facility was expected to contribute an average of 14,382 adults (5,900 for harvest) to the TAP goal of 107,000. However, since brood year 2005, the facility has a mean smolt-to-adult survival rate of 0.78 (Table 14) which is still within the range reported in the facility's HGMP (USFWS 2004b, 2015). Additionally, the URB program has contributed a mean of 28,284 adults annually for the past ten years. CWT recoveries beyond brood year 2014 were not included in this report given that adult returns reported to RMIS can take several years to be finalized.

The Yakima River-Prosser Hatchery program has a mean smolt-to-adult survival of 0.20% (based on brood years 1990-2004) contributing an additional 3,383 adult URB fall Chinook towards the TAP goal. Release and adult recoveries for the Prosser Hatchery are monitored by the Yakama Nation.

Table 14. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery data from RMIS for URB fall Chinook released from Little White Salmon NFH. Adult returns are used to estimate smolt-to-adult survival rates. All recovery information presented above is current as of 10/6/2021.

Brood Year	Hatchery Returns*	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults†	Smolt-to-Adult Survival (%)
2005	6,903	2,865	3,108	174	13,057	0.73
2006	6,793	2,308	1,768	613	11,491	0.56
2007	14,689	6,418	4,370	1,043	26,529	1.33
2008	7,983	5,301	5,033	1,812	20,139	0.43
2009	17,171	15,917	10,471	9,705	53,276	1.17
2010	29,993	28,623	25,376	9,424	93,475	2.09
2011	4,530	4,071	3,253	3,250	15,105	0.33
2012	11,737	11,622	9,893	4,797	38,050	0.86
2013	2,571	4,234	2,487	779	10,071	0.23
2014	606	748	222	30	1,646	0.04
Mean	**10,298**	**8,211**	**6,598**	**3,163**	**28,284**	**0.78**

* 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.

An average 641 CWTs have been recovered each year at Little White NFH since 2012 (Table 15). The Little White NFH URB fall Chinook program accounts for 96.2 percent of all recoveries; URB fall Chinook from other programs include Bonneville Hatchery (0.8%), Willard NFH (2.7%), other hatchery programs account for 0.3%.

Table 15. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Little White NFH 2012 - 2021. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. Data retrieved from RMIS: 12/9/2021.

Return Year	CWT Recoveries	Hatchery Origin	% of Total CWT Return
2012	392	L White Salmon NFH	99.2
	3	Bonneville Hatchery	0.8
2013	856	L White Salmon NFH	97.6
	21	Bonneville Hatchery	2.4
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	98.0
	6	Bonneville Hatchery	1.7
	1	Lyons Ferry Hatchery	0.3
2016	535	L White Salmon NFH	100.0
2017	262	L White Salmon NFH	91.0
	26	Willard NFH @ Little White	9.0
2018	492	L White Salmon NFH	100.0
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	Little 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
Mean	**641**		

b) Age Structure

Adult returns to Little White Salmon NFH are estimated annually by hatchery personnel and the USFWS marking and biosampling crew from 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 16: brood year; Table 17: return year). The majority (57%) of adult URBs return to the facility at Age-4, but 30% return at Age-3. Approximately 2% of fish mature precocially returning as jacks or jills at Age-2. Less than 1% of adults return at Age-6. The facility has produced a mean of 13,783 adult returns to the hatchery between 2012 and 2021.

Table 16. Estimated age structure of adult URB fall Chinook returns to Little White Salmon NFH by *brood year*. CRiS age composition reports run on 12/10/2021.

Brood Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2005	156	1,164	1,942	2,263	47	5,572
2006	652	961	3,009	1,174	12	5,808
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	-	-
2017*	246	2,444	6,946	-	-	-
2018*	354	3,000	-	-	-	-
2019*	35	-	-	-	-	-
Mean	**446**	**3,762**	**6,903**	**1,511**	**26**	**12,401**

* Denotes incomplete brood years given that adults have either not yet returned to the hatchery or have not been aged.

Table 17. Total number of adult URB fall Chinook returns to Little White Salmon NFH and estimated age structure by *return year*. Data retrieved from CRiS 12/10/2021.

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2012	587	4,551	2,770	1,229	12	9,149
2013	374	15,644	18,377	1,501	73	35,969
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
Mean	**310**	**4,188**	**7,793**	**1,469**	**24**	**13,783**

c) Bonneville Dam Detections

Since Return Year 2012, URB fall Chinook adults (Ages 2 - 6) PIT tagged and released from Little White NFH returned to Bonneville Dam as early as Jul-07 and as late as Nov-05 with the average median Sep-09 (Table 18). On average, 39% of URB fall Chinook adults released from Little White NFH passing upstream through Bonneville Dam's adult ladders (based on expansion of PIT tags) are counted returning to the Little White Salmon NFH.

Table 18. 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 12/10/2021.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion	95% CI	Hat. Return	Hat. Return/Bonn. Expansion (%)
2012	Sep-10	Aug-09	Oct-23	197	31,469	(24,219 – 42,144)	9,149	29
2013	Sep-09	Aug-07	Nov-02	466	84,976	(72,739 – 101,248)	35,969	42
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
Mean	**Sep-09**	**Aug-07**	**Oct-15**	**178**	**38,074**		**13,783**	**39**

d) Hatchery Ladder Detections

Since Return Year 2012, upriver bright fall Chinook adults (Ages 2 - 6) PIT tagged and released from Little White NFH returned to the Little White NFH Ladder as early as Jul-08 and as late as Nov-19 with the average median Oct-21 (Table 19). Upriver bright fall Chinook released from Willard NFH also return to Little White NFH for spawning. Since Return Year 2018, an average of 5 upriver bright fall Chinook adults (Ages 2 - 6) reared and PIT tagged at Willard NFH returned to the Little White NFH Ladder as early as Sep-30 and as late as Nov-03 with the average median Oct-21. The total number of upriver bright fall Chinook adults reared at Willard NFH that return to the Little White 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 NFH hatchery count (Table 19).

Table 19. Median detection date of adult upriver bright fall Chinook PIT tagged and released from Little White NFH (LW) and Willard NFH (WI) at the Little White NFH Adult Ladder (Ages 2 - 6). Data retrieved from PTAGIS 12/10/2021.

Return Year	Mark Site	Median Passage Date	First Detection Date	Last Det. Date	# of Fish Det.	Ladder Expansion	95% CI	Hatchery Return	Hat. Return /Ladder Expansion (%)
2012	LW	Oct-24	Oct-15	Nov-06	63	10,259	(6,493 - 17,868)	9,149	89
2013	LW	Oct-30	Jul-08	Nov-19	196	35,567	(28,181 – 47,387)	35,969	101
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
2018	WI	Oct-25	Oct-20	Oct-30	3	362	(NA – NA)*	-	-
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	(NA – NA)*	-	-
2020	LW	Oct-08	Sep-30	Oct-12	33	10,295	(5,608 – 16,234)	14,984	146
	WI	Oct-12	Sep-30	Oct-30	6	789	(NA – NA)*	-	-
2021	LW	Oct-21	Oct-15	Nov-03	30	8,948	(4,716 - 14,775)	10,716	120
	WI	Oct-23	Oct-19	Oct-29	9	799	(NA – NA)*	-	-
Mean	**LW**	**Oct-21**	**Sep-26**	**Nov-05**	**62**	**13,262**		**13,783**	**107**
	WI	**Oct-21**	**Oct-14**	**Oct-30**	**5**	**545**		**-**	**-**

Confidence limit totals do not include detections of less than five fish. The high variability of a small sample size reduces accuracy of the estimate (i.e., large confidence intervals).

Additional Monitoring and Evaluation Projects

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

To collect adult URB broodstock, the LWS NFH ladder is opened in mid-September and remains open throughout the entire URB fall Chinook salmon return. Salmon and other non-target species volitionally enter and leave the fish ladder located immediately below the hatchery barrier dam before reaching the LWS 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-clipped/marked or tagged with a coded-wire tag (CWT) are assumed to be natural-origin and released back into the Little White Salmon River below the ladder (Table 20).

In recent years, coho salmon have returned in high numbers. In 2021, detections PIT tagged coho confirmed that coho salmon re-entered the fish ladder multiple times after being released (Justin Baker Memo 12/23/2021). 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.

Table 20. Counts of non-production target fish removed, and returned to river (), at the Little White Salmon NFH 2012 – 2021. Totals include both hatchery and wild fish. Data retrieved from Fish Removal files 12/10/2021

Year	Coho Salmon	Chinook Salmon	Sockeye Salmon	Chum Salmon	Rainbow Trout	Steelhead Trout
2012	85	574	0	0	0	0
2013	158	983	0	0	0	1
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)
Mean	**597**	**897**	**3**	**0**	**1**	**7**

*In 2021, unmarked Coho were returned to the river. Returned to river fish were encountered multiple times, 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 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 (NMFS 2017). 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 since 2010 by the Washington Department of Fish and Wildlife 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 (Table 21; Fig. 7).

Table 21. 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 11/5/2021).

Year	Hatchery URB	Natural URB
2010	1,093	841
2011*	NA	NA
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	2,263	1,382
Mean	**2,689**	**1,172**

*2011 escapement estimates were unavailable due to the breach of Condit Dam.

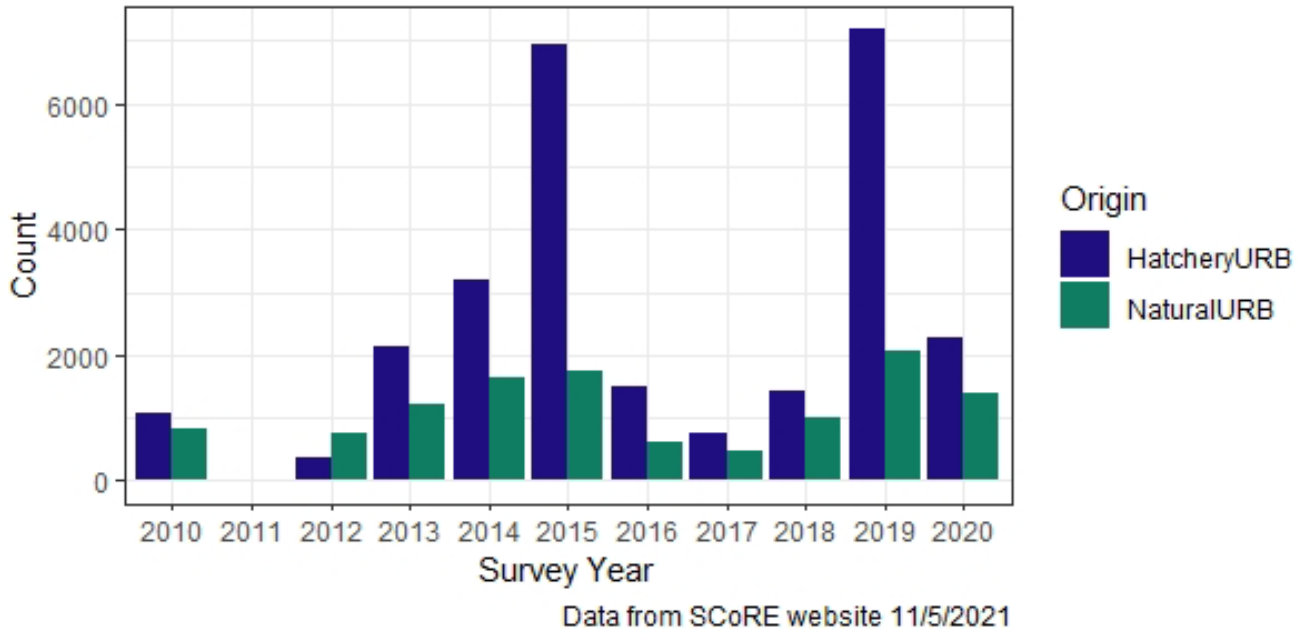

Figure 7. Escapement estimates of hatchery-origin and natural-origin upriver bright (URB) fall Chinook in the White Salmon River during annual spawning surveys (2010 - 2020). 2011 escapement estimates were unavailable due to the breach of Condit Dam.

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, with limited spawning in areas of the lower Columbia River, including the White Salmon River. For the URB spawning population (2010-2019), the mean percentage of hatchery-origin spawners was 63%, 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=0.10) or the estimated total number of Little White Salmon-*/`1 URBs (based on PIT tag expansions) passing Bonneville Dam (Pearson's r=0.23) in a given year. In particular, 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 22). The preliminary 2021 estimates of the number of hatchery-origin URBs spawning in the White Salmon River will not be available until late January (K. Dammerman, WDFW, personal communication)

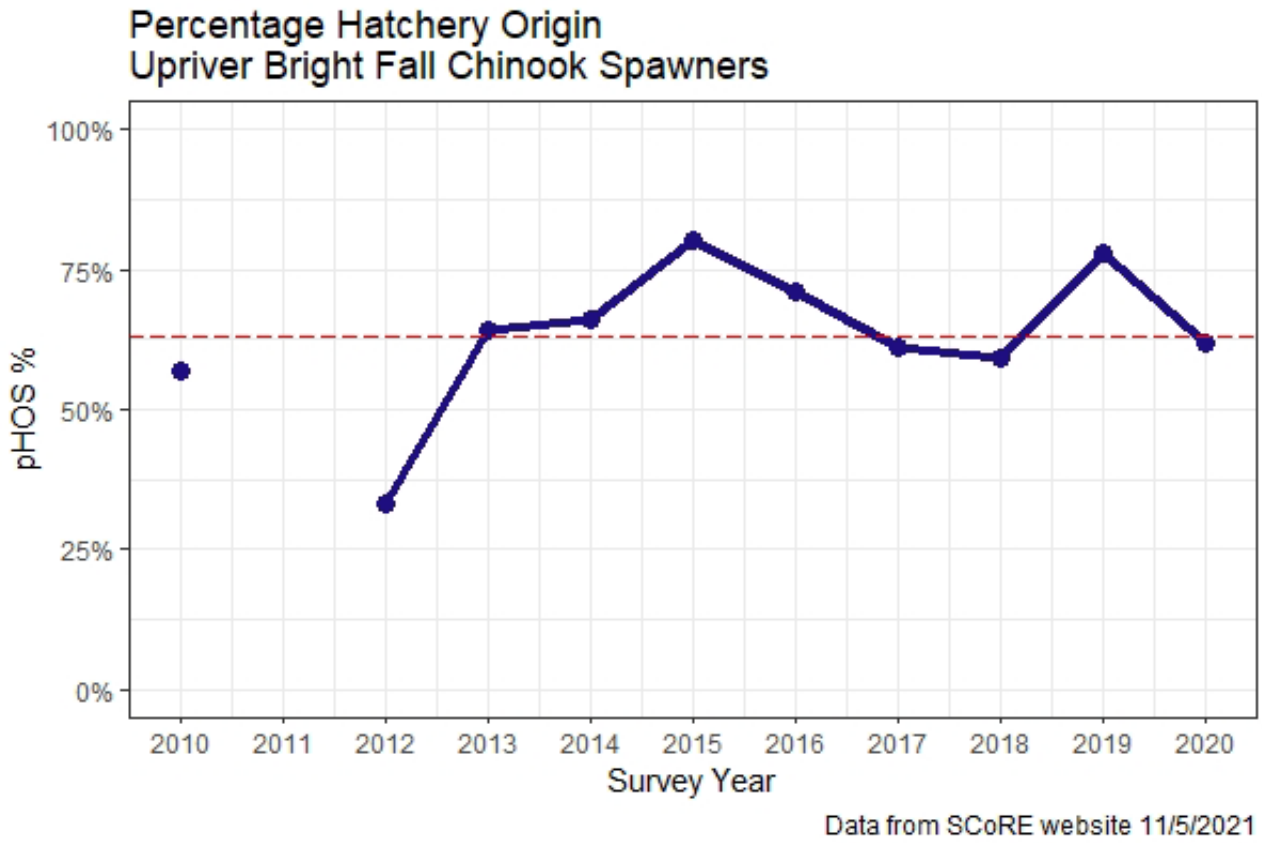

Figure 8. Estimated proportion of upriver bright (URB) fall Chinook hatchery origin spawners (pHOS) in the White Salmon River (2010 - 2020). Dotted line is the mean (63%).

Table 22. 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 (2013-2021). Hatchery counts are from the CRiS database, WDFW estimates are from the SCORE website. Data retrieved from SCoRE website 12/8/2021

Year	Hatchery Count	WDFW Estimate
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	2,263
2021	10,716	-

*The 2021 WDFW estimate was not available to include until late January (K. Dammerman, WDFW, personal communication).

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 90%-100% of the annual total coded-wire tag recoveries in the White Salmon River (recovery years 2013-2019), with the Little White NFH component averaging 90% of the total annual recoveries. The total number of coded-wire tags recovered on the spawning grounds in a given year ranged from 6 to 124. 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 23). In all years (2013-2019), 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 programs (Figure 9).

Table 23. 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. Confidence intervals (C.I.) are calculated based on proportions (i.e. tagging rate). Data from RMIS 12/13/21 and WDFW SCORE website 12/20/21 and WDFW 2020 spawning memo.

Year	CWT Estimate	80% Lower C.I.	80% Upper C.I.	WDFW Estimate
2013	2,147	1,217	4,030	2,135
2014	3,219	2,388	4,510	3,208
2015	5,679	3,994	8,622	6,944
2016	703	496	1,135	1,508
2017	518	417	655	753
2018	1,286	887	1,983	1,446
2019	5,187	3,646	7,704	7,117
2020	1,892	1,378	2,760	2,263

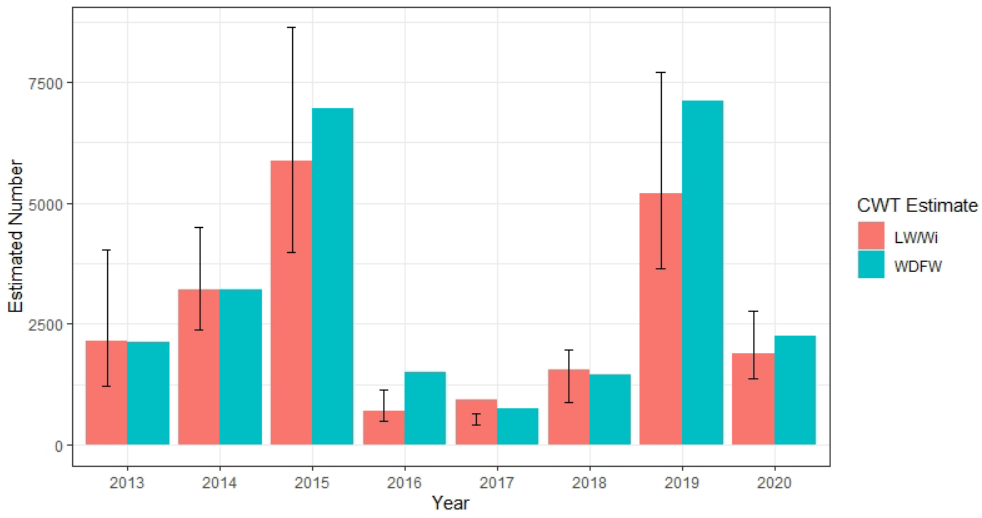

Figure 9. Estimated number of hatchery upriver bright fall Chinook from the Little White and Willard NFH programs, based on coded-wire tag expansions for tagging rate and sampling rate, and the total number of estimated hatchery Upriver Bright Fall Chinook spawning in the White Salmon River (WDFW estimate). 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 12/15/20. WDFW data 2013-2018 from SCORE website; 2019 data from WDFW spawning memo (Olk and Dammerman 2020 memorandum).

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. 2020). 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 are from the White Salmon River (Silver et al. 2020). Using the WDFW estimates of total hatchery spawners, the 3-year average for 2018 – 2020 was 3,609. Regardless of the approach, the general assessment is that the 3-year average for 2018 – 2020 would exceed the 3,000 hatchery adult threshold. Exceedance of this T&C triggered a review by the USFWS, in cooperation with NMFS, to see what happened and what actions could be taken to address this exceedance (NMFS 2021). 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 (NMFS 2021). A number of 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 (NMFS 2021). For return year 2021, the Little White Salmon NFH executed a number of actions to manage hatchery URB fall Chinook salmon staying 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.

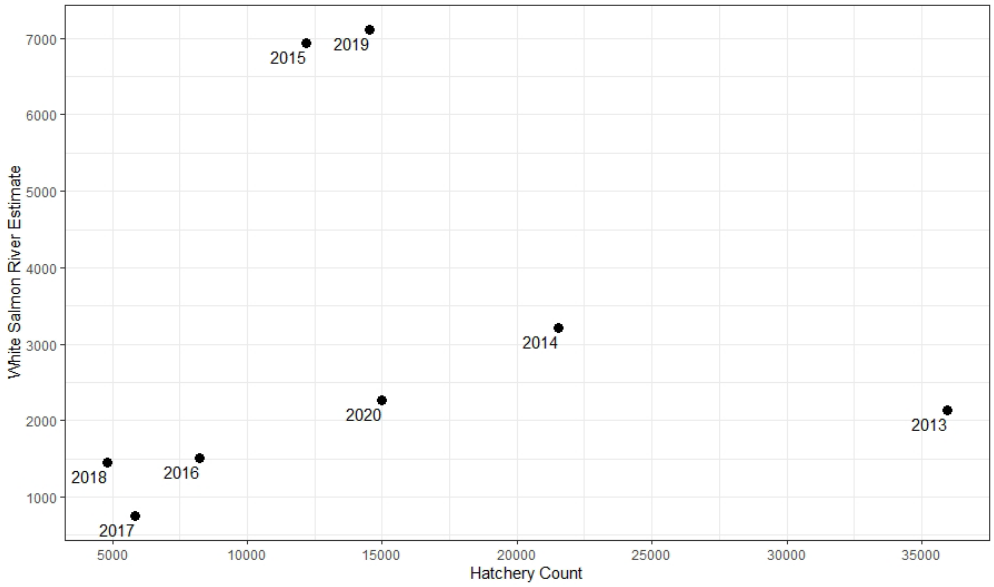

Figure 10. Estimated total hatchery Upriver Bright Fall Chinook Salmon spawning in the White Salmon River versus total number of hatchery Upriver Bright Fall Chinook Salmon collected at Little White Salmon NFH (2013-2020). Little White Salmon NFH counts are from the CRiS database. White Salmon River estimates 2013-2020 are from WDFW spawning survey data on the SCORE website (12/8/2021).

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 (Engle et al. 2006). 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 actually 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 32.9 percent of the total

CWT freshwater return in 2005 versus 22.1 percent of the total CWT freshwater return in 2004. Additionally, there was a higher percentage of recovered CWT marked fish in the Wind River and other spawning grounds in 2005 than 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 2021, an initial pilot study was performed during the fall URB run (September through November) in the Little White Salmon River near the Little White Salmon NFH to monitor movement of URBs and provide managers with a better understanding of the factors potentially leading to straying. The pilot study was primarily focused on evaluating suitable locations for placing submersible PIT detection antennas and understanding variables (e.g., water depth, flow) that influence detection efficiency. Two locations were selected within the river reach near the Little White Salmon NFH (i.e., from the Little White Salmon NFH ladder to Drano Lake). The upstream PIT antenna was located adjacent to the facilities acclimation ponds and the downstream PIT antenna was located adjacent to the lower observation deck and lower raceways building. A 6 ft diameter submersible PIT antenna (Biomark, Boise, Idaho) was weighed down and positioned resting on the bottom substrate at each of these locations. Fish with a PIT tag were detected if they swam overtop within approximately 3 feet of the antenna. Both antennas provided up to 42 days of continuous operation on a single battery pack and had a data storage capacity of 1 million records. Data from the antennas were downloaded periodically 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 16 unique PIT tags of URBs were detected over the 75 days (September 23 through December 07) that the antennas were recording, with more detections occurring at the antenna positioned upstream near the facilities acclimation ponds than the antenna positioned downstream (Tables 24 and 25). The PIT detections occurred throughout the URB return, with the first detection on October 4 and the last detection on November 10. All of the URBs detected at the submersible antennas were also detected at the Little White Salmon NFH ladder, except for three individuals (Tables 24 and 25). Directional movement of individual URBs (i.e., upstream or downstream movement) could not be determined due to detections occurring at either upstream or downstream antennas, but not both.

A number of non-target species were also detected at the submersible antennas including hatchery-origin coho salmon, summer Chinook salmon and wild spring Chinook salmon and steelhead (Tables 24 and 25). Excluding Chinook salmon of unknown run and rearing origin, hatchery-origin coho salmon were the most commonly detected species. The coho salmon detected were reared at five hatcheries (Cascade Hatchery ODFW, Eagle Creek NFH, Kooskia NFH, Willard NFH, and Winthrop NFH) and released at eight different locations (Tables 24 and 25).

Table 24. Number of Detections at the Upstream Submersible Antenna in the Little White Salmon River by Species, Run, Rearing and Mark/Release Locations

Species-Run-Rear Name	Number of Detections	Mark Location	Release Location	Number of Detections at LWS Ladder
Hat. Fall Chinook (URB)	10	LWS	LWS	8
Hat. Fall Chinook (URB)	2	WILL	LWS	2
Hat. Fall Chinook (URB)	2	WILL	WILL	2
Chinook (unknown run)	16*	BONAFF	BONAFF	13
Hat. Coho	1	CASC	EARLWP	1
Hat. Coho	1	CASC	TWISPP	1
Hat. Coho	1	EAGH	KOOS	1
Hat. Coho	1	KOOS	KOOS	1
Hat. Coho	1	WILL	CHEWUP	1
Hat. Coho	1	WILL	COULTP	1
Hat. Coho	2	WILL	EARLWP	2
Hat. Coho	3	WILL	LEAV	3
Hat. Coho	1	WILL	MDVAP	1
Hat. Coho	1	WINT	WINT	1
Hat. Summer Chinook	1	MCCA	KNOXB	1
Wild Spring Chinook	1	HOODR	HOODR	0
Wild Steelhead (unknown)	1	PANT2C	PANT2C	0
Total	**46**	**10 locations**	**15 locations**	**39**

Codes for Mark/Release Locations: BONAFF-Bonneville Dam; CASC-Cascade Hatchery (ODFW); CHEWUP-Chewuch Acclimation Pond (WDFW); COULTP-Coulter Creek Acclimation Pond; EAGH-Eagle Creek NFH; EARLWP-Early Winters Acclimation Pond; HOODR-Hood River; KNOXB-Knox Bridge; KOOS-Kooskia NFH; LEAV-Leavenworth NFH; LWS-Little White Salmon NFH; MCCA-McCall NFH; MDVAP-Mid-Valley Acclimation Pond; PANT2C-Panther Creek; TWISPP-Twisp Acclimation Pond (WFDW); WILL-Willard NFH; WINT-Winthrop NFH

* One individual was also detected at the downstream submersible antenna.

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

Species-Run-Rear Name	Number of Detections	Mark Location	Release Location	Number of Detections at LWS Ladder
Hat. Fall Chinook (URB)	1	WILL	LWS	0
Hat. Fall Chinook (URB)	1	WILL	WILL	1
Chinook (unknown run)	2*	BONAFF	BONAFF	1
Hat. Coho	1	WILL	MDVAP	1
Total	**5**	**2 locations**	**4 locations**	**3**

Codes for Mark/Release Locations: BONAFF-Bonneville Dam; LWS-Little White Salmon NFH; MDVAP-Mid-Valley Acclimation Pond; WILL-Willard NFH
* One individual was also detected at the upstream submersible antenna.

The location of the PIT antenna and water depths appeared to influence detection efficiency greater than river flow or other characteristics. The number of returning adult URB PIT tag detections at Bonneville Dam, the Little White Salmon NFH ladder, and submersible PIT detection antennas during the initial pilot study were assessed to estimate the detection efficiency of the submersible antennas. Approximately 81 percent of all URB detections at the submersible antennas were also detected at the Little White Salmon NFH ladder. Based on the detection data obtained during the initial pilot study, the detection probability was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The upstream antenna had a detection probability of 0.283 (95 % CI: 0.154 - 0.420) and the downstream antenna had a detection probability of 0.034 (0.002 - 0.082). The location selected for the upstream antenna had the highest detection efficiency and designated as the most suitable location for placing an antenna in the Little White Salmon River.

A reconnaissance survey of the White Salmon River was also completed in 2021 to identify potential locations for antenna placement within the lower 1.5 RM[1]. Aerial imagery was used to identify natural features such as braided channels with islands that may congregate tagged fish in specific areas. These areas were evaluated further in the field to determine their potential suitability for antenna placement. Based on these surveys, locations were selected to place an antenna in fall 2022 to monitor movement in the White Salmon River.

In 2022, a more detailed 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 be conducted 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.

[1] Based on WDFW spawning ground surveys of the White Salmon River in 2020 approximately 91.6 percent of tule abundance and 98.6 percent of URB abundance was within the first 1.44 RM (i.e., three tier falls to the mouth) (Olk and Dammerman 2021).

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