Monitoring and Evaluation Updates for John Day/The Dalles Dam Mitigation Programs at Spring Creek and Little White Salmon National Fish Hatcheries - FY 2020 Annual Report

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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 10.8 million juvenile tules into the Columbia River. Over the past 10 brood years, the program has contributed a mean of 85,415 adult tules (including 63,173 for harvest) annually to the JDTD program TAP goal. Since 2011, 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 28,330 adult upriver brights (including 14,763 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.

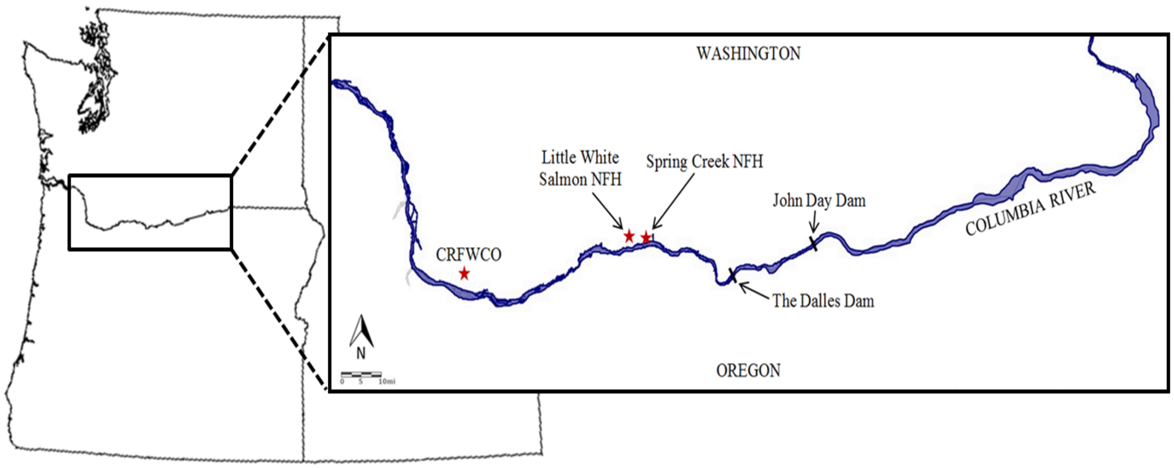

Figure 1. Spring Creek and Little White Salmon NFHs are located on the Washington side of the Columbia River downstream of the John Day and The Dalles Dams. Monitoring and evaluation of the fall Chinook production programs at these facilities is conducted by staff at the Columbia River Fish and Wildlife 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) 2020, the U.S. Fish and Wildlife Service (USFWS) requested funding from the USACE in the amount of $4,842,791 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

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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 6,000 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. 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. The actual number of juvenile tule released annually has varied with a mean of 10,844,452 since release year 2011 (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 2011 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 12/22/2020

Release Year	Release Dates	AD + CWT	CWT (DIT)	AD Only	No Mark/CWT*	Total Released	Mean Size (Fish/lb)
2011	12-Apr	203,259	202,650	5,821,137	2,047	6,229,093	112
	4-May	199,576	199,410	4,232,812	401	4,632,199	87
2012	11,13-Apr	205,066	203,460	5,862,141	1,115	6,271,782	124
	30-Apr	208,147	199,232	4,399,138	405	4,806,922	98
2013	11-Apr	196,681	203,834	6,040,240	820	6,441,575	99
	2-May	200,696	199,892	4,398,952	1,571	4,801,111	79
2014	11-Apr	205,922	205,548	5,757,948	0	6,169,418	122
	6-May	199,060	198,350	4,186,873	781	4,585,064	88
2015	13-Apr	201,918	196,759	5,975,115	5,370	6,379,162	148
	27-Apr	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
	9-May	194,817	197,566	3,425,802	391	3,818,576	90
2017	10-Apr	204,714	204,431	6,168,828	393	6,578,366	126
	8-May	195,800	194,472	3,802,122	4,354	4,196,748	84
2018	9-Apr	203,899	201,850	6,266,724	2,907	6,675,380	135
	7-May	197,100	197,321	3,666,549	1,512	4,062,482	87
2019	8-Apr	204,668	204,551	6,228,055	218,575	6,855,849	223
	6-May	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
	13-Apr	149,020	147,850	2,028,753	1,962,167	4,287,790	104
Mean	**April**	**193,797**	**193,212**	**5,498,346**	**399,569**	**10,844,452**	**128**
	May	**198,186**	**197,224**	**3,971,320**	**1,087**	**10,844,452**	**97**

* 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.

Off-Station Juvenile 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 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 tagging operations were cancelled in 2020 due to

COVID-19 and outmigration timing for Brood Year 2019 (Release Year 2020) could not be determined.

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). Due the low detection rate of Spring Creek PIT tagged juveniles downstream of Bonneville Dam, no juvenile survival estimates can be calculated.

The mean detection rate at Bonneville Dam of PIT tagged tule fall Chinook juveniles from Spring Creek NFH is approximately 5.5%, with an average median travel time from the hatchery to the dam of 1 day.

Table 2. The number of PIT tagged juvenile tule released from Spring Creek NFH and juvenile travel times to Bonneville Dam (BONN). Data retrieved from PTAGIS 11/6/2020.

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2011	14,939	922	6.2	1	(0.5 – 20)	1	1	2
2012	14,750	668	4.5	1	(0.5 – 24)	1	1	1
2013	14,940	825	5.5	2	(0.5 – 38)	1	2	3
2014	14,866	757	5.1	2	(0.5 – 37)	1	1	2
2015	13,827	788	5.7	3	(1 – 54)	2	2	3
2016	14,954	779	5.2	1	(0.5 – 9)	1	1	1
2017	14,918	513	3.4	1	(0.5 – 12)	0	1	1
2018	14,907	619	4.2	1	(0.5 – 53)	1	1	1
2019	15,225	1,519	10.0	1	(1 – 46)	1	1	1
2020*	NA	NA	NA	NA		NA	NA	NA
Mean	**14,814**	**821**	**5.5**	**1.4**	**(0.5 - 54)**	**1**	**1**	**2**

* PIT tagging operations were cancelled in 2020 due to COVID-19

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, 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 2004-2013, the facility has a mean smolt-to-adult survival rate of 0.7 (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 85,415 adults for the past ten years with the highest number of returns from the April juvenile release group. CWT recoveries beyond brood year 2013 were not included in this report given that adult returns reported to RMIS can take several years to be finalized.

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. Due to delays in reporting to RMIS, CWT recoveries may be adjusted every year for accuracy. RMIS data queried on 8/28/202020 and CRiS stock assessment reports run on 12/21/2020.

Brood Year	Hatchery Returns*	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total Adults†	Smolt-to-Adult Survival (%)
2004	2,909	4,452	2,593	329	10,411	0.07
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
Mean	**21,944**	**40,631**	**22,542**	**285**	**85,415**	**0.70**

* Hatchery returns are returns to Spring Creek NFH.

† Total Adults includes other recovery locations not listed, such as strays to other hatcheries.

An average 591 CWTs have been recovered each year at Spring Creek NFH since 2011 (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 (0.2%), 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 2011 - 2019, tag recoveries for 2020 are not yet complete. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from RMIS: 8/7/2020, 2020 Data is not yet available.

Return Year	CWT Recoveries	Hatchery Origin	% of Total Return
2011	602	Spring Creek NFH	100
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	-	-	-
Mean	**591**		

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 (~64%) return to Spring Creek NFH at Age-3, but 25% return at Age-2 as precocially mature males/females. Approximately 11% of adults return at Age-4 and less than 1% return at Age-5. The facility has produced an annual mean of 22,598 adult returns to Spring Creek NFH for return years 2011-2020.

Table 5. Estimated age structure of adult tule fall Chinook returns to Spring Creek NFH by *brood year*. CRiS Age Composition reports run on 12/11/2020

Brood Year	Age-2	Age-3	Age-4	Age-5	Total # Adults
2005	8,303	32,912	5,008	0	46,223
2006	956	8,463	1,444	34	10,897
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	NA	NA
2017*	7,695	9,938	NA	NA	NA
2018*	7,259	NA	NA	NA	NA
Mean	**5,875**	**17,702**	**2,578**	**38**	**27,914**

* 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 12/11/2020.

Return Year	Age-2	Age-3	Age-4	Age-5	Total # Adults
2011	4,049	14,618	2,108	34	20,809
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
Mean	**5,615**	**14,492**	**2,449**	**42**	**22,598**

c) Bonneville Dam Detections

Since Return Year 2011, 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-05 (Table 7). On average, 79% 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.

Table 7. Median Bonneville Dam passage date of adult tule fall Chinook PIT tagged and released from Spring Creek NFH (≥ Age 2). Total returns for Return Year 2020 are not yet complete. Data retrieved from PTAGIS 11/19/2020.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion (95% CI)*	Hatchery Count/ Bonn Exp. *100
2011	Sep-06	Aug-22	Sep-20	28	21,377 (12,175 – 37,511)	97%
2012	Sep-06	Aug-12	Sep-16	34	24,477 (17,521 – 35,337)	111%
2013	Sep-05	Aug-15	Sep-26	33	24,132 (13,121 – 38,590)	77%
2014	Sep-08	Aug-24	Sep-25	59	44,215 (29,839 – 72, 541)	72%
2015	Sep-10	Aug-20	Sep-29	80	60,056 (46,583 – 82,880)	74%
2016	Sep-03	Aug-08	Sep-26	32	23,860 (13,498 – 48,476)	73%
2017	Sep-08	Aug-23	Sep-20	22	16,131 (8,729 – 31,296)	111%
2018	Sep-01	Aug-21	Sep-13	29	20,130 (11,743 – 35,637)	77%
2019	Sep-06	Jul-31	Sep-23	40	28,813 (18,133 – 46,369)	52%
2020	Sep-02	Aug-02	Sep-18	51	36,977 (24,891 – 55,895)	48%
Mean	**Sep-05**	**Aug-14**	**Sep-21**	**41**	**30,017**	**79%**

*Confidence limits do not include detections of five fish or less per age group to reduce the variability and increase the accuracy of the estimate

d) Hatchery Ladder Detections

Since Return Year 2011, 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). Total returns for Return Year 2020 are not yet complete. Data retrieved from PTAGIS 11/20/2020.

Return Year	Median Passage Date	First Det. Date	Last Det. Date	# of Fish Det.	Ladder Expansion (95% CI)*	Hatchery Count	Hatchery Count/ Bonn Exp. *100
2011	Sep-10	Aug-28	Sep-19	12	8,932 (4,107 – 24,333)	20,809	97%
2012	Sep-08	Aug-30	Sep-16	17	12,238 (7,647 – 21,003)	27,135	111%
2013	Sep-10	Sep-04	Sep-24	12	8,773 (3,956 – 15,159)	18,649	77%
2014	Sep-10	Aug-31	Oct-01	24	18,015 (9,839 – 34,036)	31,801	72%
2015	Sep-13	Sep-04	Oct-02	22	16,526 (10,341 – 25,523)	44,159	74%
2016	Sep-06	Aug-23	Sep-20	11	7,861 (1,924 – 11,402)	17,378	73%
2017	Aug-31	Aug-30	Sep-11	5	3,435 (NA – NA)	17,915	111%
2018	Sep-08	Aug-29	Sep-14	16	10,963 (5,676 – 17,407)	15,415	77%
2019	Sep-13	Aug-27	Sep-22	14	10,055 (4,441 – 24,342)	15,032	52%
2020	Sep-01	Aug-31	Sep-18	10	7,237 (2,926 – 12,174)	17,683	48%
Mean	**Sep-08**	**Aug-29**	**Sep-21**	**15**	**10,404**	**22,598**	**79%**

*Confidence limits do not include detections of five fish or less 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 (Wilson, 2018 memorandum). Data from the spawning surveys is accessible on the Salmon Conservation Reporting Engine (SCoRE) website operated by WDFW. Preliminary 2020 data will not be available until January 2021 (K. Dammerman, WDFW, personal communication).

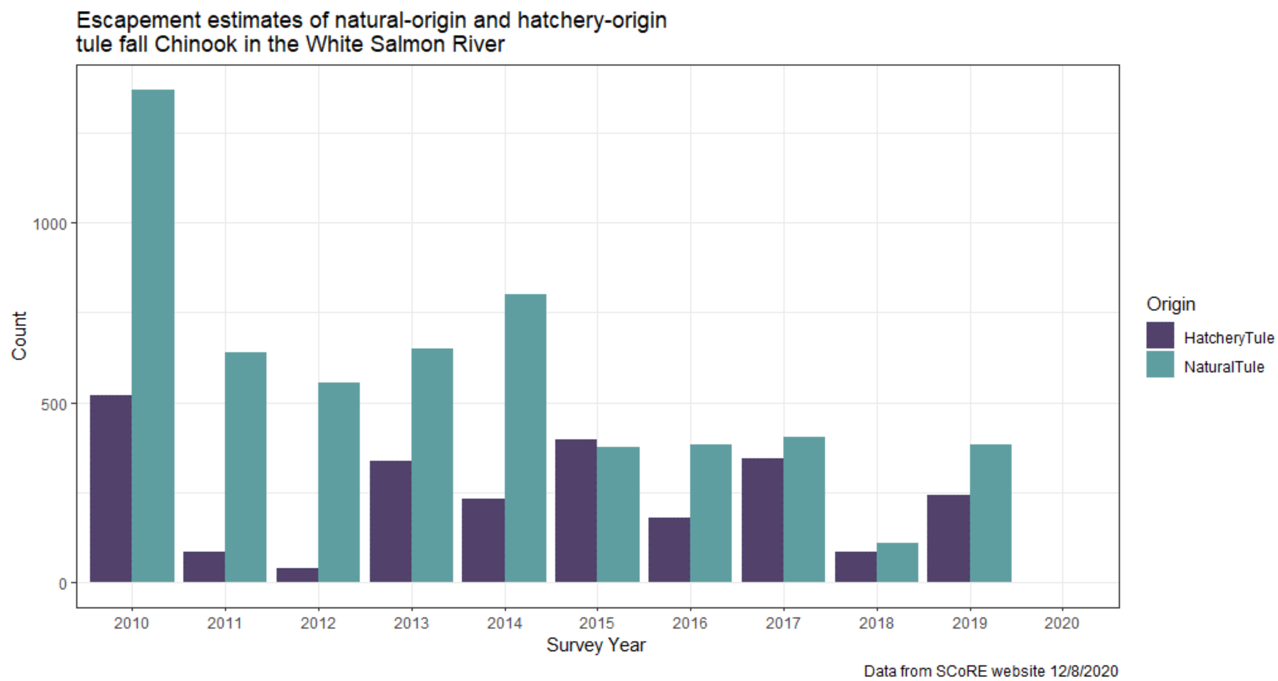

Figure 3. Annual escapement estimates of natural-origin and hatchery-origin tule fall Chinook spawning in the White Salmon River during annual spawning surveys (2010 - 2019)

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 2019, 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 has been increasing since 2012. Reasons for this apparent increase are not known and may warrant further study. Based on adult return data from Spring Creek NFH, the 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 - 2019 is (Pearson's) r = 0.62.

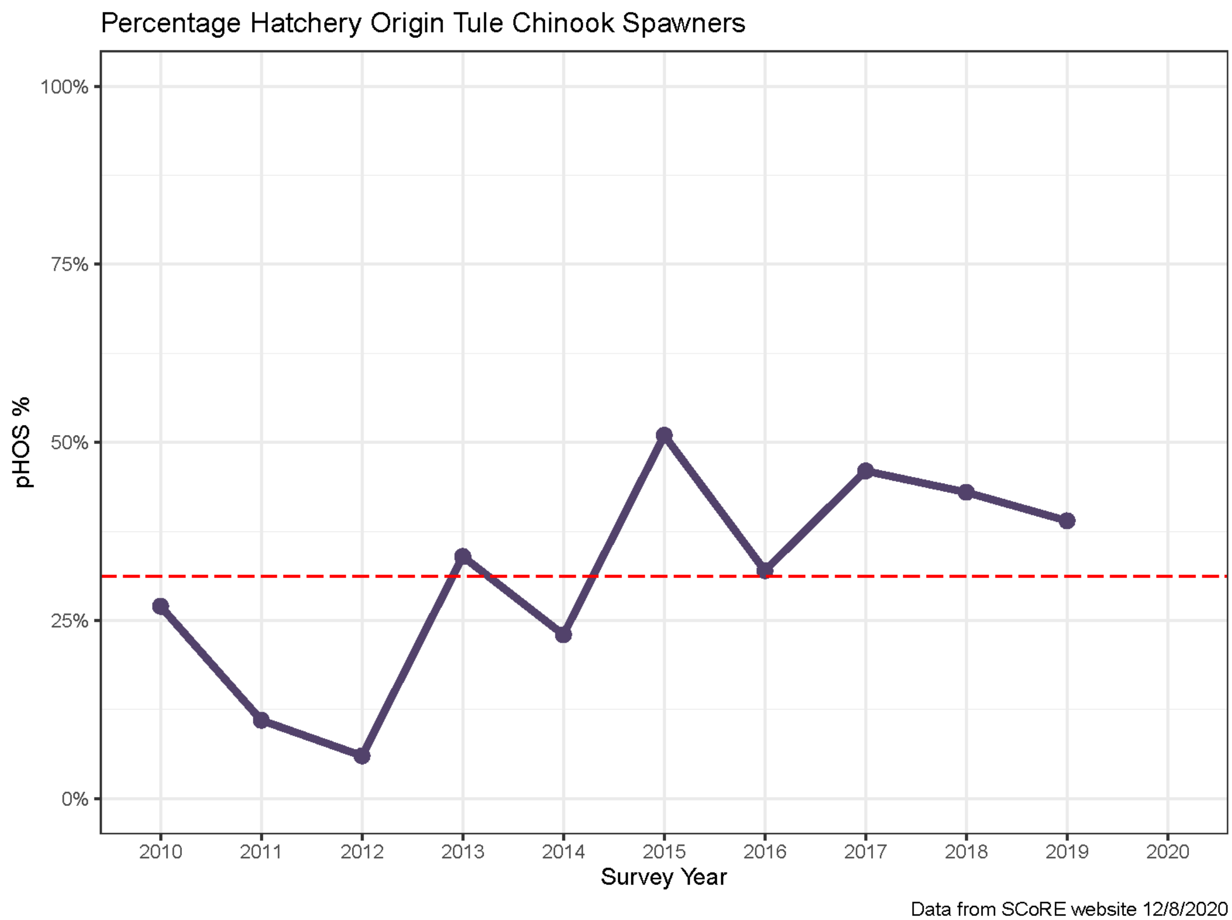

Figure 4. Estimated proportion of tule fall Chinook hatchery origin spawners (pHOS) in the White Salmon River (2010 - 2019). Dotted line is the mean (31%).

Little White Salmon NFH: URB Program

Little White Salmon 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) 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.

b) 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). 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 2011, the facility has annually released approximately 4.4M juveniles with a mean size of 82 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 9).

Table 9. 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 12/21/2020.

Release Year	Release Dates	AD + CWT	CWT (DIT)	AD Only	No Mark/ CWT *	Total Released	Mean Size (Fish/lb)
2011	23-Jun	366,279	197,794	3,909,595	2,200	4,475,868	87
2012	26-Jun, 3-Jul	565,914	194,722	3,803,310	5,483	4,569,429	87
2013	2-Jul	360,089	198,443	3,862,277	769	4,421,578	66
2014	1-Jul, 2-Jul	267,804	99,702	4,038,588	298	4,406,392	86
2015	2-Jul	188,763	186,398	3,583,770	13,595	3,972,526	82
2016	11-Jul	196,105	196,772	3,565,052	3,186	3,961,115	85
2017	5-Jul	197,829	198,487	4,297,331	1,381	4,695,028	77
2018	11-Jul	189,005	186,872	3,475,401	13,093 (419,000)†	3,864,371 (419,000)†	78
2019	9-Jul,	104,346	98,088	2,961,342	3,545	3,167,321	81
	15-Jul	97,123	96,545	1,120,176	3,490	1,317,334	90
2020	14-Jul	198,573	199,339	2,225,542	2,149,865	4,773,319	85
Mean		**273,183**	**185,316**	**3,684,238**	**219,690**	**4,362,428**	**82**

* 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.

c) 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 10). 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 CWT. The Yakima River-Prosser Hatchery program is moving towards taking eyed eggs with the entire 1.7M. In 2020 marking and tagging operations were suspended due to COVID-19, no fish were marked or CWTed before their transfer to Prosser Hatchery. The actual number of URB juveniles that have been marked, tagged, and transferred to the Prosser program since 2011 are presented in Table 10. 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 2018 no eggs were transferred, in 2019 no fish or eggs were transferred due to low adult returns to Little White Salmon. To fulfill full production at Little White Salmon NFH for BY2018, 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.

Table 10. Annual transfer dates and total number of juveniles transferred *to* the Prosser program from Little White Salmon NFH. Data retrieved from CRiS 8/4/2020.

Transfer Year	Transfer Dates	Transfer Location	Total Transferred
2011	4/25.	Prosser	1,700,662
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
2019	No Transfers		NA
2020	3/31, 4/1, 4/6, 4/7, 4/9, 4/10	Prosser	1,701,568
Mean			**1,585,148**

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 11). The mean detection rate at Bonneville Dam of PIT tagged URB juveniles from Little White Salmon is approximately 11.4%, with an average median travel time from the hatchery to the dam of 12 days. Interestingly, a few PIT tagged juveniles take a substantially longer time to migrate downstream, with the longest migration time per year ranging from 44 to 252 days.

Table 11. The number of PIT tagged juvenile URB fall Chinook released from Little White Salmon NFH and juvenile travel times to Bonneville Dam (BONN). Data retrieved from PTAGIS 11/6/2020.

Release Year	Release Dates	# PIT Tagged	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2011	23-Jun	24,878	1,193	4.8	20	(2 - 126)	12	32	42
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
2014	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	9-Jul, 15-Jul	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
Mean		**16,840**	**1,799**	**11.4**	**14**		**12**	**18**	**25**

* The PIT tagging goal was decreased in release year 2013 from 25K to 15K juveniles. 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 a review of directionality of ladder detections for a sub-sample of each stock of fish, a day of year cut-off, September 1, 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 after the mini-jack cut-off date. 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 2009-2018 (release years 2010-2019) ranged from 0.4 to 0.74 (Table 12; Fig. 6). The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years. This is due to the fact that adult returns are added in 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 a larger variances. In subsequent years, as more adults from a brood year return, the variance of the estimates should decrease.

In 2020, a main downstream detection site (Lower River Trawl) was not operated due to COVID-19. With no PIT tag detections of fish downstream of Bonneville Dam, we were unable to estimate survival for Brood Year 2019 (Release Year 2020). However, we will be able to back-calculate juvenile survival in the future with data from adult returns.

Table 12. *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 CRiS: 12/4/2020.

Brood Year	Release Year	Median Survival	95% Lower	95% Upper
2009	2010	0.59	0.52	0.67
2010	2011	0.69	0.57	0.81
2011	2012	0.67	0.56	0.80
2012	2013	0.70	0.63	0.77
2013	2014	0.58	0.50	0.70
2014	2015	0.49	0.41	0.64
2015	2016	0.74	0.58	0.94
2016	2017	0.55	0.42	0.71
2017	2018	0.67	0.55	0.78
2018	2019	0.40	0.32	0.55
2019*	2020	NA	NA	NA
Mean		**0.61**	**0.51**	**0.74**

* We were unable to estimate survival for Brood Year 2019 due to lack of PIT tag detections of fish downstream of Bonneville Dam

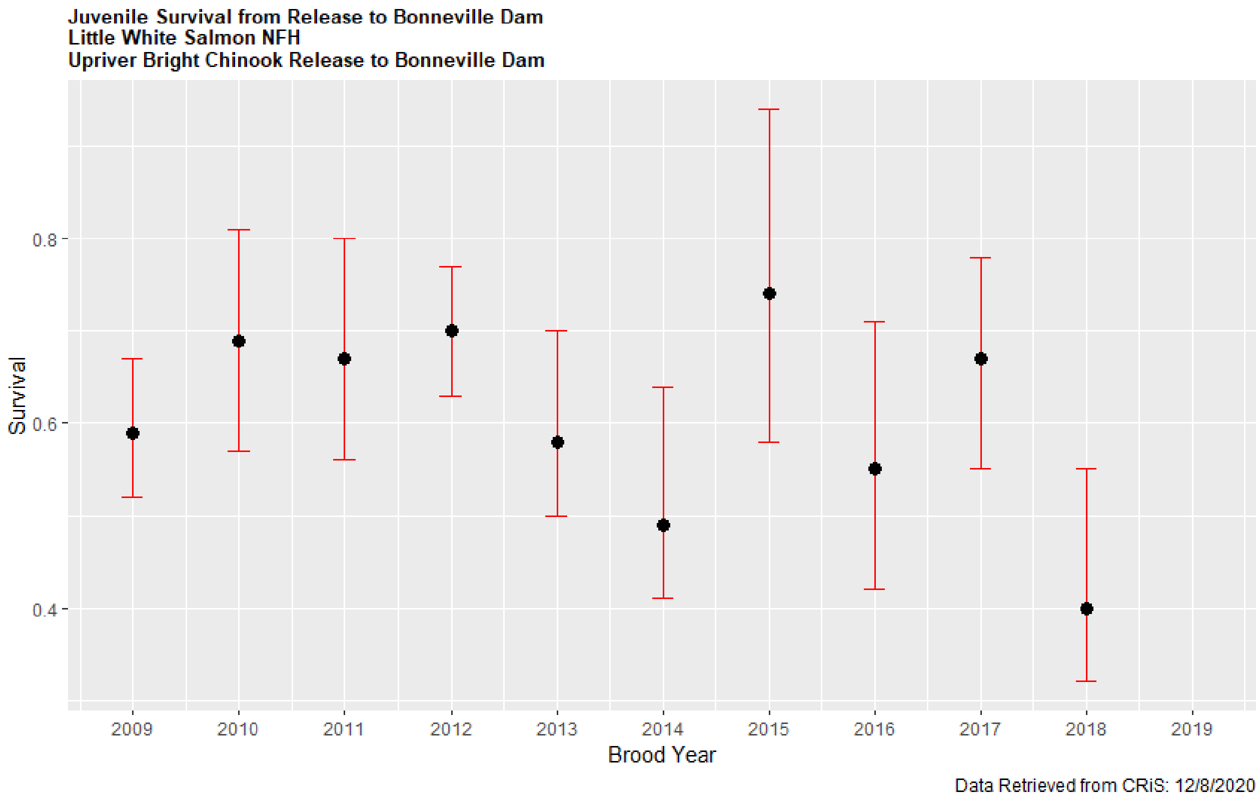

Figure 6. Little White Salmon NFH Upriver Bright Fall Chinook apparent juvenile survival from release to Bonneville Dam (2009 - 2018). Error bars are lower and upper credible intervals.

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 13; Pastor 2004, 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 2004, the facility has a mean smolt-to-adult survival rate of 0.79 (Table 13) which is still within the range reported in the facility's HGMP (USFWS 2004b, 2015). Additionally, the URB program has contributed a mean of 28,454 adults annually for the past ten years. CWT recoveries beyond brood year 2013 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 13. 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. Due to delays in reporting to RMIS, CWT recoveries may be adjusted every year for accuracy. All recovery information presented above is current as of 8/17/2020 and CRiS stock assessment reports run on 1/4/2021.

Brood Year	Hatchery Returns*	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults†	Smolt-to-Adult Survival (%)
2004	1,774	323	1,185	70	3,352	0.23
2005	6,903	2,865	3,108	174	13,057	0.72
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
Mean	**10,414**	**8,168**	**6,694**	**3,167**	**28,454**	**0.79**

* Hatchery returns are returns to Little White Salmon NFH.

† Total Adults includes other recovery locations not listed, such as strays to other hatcheries.

An average 632 CWTs have been recovered each year at Little White NFH since 2011 (Table 14). The Little White NFH URB fall Chinook program accounts for 98.4 percent of all recoveries; URB fall Chinook from other programs include Bonneville Hatchery NFH (1%), Willard NFH (0.5%), other hatchery programs account for less than <0.1%.

Table 14. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Little White NFH 2011 - 2020, tag recoveries for 2020 are not yet complete. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. Data retrieved from RMIS: 8/7/2020, 2020 Data is not yet available.

Return Year	CWT Recoveries	Hatchery Origin	% of Total Return
2011	859	L White Salmon NFH	99.3
	6	Bonneville Hatchery	0.7
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
	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	1315	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	-	-	-
Mean	**632**		

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 15: brood year; Table 16: return year). The majority (52%) of adult URBs return to the facility at Age-4, but 33% return at Age-3. Approximately 3% 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 13,880 adult returns to the hatchery between 2011 and 2020.

Table 15. Estimated age structure of adult URB fall Chinook returns to Little White Salmon NFH by *brood year*. CRIS age composition reports run on 12/11/20.

Brood Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2004	283	543	2,526	706	34	4,092
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	NA	NA
2016*	676	5,861	10,812	NA	NA	NA
2017*	246	2,444	NA	NA	NA	NA
2018*	354					
Mean	**463**	**3,587**	**6,563**	**1,508**	**29**	**11,686**

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

Table 16. Total number of adult URB fall Chinook returns to Little White Salmon NFH and estimated age structure by *return year*. Data retrieved from CRiS 12/11/2020.

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2011	612	2,990	6,863	1,174	47	11,686
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
Mean	**367**	**4,187**	**7,784**	**1,513**	**28**	**13,880**

c) Bonneville Dam Detections

Since Return Year 2011, URB fall Chinook adults (Ages 2 - 6) PIT tagged and released from Little White NFH returned to Bonneville Dam as early as Jul-16 and as late as Nov-05 with the average median Sep-08 (Table 17). 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 17. Median Bonneville Dam passage date of URB Fall Chinook adults PIT tagged and released from Little White NFH (Ages 2 - 6). Total hatchery returns for 2020 are not yet complete. Data retrieved from PTAGIS 12/4/2020.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion (95% CI)*	Hatchery Count/ Bonn Exp. *100
2011	Sep-12	Aug-19	Nov-01	171	18,528 (14,224 – 25,384)	63%
2012	Sep-10	Aug-09	Oct-23	197	31,469 (24,219 – 42,144)	29%
2013	Sep-09	Aug-07	Nov-02	466	84,976 (72,739 – 101,248)	42%
2014	Sep-10	Aug-17	Oct-15	375	70,175 (58,673 – 86,198)	31%
2015	Sep-11	Aug-15	Oct-22	302	66,095 (54,249 – 81,529)	18%
2016	Sep-04	Jul-29	Sep-22	92	24,941 (17,816 – 38,159)	33%
2017	Sep-12	Aug-24	Oct-12	62	18,174 (11,725 – 25,210)	32%
2018	Sep-11	Aug-20	Oct-13	41	11,581 (6,472 – 24,149)	41%
2019	Sep-13	Aug-22	Nov-05	83	23,703 (16,608 – 31,836)	61%
2020	Sep-08	Jul-16	Oct-07	84	25,507 (17,138 – 36,442)	59%
Mean	**Sep-10**	**Aug-11**	**Oct-18**	**187**	**37,515**	**41%**

*Confidence limits do not include detections of five fish or less per age group to reduce the variability and increase the accuracy of the estimate

d) Hatchery Ladder Detections

Since Return Year 2011, 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-22 (Table 18). Upriver bright fall Chinook released from Willard NFH also return to Little White NFH for spawning. Since Return Year 2018, an average 3 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 18).

Table 18. 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). Total hatchery returns for 2020 are not yet complete. Data retrieved from PTAGIS 12/4/2020.

Return Year	Mark Site	Median Passage Date	First Det. Date	Last Det. Date	# of Fish Det.	Ladder Expansion (95% CI)*	Hat. Count	Hat. Count/ Bonn Exp. *100
2011	LWS	Oct-31	Oct-16	Nov-16	78	8,185 (5,326 – 11,121)	11,686	63%
2012	LWS	Oct-24	Oct-15	Nov-06	63	10,259 (6,493 – 17,868)	9,149	29%
2013	LWS	Oct-30	Jul-08	Nov-19	196	35,567 (28,181 – 47,387)	35,969	42%
2014	LWS	Oct-23	Sep-24	Nov-05	101	18,712 (12,985 – 25,402)	21,524	31%
2015	LWS	Oct-27	Oct-09	Nov-08	81	17,529 (12,068 – 26,644)	12,160	18%
2016	LWS	Oct-16	Sep-27	Nov-05	39	10,286 (6,166 – 19,076)	8,222	33%
2017	LWS	Oct-20	Oct-17	Oct-26	15	4,403 (2,071 – 10,490)	5,824	32%
2018	LWS	Oct-24	Sep-29	Nov-14	24	6,670 (2,840 – 7,793)	4,798	41%
	WI	Oct-25	Oct -20	Oct-30	3	362 (NA – NA)	-	-
2019	LWS	Oct-22	Oct-07	Nov-16	34	9,951 (5,800 – 16,503)	14,486	61%
	WI	Oct-27	Oct -20	Nov-3	2	230 (NA – NA)	-	-
2020	LWS	Oct-08	Sep-30	Oct-12	11	3,519 (1,770 – 6,776))	14,984	59%
	WI	Oct-12	Sep-30	Oct-12	4	508 (NA – NA)	-	-
Mean	**LWS**	**Oct-22**	**Sep-27**	**Nov-06**	**64**	**12,508**	**13,880**	**41%**
	WI	**Oct-21**	**Oct-13**	**Oct-25**	**3**	**366**	**-**	**-**

*Confidence limits do not include detections of five fish or less 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 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, 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 19; Fig. 7).

Table 19. 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 12/8/2020).

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
Mean	**2,736**	**1,149**

* 2011 escapement estimates were unavailable due to the breach of Condit Dam.
** 2019 Data is from the WDFW 2019 Spawning memo (Olk and Dammerman 2020 memorandum).

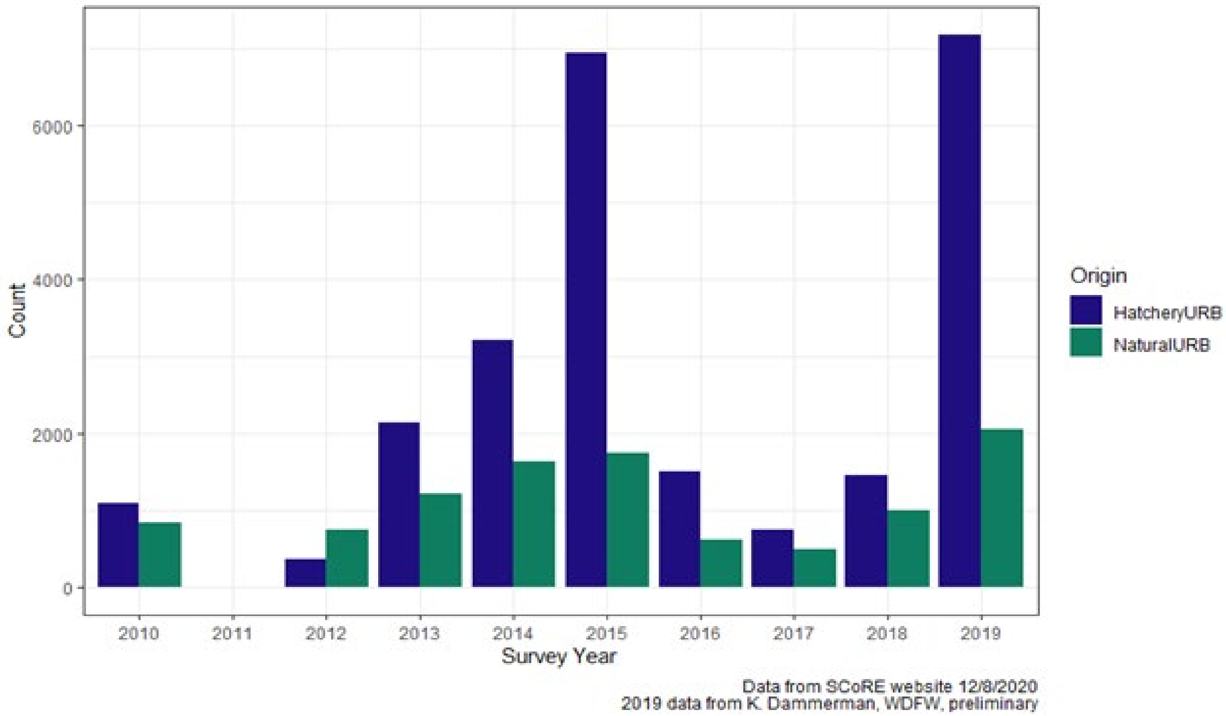

Figure 7. Escapement estimates of hatchery-origin and natural-origin upriver bright (URB) fall Chinook in the White Salmon River during annual spawning surveys (2010 - 2019). 2011 escapement estimates were unavailable due to the breach of Condit Dam.

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 20). The preliminary 2020 estimates of the number of hatchery-origin URBs spawning in the White Salmon River are in the range of approximately 5,000 fish (Elise Olk, WDFW, personal communication), and Little White Salmon NFH's hatchery count of URBs in 2020 was 14,992 (CRiS Data).

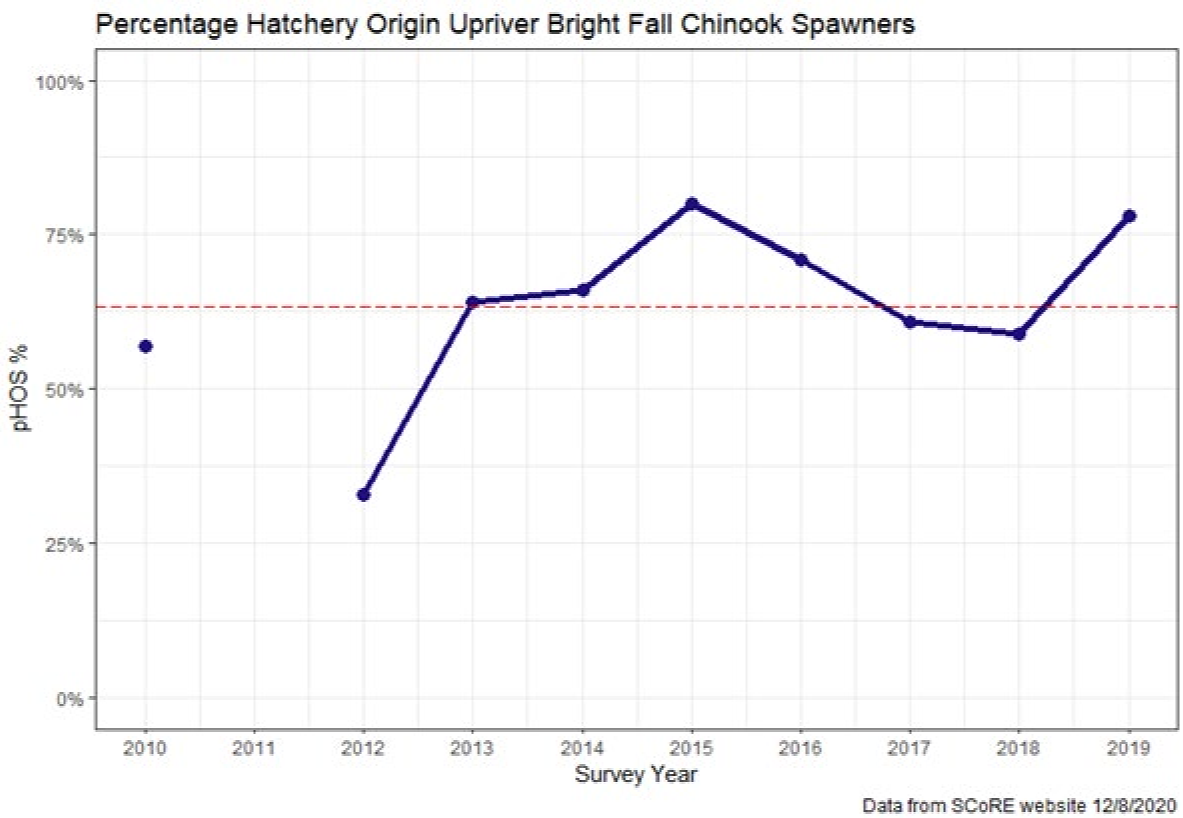

Figure 8. Estimated proportion of upriver bright (URB) fall Chinook hatchery origin spawners (pHOS) in the White Salmon River (2010 - 2019). Dotted line is the mean (63%).

Table 20. 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 (2013-2020). Hatchery counts are from the CRiS database, WDFW estimates are from the SCORE website. *The 2020 WDFW estimate is a rough preliminary estimate (E. Olk, WDFW, personal communication)

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	1,377
2019	14,513	7,117
2020	14,992	5,000*

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 21). 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 21. 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 12/15/20 and WDFW SCORE website.

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	1,377
2019	5,187	3,646	7,704	7,117

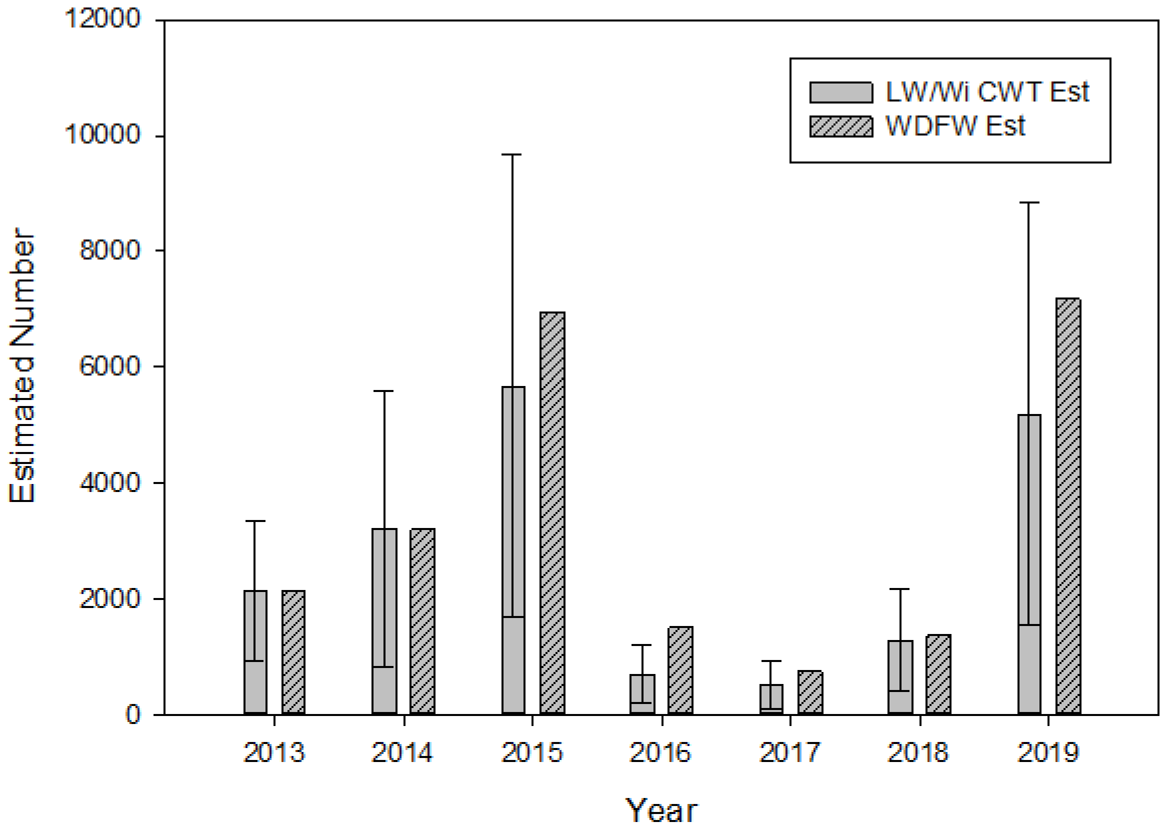

Figure 9. Estimated number of hatchery upriver bright fall Chinook from the Little White and Willard NFH programs, based on coded-wire tag expansions for tagging rate and sampling rate, and the total number of estimated hatchery upriver bright fall Chinook spawning in the White Salmon River (WDFW estimate). 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).

As part of the Reasonable and Prudent Measures in the Biological Opinion for upriver bright fall Chinook increased production at Little White Salmon NFH (NMFS (2017); RPA 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. The Biological Opinion, however, does not specify what level of certainty around the 3,000 adult number is appropriate. Both spawning survey counts and coded-wire tag recovery counts have a level of uncertainty due to sampling error and measurement error. Accounting for this error is complicated by the inherent difficulties in sampling fish in the natural environment and assessing whether the 3,000 adult threshold has been exceeded depends on the level of uncertainty that the managers are willing to accept. Using the WDFW estimates of total hatchery spawners, the three-year average for 2017-2019 was 3,082. If the preliminary estimate for 2020 (~5,000 hatchery URB) is close to the final estimate, the 3-year average for 2018-2020 would be approximately 4,500 fish. The WDFW estimates of hatchery origin spawners on the SCORE website do not include confidence intervals around the point estimates, but the preliminary estimates produced by the area biologists as part of their annual spawning memoranda do. The two estimates are produced using different methods, with the SCORE website data superseding the preliminary estimates in the spawning memos as the official estimates (E. Olk and K. Dammerman, 2020 memorandum to interested parties, Washington Department of Fish and Wildlife, on the 2019 White Salmon Chinook salmon spawning ground survey methods and results). For the 2019 preliminary estimate, the mean hatchery URB abundance was 7,177 with a 95% confidence interval of 4,277-11,910 hatchery URBs, indicating a high level of uncertainty in the preliminary estimate (Olk and Dammerman, memorandum). It is likely that the final estimates posted on the SCORE website also have a level of uncertainty comparable, but possibly somewhat lower than, the preliminary estimates.

To assess whether the 3,000 hatchery adults from the Little White Salmon NFH URB program threshold has been exceeded, several different methods can be used. First, the WDFW point estimates of number of hatchery spawners can be used, ignoring any uncertainty around the estimate and assuming that all of the hatchery URBs are from the Little White Salmon NFH program. This method results in the 3-year average being 3,082 for 2017-2019 and approximately 4,500 for 2018-2020. Another approach would again ignore the uncertainty in the WDFW estimates but assume that 90% of the hatchery fish are from the Little White Salmon NFH program (the average proportion of coded-wire tags in the White Salmon River from Little White Salmon NFH). With this approach, the estimated three-year average of strays would be 2,773 (2017-2019) and 4,050 (2018-2020). However, this approach introduces another level of uncertainty, the uncertainty in coded-wire tag sampling and recovery, but again ignores that uncertainty. A third approach would be to use the expanded coded-wire tag recoveries. In this scenario, the 2017-2019 average would be 2,330 fish but the estimated range would be approximately 1,650-3,450 fish (at an 80% confidence interval; a 95% interval would result in an even wider range). An estimate for the 2018-2020 three-year period is not available at this time due to the lag in reading and uploading the 2020 coded-wire tag recoveries. Regardless of the approach, the general assessment is that in 2018, 2019, and apparently 2020, a large number of hatchery fish from the Little White Salmon NFH program have strayed into the White Salmon River.

Interactions between hatchery–origin URBs and natural-origin tule fall Chinook in the White Salmon River may lead to loss of a productivity in the tule population. Since URBs typically spawn later, and in areas used by tule spawners, redd superimposition of URB redds on tule redds may occur. Redd superimposition may result in tule egg displacement and reduce the egg-to-fry survival rate. Monitoring and assessing the impact of tule redd superimposition directly is difficult, therefore the abundance of hatchery URBs spawning naturally was established in the Biological Opinion as a surrogate measure for impacts on the tule population. Additionally, with some level of overlap in spawn timing and spawning location between URBs and tules, spawning between URBs and tules could produce hybrid juveniles (NMFS 2017; Smith and Engle 2011). At the time of the 2017 Biological Opinion, the available evidence indicated that the risk of genetic introgression between the tule and URB populations was low (NMFS 2017). Smith and Engle (2011) found no evidence of hybrid juveniles surviving to adulthood and potentially crossing back into the parental populations. Their study did find, however, that 4.3% to 15% of the fall Chinook juvenile production in the White Salmon River in a given year were tule-URB hybrids. While genetic introgression of tules and URBs did not appear to be a concern, hybrids could be thought of as representing lost tule production, in that if no URBs had been present, the tules could have contributed an additional 4.3% to 15% to the tule population productivity (NMFS 2017). A more recent analysis, which has taken advantage of a larger dataset and newer genetic identification techniques, has found evidence of progeny of first generation tule-URB crosses surviving to adulthood in both the natural populations in the White Salmon River and in the hatchery broodstock at Little White Salmon NFH (Smith et al. 2020 DRAFT). In addition, the recent analysis also identified backcross hybrids (individuals with one hybrid parent) in both the juvenile and adult populations in the White Salmon River, indicating that first generation hybrids and subsequent generations of hybrids are surviving and contributing to the spawning populations. In light of the new analysis, the risk of genetic introgression between URB and tule populations needs to be revisited.

The factors affecting the hatchery–origin stray rate and total number of hatchery fish spawning in the White Salmon River are not fully understood but hatchery operations do have some affect. A previous study (Engle et a. 2006) found that ladder operations (i.e. opening and closing the hatchery ladder entrance) had an affect on the number of hatchery fish straying into the White Salmon River. Straying into the White Salmon River increased if the hatchery ladder was closed during the second half of October. Based on this information, both the 2007 and the 2017 Biological Opinions requested that the hatchery operate their ladder and catch ponds to not only collect broodstock but also remove excess hatchery fish during the month of October and into November, and, as a Term and Condition, manage the program to maximize the removal of hatchery adults returning to the facility (NMFS 2017; Terms and Conditions 2a). Little White Salmon's broodstock collection goal, to meet all program requests, is approximately 9,300 adults annually. Approximately 4,000 of those adults are used to meet the John Day-The Dalles Dam mitigation program's release goal of 4.5 million juveniles. The hatchery's catch pond can hold approximately 6,000-7,000 adults at one time (B. Turik, USFWS, personal communication). The design of the catch ponds, hatchery infrastructure, and staffing requirements makes it difficult for the hatchery staff to surplus out excess hatchery adults while still holding adults for spawning purposes. During years of large numbers of adult returns, the hatchery's catch pond can be filled in a matter of hours or days, necessitating the closure of the ladder entrance. During these times, ladder closures may last for 1-4 days, particularly over weekends. Due to ladder closures and the potential for fish to stray into the White Salmon River or other locations, the hatchery counts of fish collected do not necessarily reflect the total number of fish that returned to the hatchery and attempted to enter the fish ladder. Fish trying to enter the hatchery ladder during ladder closures may end up straying to another location (Engle et al. 2006). This may be one reason why there is little correlation between the hatchery counts and the number of strays in the White Salmon River in a particular year (Pearson's r=0.10; Figure 10). The proportion of fish straying onto the spawning grounds was reduced during the first several years of the implementation of the ladder opening protocol (return years 2007-2010) before going back to a higher lever for return years 2012-2019 (Figure 11). Looking at stray rates onto the spawning grounds by *brood year*, the increase in stray rate beginning with brood year 2008, which is roughly analogous to adult returns beginning in 2012, coincided with the increase in the release goal from 2.0 to 4.5 million (Figure 12).

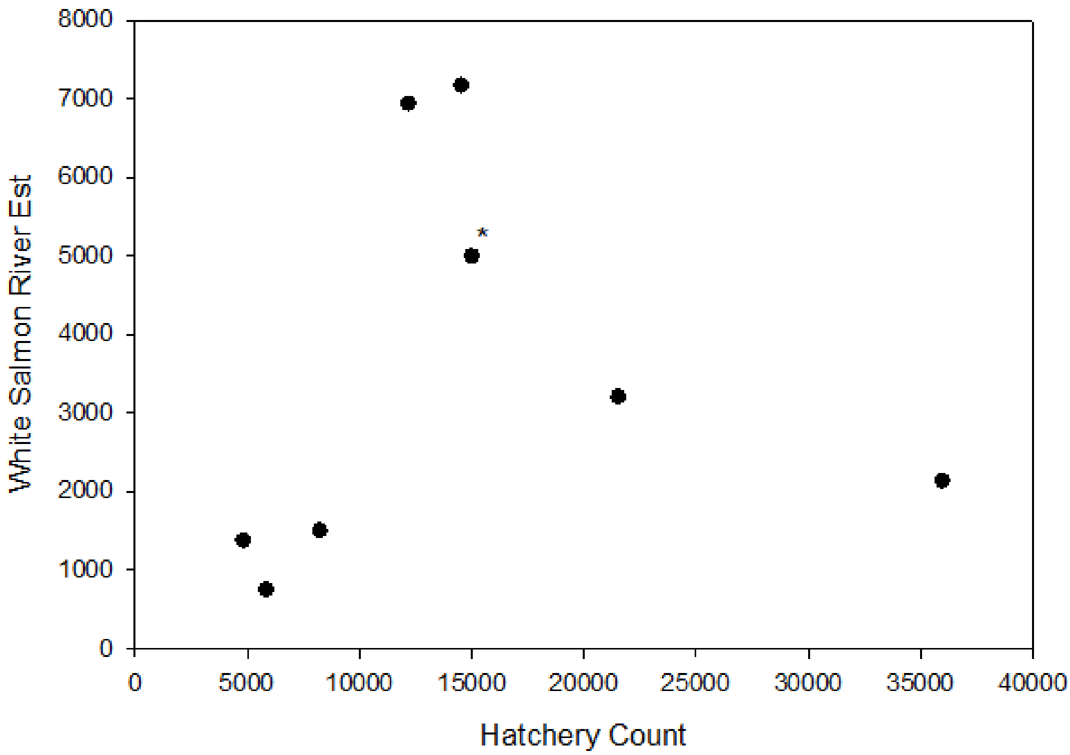

Figure 10. Estimated total hatchery Upriver Bright Fall Chinook Salmon spawning in the White Salmon River versus total number of hatchery Upriver Bright Fall Chinook Salmon collected at Little White Salmon NFH (2013-2020). Little White Salmon NFH counts are from the CRiS database. White Salmon River estimates 2013-2019 are from WDFW spawning survey data on the SCORE website (12/14/2020). *2020 WDFW preliminary rough estimate (E. Olk WDFW personal communication).

Harvest of hatchery URBs often occurs in Drano Lake. Harvest, which is one of the main purposes of the hatchery production, is another method of removing hatchery returns and potentially reducing the number of strays. In recent years, harvest in Drano Lake has fluctuated, with harvest in 2019 curtailed due to forecasted low returns. Sport harvest is managed by the State of Washington and tribal harvest is managed by the various tribal entities. While harvest can reduce the number of hatchery fish that return to the hatchery, and potentially reduce the number of fish that return to the hatchery area but eventually stray into the White Salmon River, the impact of harvest on reducing stray rates is unknown.

It is possible that hatchery fish from other programs are contributing to the straying issue in the White Salmon River but that the tagging rates at these programs are not sufficient to reliably detect through spawning ground recoveries. Based on coded-wire tag recoveries, >90% of the tags recovered in the White Salmon River are from the Little White Salmon NFH program. The estimated number of strays from Little White Salmon NFH, based on coded-wire tag expansions, are approximately equal to, or lower than, the point estimates of the total number of hatchery strays, with the confidence intervals of the coded-wire tags encompassing the point estimates in each year (Figure 9). It is likely that there are some hatchery strays from other programs contributing to the stray totals, but the vast majority of strays are from Little White Salmon NFH.

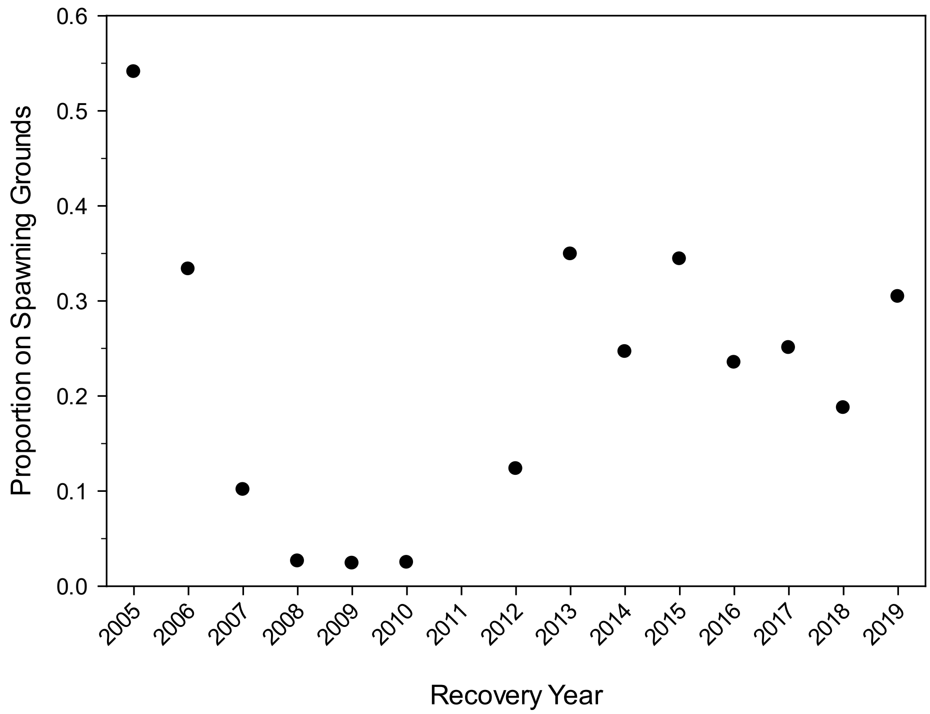

Figure 11. Proportion of Little White Salmon NFH Upriver Bright Fall Chinook freshwater coded-wire tag recoveries recovered on spawning grounds (includes all spawning grounds), by *recovery year*. In the 2007 BiOP, ladder management was changed to keep ladder open as much as possible after the 3rd week of October. 2011 spawning ground date excluded due to Condit Dam removal. Data from RMIS HS-1 report 1/5/21.

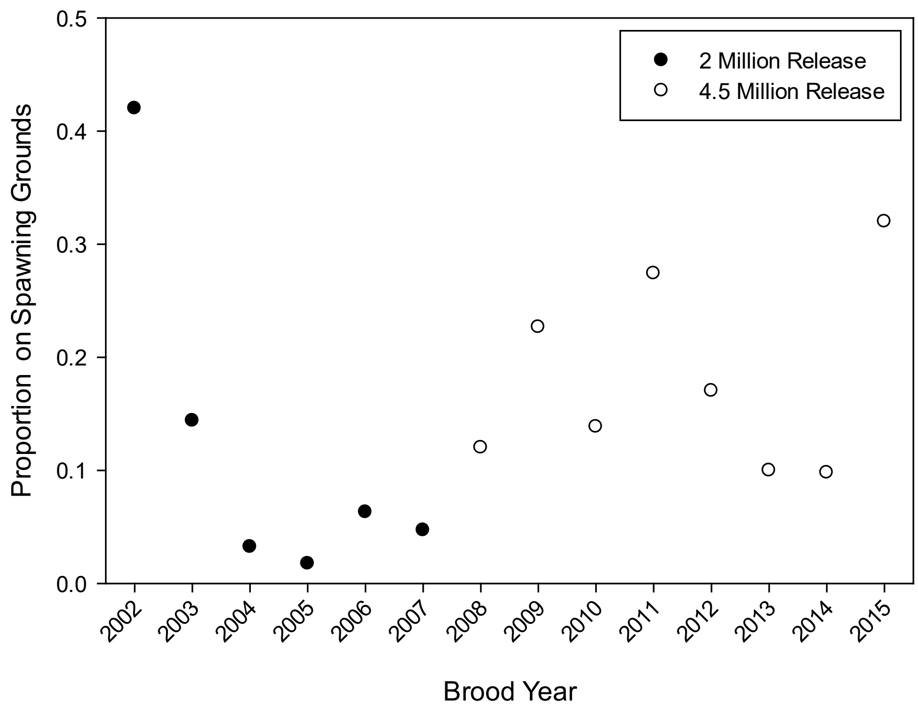

Figure 12. Proportion of LWSNFH freshwater coded-wire tag recoveries recovered on spawning grounds (includes all spawning grounds), by *brood year*. Beginning with BY2008, the release goal was increased to 4.5 million. Data from RMIS HS-1 report 1/5/21.

Flow conditions in the area around Little White Salmon NFH and the mainstem Columbia may also affect stray rates. The Bonneville Pool level of the Columbia River may affect the attractant flow from the Little White Salmon River and from Little White Salmon NFH at the ladder entrance (B. Turik, USFWS, personal communication). If pool levels are low, the entrance to the hatchery ladder becomes more channelized, while if pool levels are high the flow of the Little White Salmon River and hatchery ladder may become more diffuse with more water exchange from the mainstem Columbia. There is limited data on the flow conditions at the hatchery ladder entrance and within Drano Lake with which to make inferences about the affect of flow on hatchery straying.

Given the available information, maximizing the collection of hatchery URBs at Little White Salmon NFH is one objective that can be targeted to reduce the straying into the White Salmon River. Facility upgrades and additional staffing may be required to effectively achieve this objective. Additional actions may also reduce the straying rate, however data is lacking on the effectiveness of those potential actions. For example, reducing hatchery production would likely lead to fewer strays in the White Salmon River. Assuming a fixed stray rate in any particular year, fewer returning adults would lead to fewer strays. Fewer returning adults may actually reduce the overall stray *rate* in a particular year, if ladder closures are a primary driver of stray rates, with fewer returning adults presumably leading to a reduction in ladder closure times. Another option could be to release a portion of the production at a location other than Little White Salmon NFH, assuming adults would return to the location of release. The location of release, the ability to collect adults at the release location, and the impact on Little White Salmon adult broodstock goals would need to be assessed before taking such an action. Additionally, the risk of adults homing and returning to Little White Salmon NFH instead of the release location would have to be evaluated. Prior to taking any alternative actions, managers should identify all of the objectives they are trying to achieve so that a comprehensive assessment of alternatives can be undertaken.

Acknowledgements

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