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

FY 2018 Annual Report

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On the cover: *Male adult tule fall Chinook salmon sampled during spawning at Spring Creek National Fish Hatchery. The facility rears and releases juvenile tule as part of the John Day/The Dalles Dam Mitigation Program. Adult returns to the facility are utilized as broodstock to meet tribal trust mandated responsibilities and mitigation requirements. Photo credit: Cheri Anderson.*

Disclaimers

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MONITORING AND EVALUATION UPDATES FOR JOHN DAY/THE DALLES DAM MITIGATION PROGRAMS AT SPRING CREEK AND LITTLE WHITE SALMON NATIONAL FISH HATCHERIES

2018 ANNUAL REPORT

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Abstract

The John Day/The Dalles Dam Mitigation (JDTD) program provides mitigation for the escapement of 30,000 adult fall Chinook salmon (*Oncorhynchus tshawytscha*) due to the loss of spawning habitat and production caused by construction of the John Day and The Dalles Dams in the Columbia River. The program is funded by the U.S. Army Corps of Engineers (USACE) and operates with a total adult production (TAP) goal of 107,000 adults 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, and contributed a mean of 68,631 adult tules (including 47,335 for harvest) annually to the JDTD program TAP goal. Since 2009, Little White Salmon NFH has annually released a mean of 4.4M juvenile upriver brights into the Little White Salmon River, and supported JDTD programs at other facilities through egg and juvenile transfers. The program at Little White Salmon NFH contributes a mean of 24,280 adult upriver brights (including 12,376 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. Collectively, both facilities are successfully contributing to their mitigation obligations. 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 (and ESA compliance) 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 (Fig. 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 the 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 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 (Fig. 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 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/Yakima River program. Juvenile production fish released as part of the JDTD program provide locally adapted adult broodstock as well as harvest opportunities for sport, commercial, and tribal fisherman, contributing to the TAP goal and mitigation agreements negotiated by *U.S. v Oregon* parties and USACE.

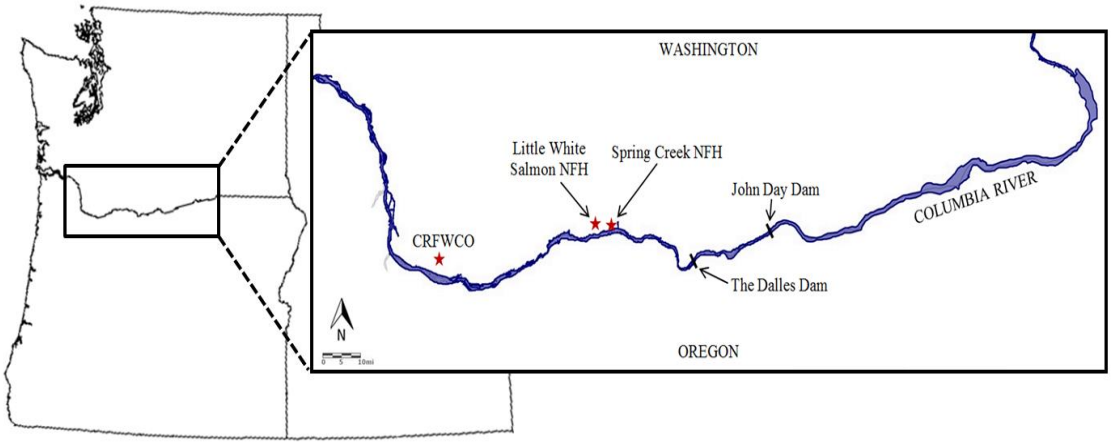

Figure 1. Spring Creek and Little White Salmon NFHs are located on the Washington side of the Columbia River (purple) downstream of the John Day and The Dalles Dams. Monitoring and evaluation of the fall Chinook production programs at these facilities is conducted by staff at the Columbia River Fish 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) 2018, the U.S. Fish and Wildlife Service (USFWS) requested funding from the USACE in the amount of $4,328,000 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 (NMFS) 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.

SECTION 1. Spring Creek NFH: Tule Program

1.1) Program Description

Spring Creek NFH (Fig. 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.

1.2) 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 10,774,855 since 2009 (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). Since release year 2009, the mean size of juveniles released in April and May are 123.29 and 86.65 fish/lb, respectively. Ninety-three percent (~10M) of the annual production is mass marked with an adipose fin-clip (AD) only. The remaining fish are marked with CWTs with ~400K being AD and marked with CWTs, and ~400K 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 2009 are presented below (Table 1). Coded-wire tag codes are stored in the USFWS CRiS database at the CRFWCO, and reported annually to the Regional Mark Information System (RMIS).

Table 1. Annual release dates, marking and tagging information, number of juveniles released, and mean size at release in April (A) and May (M) for juvenile tule fall Chinook released from Spring Creek NFH.

Release Year	Release Dates	AD + CWT	CWT (DIT)	AD ONLY	Total Released	Mean Size (fish/lb)
2009	13-Apr	179,893	180,030	6,119,393	11,252,949[a]	A: 144.36
	1-May	179,973	179,937	4,413,723		M: 90.95
2010	12-Apr	204,288	204,772	5,790,205	10,479,319	A: 111.26
	10-May	199,336	199,385	4,151,333		M: 75.64
2011	12-Apr	203,259	202,650	5,822,555	10,860,622	A: 112.11
	4-May	199,576	199,410	4,233,172		M: 88.68
2012	11,13-Apr	205,066	203,460	5,862,703	11,077,746	A: 123.87
	1-May	208,147	199,232	4,399,138		M: 98.32
2013	11-Apr	196,681	203,834	6,040,240	11,240,295	A: 99.00
	2-May	20,696	199,892	4,578,952		M: 78.72
2014	11-Apr	205,922	205,548	5,757,948	10,753,701	A: 121.83
	6-May	199,060	198,350	4,186,873		M: 87.80
2015	13-Apr	202,719	202,129	5,974,314	10,415,634	A: 147.59
	1-May	190,848	191,210	3,654,414		M: 105.44
2016	11-Apr	203,461	201,944	5,941,689	10,165,279	A: 112.30
	9-May	194,817	197,566	3,425,802		M: 89.55
2017	10-Apr	204,714	204,431	6,168,828	10,770,367	A: 125.56
	8-May	195,800	194,472	3,802,122		M: 84.41
2018	9-Apr	203,899	201,850	6,265,921	10,732,640	A: 135.00
	7-May	197,100	197,321	3,666,549		M: 87.00
Means	**Apr**	**200,990**	**201,065**	**5,974,380**	**10,774,855**	**A: 123.29**
	May	**178,535**	**195,678**	**4,051,208**		**M: 88.65**

[a]***Reprogramming in release year 2009 reduced the release goal from 15.1M to 10.5M juvenile tules.***

1.3) Off-Station Juvenile Survival

a) PIT Tagging Program: Juvenile Survival and Migration Time

Approximately 15,000 juveniles have been 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 tagged juvenile tule released from Spring Creek NFH are typically detected at Bonneville Dam (BONN) located 35 kilometers downstream from the facility as they migrate to the Pacific Ocean. 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 operating turbines, etc.). Travel times and detection rates to BONN are estimated annually (Table 2). The facility has an annual mean of 14,767 juveniles that have been PIT tagged since release year 2009. A mean of 799 juveniles released from Spring Creek NFH are detected annually at BONN for a mean detection rate of 5.41%. Mean travel time to BONN is 1.66 days with the majority of juveniles (90th percentile) passing over BONN within 2 days of release. However, some juveniles have spent up to 62 days upstream of BONN before migrating downstream.

Table 2. The number of PIT tagged juvenile tule released from Spring Creek NFH and juvenile travel times to BONN.

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Travel Time (Days)					
				Mean	Median	Range	Percentile		
							50th	75th	90th
2009	14,636	840	5.74	2.39	1.00	(1 – 62)	1	2	3
2010	14,933	1,277	8.55	2.57	2.00	(0.5 – 42)	2	3	3
2011	14,939	922	6.17	1.38	1.00	(0.5 – 20)	1	1	2
2012	14,750	668	4.53	1.02	1.00	(0.5 – 24)	1	1	1
2013	14,940	825	5.52	1.89	1.00	(0.5 – 38)	1	2	3
2014	14,866	757	5.09	1.70	1.00	(0.5 – 37)	1	1	2
2015	13,827	788	5.70	2.51	2.00	(1 – 54)	2	2	3
2016	14,954	779	5.21	1.11	1.00	(0.5 – 9)	1	1	1
2017	14,918	513	3.44	0.80	0.50	(0.5 – 12)	0.5	1	1
2018	14,907	619[a]	4.15	1.22	1.00	(0.5 – 53)	1	1	1
Means	**14,767**	**799**	**5.41**	**1.66**	**1.15**	**-**	**1**	**2**	**2**

[a]***Current estimate as of 08/28/2018.***

1.4) Adult Returns, 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 2002-2011, the facility has a mean smolt-to-adult survival rate of 0.539 (Table 3; Table A1) 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 68,631 adults for the past ten years with the highest number of returns from the April juvenile release group. CWT recoveries beyond brood year 2011 were not included in this report given that adult returns reported to RMIS can take several years to be finalized. See Appendix A for CWT data by brood year not broken down by release group (Table A1).

Table 3. 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 tules released from Spring Creek NFH. Returns are reported based on juvenile release group: March (MA), April (A), or May (M). Adult returns are used to estimate smolt-to-adult survival rates.

Brood Year	Hatchery Returns[a]	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # of Adults	Smolt-to-Adult Survival (%)
2002	Ma: 10,070 A: 3,103 M: 4,424	Ma: 7,791 A: 3,103 M: 2,660	Ma: 7,314 A: 3,509 M: 1,960	Ma: 424 A: 232 M: 84	Ma: 25,599 A: 9,947 M: 9,128	Ma: 0.170 A: 0.066 M: 0.061
2003	Ma: 3,214 A: 3,161 M: 1,656	Ma: 3,729 A: 3,712 M: 1,150	Ma: 1,764 A: 4,205 M: 1,104	Ma: 0 A: 203 M: 0	Ma: 8,707 A: 11,281 M: 3,910	Ma: 0.059 A: 0.077 M: 0.027
2004	Ma: 1,661 A: 975 M: 260	Ma: 2,178 A: 1,539 M: 860	Ma: 1633 A: 734 M: 220	Ma: 329 A: 0 M: 0	Ma: 5,801 A: 3,248 M: 1,340	Ma: 0.040 A: 0.022 M: 0.001
2005	Ma: 12,051 A: 14,670 M: 9,579	Ma: 14,000 A: 18,022 M: 11,003	Ma: 6,125 A: 9,200 M: 4,035	Ma: 0 A: 140 M: 0	Ma: 32,176 A: 42,032 M: 24,617	Ma: 0.211 A: 0.276 M: 0.162
2006	Ma: 5,015 A: 3,693 M: 2,413	Ma: 7,018 A: 4,321 M: 1,650	Ma: 2,293 A: 1,422 M: 826	Ma: 0 A: 0 M: 0	Ma: 14,326 A: 9,436 M: 4,889	Ma: 0.093 A: 0.060 M: 0.032
2007	Ma: 16,059 A: 22,155 M: 16,808	Ma: 24,450 A: 22,692 M: 22,637	Ma: 10,987 A: 14,329 M: 16,117	Ma: 0 A: 520 M: 0	Ma: 51,496 A: 59,696 M: 55,562	Ma: 0.346 A: 0.401 M: 0.373
2008	A: 11,916 M: 7,171	A: 18,506 M: 11,505	A: 9,251 M: 9,511	A: 175 M: 0	A: 39,848 M: 21,187	A: 0.354 M: 0.251
2009	A: 15,196 M: 5,180	A: 22,479 M: 8,261	A: 14,349 M: 6,873	A: 145 M: 6	A: 52,169 M: 20,320	A: 0.485 M: 0.189
2010	A: 8,403 M: 4,308	A: 19,085 M: 10,676	A: 10,166 M: 5,711	A: 12 M: 15	A: 37,666 M: 20,710	A: 0.347 M: 0.191
2011	A: 10,102 M: 8,456	A: 31,675 M: 35, 683	A: 18,030 M: 16,984	A: 0 M: 289	A: 59,807 M: 61,412	A: 0.540 M: 0.554
Means (Monthly)	**Ma: 8,012 A: 9,337 M: 6,026**	**Ma: 9,861 A: 14,513 M: 7,822**	**Ma: 5,019 A: 8,520 M: 6,334**	**Ma: 126 A: 143 M: 39**	**Ma: 23,018 A: 32,513 M: 22,308**	**Ma: 0.153 A: 0.263 M: 0.184**
(Annual)	**20,170**	**27,470**	**17,865**	**257**	**68,631**	**0.539**

[a]***Hatchery returns include fish collected at all hatcheries within the Columbia River basin.***

[b]***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 8/31/2018.***

Adult returns to Spring Creek NFH are estimated by hatchery personnel and the USFWS marking and biosampling crew from CRFWCO (Table A2). 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 (Table 4; Table A2). The majority of adult tule (~64%) return to Spring Creek NFH at Age-3, but 18% return at Age-2 as precocially mature males (jacks) or precocially-mature females (jills).

Table 4. Estimated age structure of adult tule returns to Spring Creek NFH by brood year. Total number of adults is used to estimate the smolt-to-adult return rate (%) to the facility.

Brood Year	Age-2	Age-3	Age-4	Age-5	Total Adults	Smolt-to-Adult Return Rate (%)
2003	2,268	6,950	2,160	0	11,378	0.078
2004	757	3,667	810	228	5,462	0.038
2005	8,303	32,912	5,008	0	46,223	0.303
2006	956	8,463	1,444	34	10,897	0.070
2007	11,988	43,835	2,108	50	57,981	0.389
2008	4,856	14,618	4,321	29	23,824	0.212
2009	4,049	20,852	3,178	119	28,198	0.262
2010	1,912	12,615	3,433	66	18,026	0.166
2011	2,827	18,221	5,203	124	26,375	0.238
2012	10,028	36,152	3,865	0	50,045	0.445
2013	*2,738*	*4,823*	*487*	-	-	-
2014[a]	*8,566*	*11,327*	-	-	-	-
2015[a]	*6,101*	-	-	-	-	-
Means	**5,027**	**17,870**	**2,911**	**65**	**27,841**	**0.220**

[a]Denotes incomplete brood years given that adults have either not yet returned to the hatchery or have not been aged. Incomplete years were not used in estimating means given that the information will be updated.

Approximately 11% of adults return at Age-4 and less than 1% return at Age-5. The facility has produced an annual mean of 27,841 adult returns to Spring Creek NFH, and a mean smolt-to-adult return rate of 0.220% since brood year 2003. See Appendix A for a table of adult returns by return year to Spring Creek NFH (Table A2).

1.5) 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 (J.T. Wilson, 2018 memorandum to WDFW).

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 (Fig. 3). Escapement estimates include the number of live and dead spawners observed from Husum Falls (at rkm 12.54) 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, 2017 memorandum). Data from the spawning surveys is accessible on the Salmon Conservation Reporting Engine (SCoRE) website operated by WDFW.

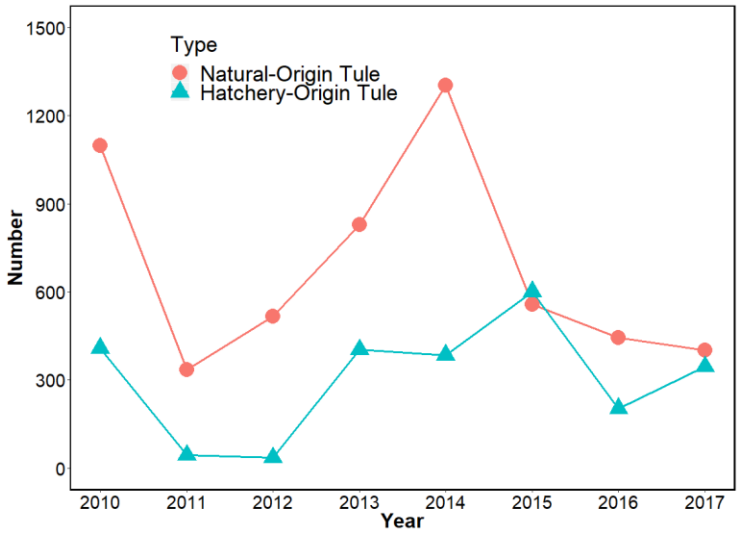

Figure 3. Escapement estimates of natural-origin and hatchery-origin tule spawning in the White Salmon River during annual spawning surveys. Data belongs to WDFW, and was accessed from the SCoRE website.

As part of the JDTD program, data downloaded from SCoRE is used to estimate the proportion of hatchery-origin spawners (pHOS) for tule on the White Salmon River. These estimates can include tule released from Spring Creek NFH. Based on escapement estimates of natural and hatchery-origin tule for spawning ground surveys from 2010 to 2017 (Fig. 3), pHOS estimates range from 6.51 to 51.90% with a mean pHOS of 28.78%. Using the 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 2010-2017 is (Pearson's) r = 0.53. Monitoring and evaluation activities currently monitoring the effect of hatchery-origin fish on native stocks in the White Salmon River are discussed in more detail under the ongoing studies section of this report.

SECTION 2. Little White Salmon NFH: URB Program

2.1) Program Description

Little White Salmon NFH (Fig. 4) 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 URB fall Chinook in 1982 to fulfill mitigation agreements for the JDTD program. The USACE 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 4. 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.

2.2) On-Station Juvenile Production

a) Egg-to-Smolt Survival

The survival objectives for the facility are the same as Spring Creek NFH (section 1.2a). 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 5). 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 and 2015). Since release year 2009, the facility has annually released approximately 4.4M juveniles with a mean size of 81.08 fish/lb. Eighty-eight percent (~3.8M) 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 since 2008 are presented below (Table 5).

Table 5. Annual release dates, marking and tagging information, total number of juveniles released, and mean juvenile size for URBs released from Little White Salmon NFH.

Release Year	Release Dates	AD + CWT	CWT (DIT)	AD ONLY	Total Released	Mean Size (fish/lb)
2009	18-Jun, 25-Jun	361,948	197,857	4,126,102	4,685,907[a]	77.08
2010	17-Jun, 24-Jun	362,931	199,338	3,988,990	4,551,259	84.96
2011	23-Jun	366,279	197,794	3,911,795	4,475,868	86.80
2012	26-Jun, 3-Jul	565,914	194,722	3,808,793	4,569,429	87.10
2013	2-Jul	360,089	198,443	3,863,046	4,421,578	65.80
2014	1-Jul, 2-Jul	267,804	99,702	4,038,886	4,406,392	85.90
2015	2-Jul	188,763	186,398	3,597,365	3,972,526	82.44
2016	11-Jul	196,105	196,772	3,568,238	3,961,115	85.40
2017	5-Jul	197,829	198,487	4,298,712	4,695,028	77.28
2018	11-Jul	189,005	186,872	3,475,851	4,270,728[b]	78.03
Means	**Jun/Jul**	**305,667**	**185,639**	**3,867,778**	**4,400,983**	**81.08**

[a]***The annual release goal was increased from 2.05M to 4.5M juvenile URBs in RY 2009 (brood year 2008).***
[b]***Release includes the 419,000 unmarked fish accidentally released on 4/18/2018 due to a loose screen.***

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 6). 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 actual number of URB juveniles that have been marked, tagged, and transferred to the Prosser program since 2009 are presented in Table 6. 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/Yakima River programs. These egg and juvenile transfer programs are planned through brood year 2018, but may change in the future depending on survival and program broodstock needs.

Table 6. Annual transfer dates, number of marked and tagged individuals, and total number of juvenile URBs transferred to the Prosser program from Little White Salmon NFH.

Transfer Year	Transfer Dates	Number AD ONLY	Number ADCWT	Total # Transferred
2009	4/2, 4/9, 4/20	1,030,096	199,657	1,229,753
2010	4/15, 4/16, 4/19, 4/21	1,023,272	199,016	1,222,288
2011	4/25	1,499,853	200,809	1,700,662
2012	4/2, 4/9, 4/13, 4/23	1,305,624	201,493	1,507,117
2013	4/4, 4/8, 4/15, 4/18	1,350,364	200,751	1,551,115
2014	4/9, 4/15, 4/22, 4/30	1,348,712	200,914	1,549,626
2015	4/6, 4/13, 4/15, 4/21, 4/28	1,500,536	200,113	1,700,649
2016	4/19	1,450,055	200,015	1,650,070
2017	4/4, 4/10, 4/13, 4/19, 4/21	1,498,078	203,772	1,701,850
2018	4/16, 4/18, 4/23, 5/2	1,053,419	150,256	1,203,675
Means	**-**	**1,306,001**	**195,680**	**1,501,681**

2.3) Off-Station Juvenile Survival

a) PIT Tagging Program: Juvenile Survival and Migration Time

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, 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.).

PIT tagging of the juvenile production began with brood year 2007 with 25,000 juvenile URBs being PIT tagged annually. Beginning in brood year 2012, the number of juveniles that were PIT tagged was decreased to 15,000 to monitor juvenile migration through the Columbia River basin (Table 7). In RY 2018, 14,840 juveniles were PIT tagged prior to release from Little White Salmon NFH. A mean of 1,930 juveniles released from Little White Salmon NFH are detected annually at BONN for a mean detection rate of 10.75%. Mean travel time to BONN is 17.23 days with the majority of juveniles (90th percentile) passing over BONN within 29 days of release. However, some juveniles have spent up to 154 days upstream of BONN before migrating downstream.

Table 7. The number of PIT tagged juvenile URBs released from Little White Salmon NFH and juvenile travel times to BONN.

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Travel Time (Days)					
				Mean	Median	Range	Percentile		
							50th	75th	90th
2009	24,947	2,354	9.44	31.45	28.00	(9 – 154)	28	39	44
2010	24,951	2,247	9.01	25.68	22.00	(1 – 149)	22	30	44
2011	24,640	2,313	9.39	20.23	12.00	(2 – 126)	12	32	41
2012	24,964	1,440	5.77	16.03	10.00	(0.5 – 127)	10	19	37
2013	14,959[a]	1,978	13.22	14.52	12.00	(0.5 – 143)	12	20	25
2014	14,925	1,806	12.10	19.16	17.00	(1 – 137)	17	26	36
2015	14,958	1,194	7.98	11.24	10.00	(1 – 44)	10	12	16
2016	14,823	1,647	11.11	11.28	11.00	(2 – 50)	11	13	15
2017	14,478	1,854	12.81	11.73	10.00	(1 – 47)	10	14	20
2018	14,840	2,467[b]	16.62	10.98	10.00	(0.5 – 45)	10	12	16
Means	**19,281**	**1,930**	**10.75**	**17.23**	**14.20**	**-**	**14**	**22**	**29**

[a]***The PIT tagging goal was decreased in release year 2013 from 25K to 15K juveniles.***
[b]***Current estimate as of 08/28/2018.***

2.4) Adult Returns, 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 8; 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 2002, the facility has a mean smolt-to-adult survival rate of 0.711 (Table 8) which is within the range reported in the facility's HGMP (USFWS 2004b and 2015). Additionally, the URB program has contributed a mean of 24,280 adults annually for the past ten years. CWT recoveries beyond brood year 2011 were not included in this report given that adult returns reported to RMIS can take several years to be finalized.

Table 8. 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 URBs released from Little White Salmon NFH. Adult returns are used to estimate smolt-to-adult survival rates.

Brood Year	Hatchery Returns[a]	Columbia River Harvest	Ocean Harvest	Spawning Ground	Total # of Adults	Smolt-to-Adult Survival (%)
2002	341	759	979	814	2,893	0.139
2003	1,600	530	990	360	3,480	0.171
2004	1,774	323	1,185	70	3,352	0.176
2005	6,903	2,865	3,115	174	13,057	0.725
2006	6,793	2,308	1,777	613	11,491	0.557
2007	14,689	6,418	4,379	1,043	26,529	1.325
2008	7,983	5,301	5,043	1,812	20,139	0.430
2009	17,171	15,917	10,483	9,705	53,276	1.171
2010	29,993	28,623	25,435	9,424	93,475	2.088
2011	4,530	4,071	3,254	3,250	15,105	0.331
Means	**9,178**	**6,712**	**5,664**	**2,727**	**24,280**	**0.711**

[a]***Hatchery returns include fish collected at all hatcheries within the Columbia River basin.***
[b]***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 8/31/2018.***

Adult returns to Little White Salmon NFH are estimated annually by hatchery personnel and the USFWS marking and biosampling crew from CRFWCO (Table A3). 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 9; Table A3). The majority (52%) of adult URBs return to the facility at Age-4, but 30% return at Age-3. Approximately 4% 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 11,208 adult returns with a mean smolt-to-adult return rate of 0.353 since brood year 2002. See Appendix A for a table of adult returns by return year to Little White Salmon NFH (Table A3).

Table 9. Estimated age structure of adult URB returns to Little White Salmon NFH by brood year. Total number of adults is used to estimate the smolt-to-adult return rate (%) to the facility.

Brood Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total Adults	Smolt-to-Adult Return Rate (%)
2002	13	218	618	246	6	1,101	0.053
2003	39	373	1,331	1,096	10	2,849	0.140
2004	283	543	2,526	706	34	4,092	0.280
2005	156	1,164	1,942	2,263	47	5,572	0.309
2006	652	961	3,009	1,174	12	5,808	0.282
2007	1,156	5,675	6,863	1,229	73	14,996	0.749
2008	1,021	2,990	2,770	1,501	0	8,282	0.177

2009	612	4,551	18,377	2,363	13	25,916	0.569
2010	587	15,644	17,023	2,956	75	36,285	0.811
2011	374	1,480	3,568	1,713	39	7,174	0.157
2012[a]	*658*	*5,558*	*5,675*	*2,000*	-	-	-
2013[a]	*65*	*759*	*3,384*	-	-	-	-
2014[a,b]	*0*	*300*	-	-	-	-	-
2015[a.,b]	*101*	-	-	-	-	-	-
Means	**489**	**3,360**	**5,803**	**1,525**	**31**	**11,208**	**0.353**

[a]Denotes incomplete brood years given that adults have either not yet returned to the hatchery or have not been aged. Incomplete years were not used in estimating means given that the information will be updated.
[b]Smolt-to-Adult Survival Return Rates are based on returns to Little White Salmon NFH as part of the JDTD program, and returns as part of the Mitchell Act funded program at Willard NFH that began in BY 2013. Juveniles released from Willard NFH cannot access the hatchery as returning adults, and are annually sampled at Little White Salmon NFH. Therefore, return rates will be estimated as the total number of adult returns to Little White Salmon NFH divided by the total juvenile production of 6.5 million given the inability to delineate fish from these two programs.

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 Chinook towards the TAP goal. Release and adult recoveries for the Prosser Hatchery are monitored by the Yakama Nation.

2.5) Additional Monitoring and Evaluation Projects

a) Escapement of Hatchery Fish to Spawning Grounds

Coded-wire tag recovery data stored in the RMIS database has been useful for estimating the number of adults that originated from Little White Salmon NFH and were observed on spawning grounds in nearby watersheds (Table 8) including the White Salmon River (Pastor 2004). Monitoring on the abundance of adult URB in the White Salmon basin has been conducted since 1989 (Wilson, 2017 memorandum). Spawning ground surveys conducted since 2010 by the WDFW include identification of hatchery-origin (for all facilities including Little White Salmon NFH) and natural-origin (wild) adult URBs in the White Salmon River (Fig. 5).

Data accessible from the SCoRE website allow for estimation of the pHOS for URBs. The pHOS estimates for URBs observed on the White Salmon River spawning grounds range from 33.66 to 80.04% with a mean pHOS of 61.65%. Using the adult return data from Little White Salmon NFH, the correlation between the number of hatchery-origin URBs on the White Salmon River spawning grounds and the number of total adult returns to the facility is (Pearson's) $r = 0.17$. Monitoring and evaluation plans for assessing the effects of hatchery-origin fish straying into the White Salmon River are discussed under the ongoing and future studies section of this report.

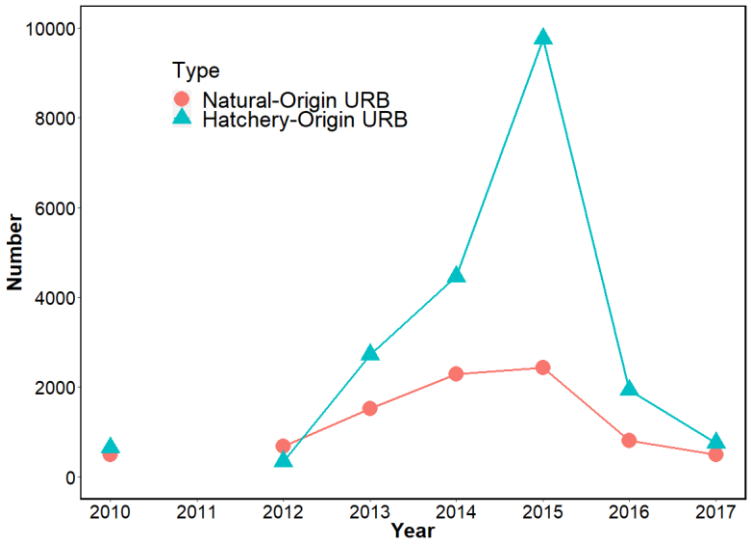

Figure 5. Escapement estimates of natural-origin and hatchery-origin URBs in the White Salmon River during annual spawning surveys. 2011 escapement estimates were unavailable due to the breach of Condit Dam. Data belongs to WDFW, and was accessed from the SCoRE website.

b) Genetic Introgression of URBs and Tules in the White Salmon River

URB fall Chinook typically spawn later in the fall than tule fall Chinook. However, the construction of BONN and rearing of URBs at Little White Salmon NFH (and elsewhere) has led to the synchronous escapement of tule and URBs to the White Salmon River over the past twenty years. Concerns of genetic introgression between the lineages led to a study funded by the USFWS from 2006 to 2008 (Smith and Engle 2011). The authors found:

1) a small proportion of hybrid juveniles
2) no hybrid adults suggesting that hybrid juveniles do not survive; and
3) genetic divergence among the lineages that is comparable to allopatric populations suggesting that gene flow in the White Salmon River is not higher than other locations

Collectively, results suggest that URBs from the Little White Salmon NFH were not posing a genetic risk to the tule stock in the White Salmon River based on the level of introgression observed in the study. However, the authors suggest future studies examining potential demographic and ecological risks that hatchery-reared URBs may have on the ESA-listed, native tule stock in the White Salmon River (Smith and Engle 2011). Since the USFWS study was conducted, production levels at Little White Salmon NFH have doubled, and the current risk of straying URBs on the White Salmon River tule stock is unknown. Study plans currently underway for assessing current genetic introgression rates between hatchery-origin URBs and ESA-listed tules in the White Salmon River are discussed in more detail below under the ongoing and future studies section of this report.

Summaries and Future Studies

a) Spring Creek NFH Tule Program

Since production levels were changed to 10.5M juveniles being released annually, the tule program at Spring Creek NFH has exceeded the annual release goal by an average 4% except in 2015 and 2016. In 2018, the program exceeded the number of juvenile release goal by 2%. PIT tagging efforts by the USFWS have been a valuable resource for monitoring post-release juvenile detection rates, survival, and downstream migration times. PIT tag detections at BONN indicate that juvenile tule released from the facility migrate downstream quickly with the majority of juveniles passing over BONN within 2 days of release.

Mass marking efforts of juveniles has provided reliable adult return information and smolt-to-adult survival rates. Since brood year 2002, the mean smolt-to-adult survival rate for juveniles released from the facility is 0.54% indicating an increase from the previous average of 0.47% used for mitigation planning. Additionally, reprogramming of the tule program to release fewer juveniles per year has not substantially affected the smolt-to-adult survival rate which has been 0.4% or higher since brood year 2007. Through juvenile releases, the program has produced a mean of 68,631 adults since brood year 2002 with a mean of 45,335 harvested in sport, tribal, and commercial fisheries. Additionally, the tule program has produced a mean of 27,841 adult returns to Spring Creek NFH since brood year 2003 with a mean smolt-to-adult return rate to the facility of 0.220%. Collectively, these results indicate that the program is successfully contributing to the TAP goal agreed upon by the USACE and *U.S. v. Oregon* parties.

Since brood year 2003, annual adult returns to the facility have ranged from 5,462 to 57,981 adults (Table 4) providing adequate numbers to satisfy broodstock needs. The estimated age structure of the adult returns based on aging of a subsample of the adults indicate that the mean proportion of Age-2 returns is low compared to the number of Age-3 and Age-4 fish; however, approximately 18% of the adult returns are precocial fish (i.e. jacks or jills). Jacks are utilized as broodstock at the facility and naturally occur at low rates in wild populations of Chinook, Coho, and Sockeye salmon, but at lower rates than observed at hatcheries (Berejikian et al. 2010). Hatchery rearing environments have been shown to cause early maturation leading to high rates of jack returns to the facilities (Harstad et al. 2014). Monitoring the prevalence of jacks at Spring Creek NFH would be beneficial for optimizing hatchery procedures, and determining whether the program will continually fulfill the JDTD program goals.

Data from the spawning ground surveys conducted by the WDFW indicate that the proportion of hatchery-origin tule in the White Salmon River has been high (mean pHOS of 28.78%) suggesting high levels of straying. However, biologists are not able to determine the hatchery of origin for a straying tule during the spawning ground surveys unless the fish contains a CWT. The number of adult tules that are released from Spring Creek NFH as juveniles and stray into the White Salmon River will be investigated in future monitoring projects. Currently, there is a possible correlation between the number of adult returns to Spring Creek NFH and the number of hatchery-origin tule on the spawning grounds ($r = 0.53$), but additional data is needed to determine the strength of the correlation.

b) Little White Salmon NFH URB Program

In the past ten years, the URB program has exceeded the annual juvenile release goal of 4.5M juveniles in four release years. The program has a mean juvenile production of 2% below the release goal, but has met the juvenile size at release goals every year since reprogramming in

brood year 2009. Additionally, the facility has successfully provided URB juveniles on an annual basis to the Yakima River-Prosser Hatchery program for the Yakama Nation. In a concerted effort with the Willard NFH Mitchell Act URB funded program, surplus URB eggs have been provided to other programs as well. PIT tagging of juvenile URBs released from Little White Salmon NFH indicate that juveniles reach BONN in a mean of 17.23 days post-release. However, some individuals take up to 154 days to reach BONN indicating that juveniles may be residing within the Little White Salmon River, Drano Lake, the mainstem of the Columbia River, or straying into other streams before beginning their migration to the Pacific Ocean.

Since brood year 2002, the mean smolt-to-adult survival rate for the facility is 0.711% which is greater than the 0.32% rate used for mitigation planning for the program. Since brood year 2002, the URB program has produced a mean of 24,280 adults which includes 12,376 adults for harvest by sport, tribal, and commercial fishermen. Additionally, the juvenile URB program has produced a mean of 11,208 adult returns to Little White Salmon NFH with a smolt-to-adult return rate of 0.353%. The number of annual adult returns to the facility has ranged from 1,101 to 36,285 adults since brood year 2002 (Table 9). Since reprogramming in 2009, the number of adult returns has increased providing adequate numbers to satisfy broodstock needs for Little White Salmon NFH as well as for other programs in most years. Aging of adult returns indicate that the majority of fish are returning to the facility at Age-3 and Age-4. Approximately 4% of adults return to the facility as precocial fish (i.e. jacks or jills). Collectively, the program has been successfully contributing to the TAP goal agreed upon by USACE and *U.S. v. Oregon* parties.

Data accessed from the SCoRE website operated by WDFW indicate that a high proportion of hatchery-origin URBs are present on the spawning grounds in the White Salmon River. Since 2010 (excluding 2011 when Condit Dam was removed), the mean pHOS is 61.65% indicating high levels of hatchery strays into the White Salmon River. Similar to the tule, determining what proportion of those hatchery-origin fish originated from the Little White Salmon NFH can only be determined if the fish contains a CWT. Determining the number of URBs released from Little White Salmon NFH that stray into the White Salmon River will be investigated in future monitoring projects. Unlike the tules from Spring Creek NFH, there appears to be no correlation between the number of adult returns to Little White Salmon NFH and the number of hatchery-origin URBs on the spawning grounds ($r = 0.17$). However, the influence of straying URBs on native tules in the White Salmon River is currently being assessed as discussed in the ongoing studies section below.

c) Ongoing and Future Monitoring and Evaluation Studies

Collectively, monitoring and evaluation of the tule and URB programs at Spring Creek and Little White Salmon NFHs indicate that both programs are successfully contributing to their mitigation obligations. Both programs have been sufficiently rearing and releasing numbers of juveniles that are close to their release goals as well as satisfying any egg and juvenile transfer requirements as part of the JDTD program. Additionally, both programs are exceeding their expected adult contributions to the TAP adult goal when considering the mean number of adults being produced by the facilities. However, there are several monitoring projects that are currently being conducted and/or are currently being developed in order to determine the success and longevity of both programs in terms of salmonid production and mitigation. These projects include:

1. **Assessment of potential demographic and genetic impacts of hatchery upriver bright fall Chinook salmon production on the ESA listed tule fall Chinook salmon population in the White Salmon River.** The high proportion of hatchery-origin spawners (particularly for the URBs) on the spawning grounds of the White Salmon River suggests a high level of straying. Both the USFWS and NMFS have concerns regarding the potential impacts hatchery strays from Little White Salmon NFH have on the native tule fall Chinook population in the White Salmon River. As part of a recently-issued Biological Opinion on the Little White Salmon upriver bright program (NMFS 2017), the USFWS, with USACE funding, has implemented a monitoring program in the White Salmon River with the goals of estimating the level of hybridization between naturally produced juvenile tule and URB fall Chinook salmon. USFWS staff at the CRFWCO began field sampling for juvenile fall Chinook in the White Salmon River in March of 2018. Using beach seines, minnow traps, backpack electrofishers, and dip nets, seven juvenile Chinook were captured (see all capture data in Table A4 in Appendix A). Fin clips were taken and stored at CRFWCO until genetic analysis at Abernathy Fish Technology Center. Additionally, USFWS personnel coordinated with USGS personnel operating a screw trap on the White Salmon River, and will obtain juvenile fall Chinook fin clips that were collected during daily operations of the screw trap. USFWS personnel are investigating the installation of an inclined-plane trap on the White Salmon River for use in 2019 and 2020 for capturing out-migrating juvenile fall Chinook salmon as part of the hybridization study.
2. **Determining the effect of hatchery-rearing practices on male maturity including jack production.** Although the presence of jacks (and jills) is a natural occurrence in captive and wild populations of salmonids, the high proportion of jacks returning to Spring Creek NFH should be monitored to determine whether hatchery practices are influencing the timing of male maturity. Research has shown that growth rates and fat levels due to hatchery feeding regimes can promote early male maturation (Spangenberg et al. 2015; Poirier and Olson 2017). A study examining the influence of feed ration during critical growth periods on precocial male maturation and smoltification rates for juvenile URB reared at Willard NFH (a Mitchell-Act funded program near Little White Salmon NFH) was conducted from March to August of 2017. Laboratory work indicated that approximately 3% of the fish sampled were precocially mature, and a higher number of precocial fish were detected in the reduced feed ration group. However, there were no differences in smolt NAK^{+}ATP-ase levels between the two groups. Pending results on adult return rates of these study fish, the work may be expanded to the URB program at Little White Salmon NFH or the tule program at Spring Creek NFH to determine whether hatchery practices (including high feeding rates to meet size at release goals) are influencing the number of precocial parr, mini-jacks, and jacks at the facilities.
3. **Understanding the influence of environmental conditions on post-release movement of juveniles.** Juvenile travel times to BONN can vary among release years, facilities, and runs (tule versus URB). In 2017, the maximum travel time to BONN for juvenile tule released from Spring Creek NFH was 12 days which was less than half the mean travel time observed in previous years. For juvenile URBs released from Little White Salmon NFH, mean travel times for the past four years have been lower than observed in previous years. Elevated temperatures in the mainstem of the Columbia River is known to strongly influence juvenile downstream migration; however, knowledge on how additional environmental covariates at the time of release influence juvenile post-release movement is

lacking. Studies utilizing PIT tag detections, downstream migration data, and environmental data for the mainstem of the Columbia River collected at BONN are being developed to determine the influence of post-release environmental conditions on juvenile behavior and potential survival. Results can be used to determine "optimal" juvenile release dates from the facilities while accounting for annual fluctuations in environmental conditions.

4. **Use long-term data collected at the facilities and environmental covariates to develop improved forecasting models.** Long-term datasets of run reconstruction information and smolt-to-adult survival rates have been compiled from monitoring of the juvenile tule and URB programs at Spring Creek and Little White Salmon NFHs. Utilization of these datasets in conjunction with environmental covariates (ocean and freshwater) to develop improved forecasting tools for predicting the number of adult returns to the facilities is ongoing. Accurately predicting the number of adult returns is essential for determining whether the programs will continue to fulfill their mitigation agreements and have access to adequate levels of broodstock for the JDTD program.

Acknowledgements

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Appendix A

Table A1. 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 tules released from Spring Creek NFH. Adult returns are used to estimate smolt-to-adult survival rates.

Brood Year	Hatchery Returns[a]	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # of Adults	Smolt-to-Adult Survival (%)
2002	17,597	13,554	12,783	740	44,674	0.297
2003	8,031	8,591	7,073	203	23,898	0.163
2004	2,896	4,577	2,587	329	10,389	0.063
2005	36,300	43,025	19,360	140	98,825	0.649
2006	11,121	12,989	4,541	0	28,651	0.185
2007	55,022	69,779	41,433	520	166,754	1.120
2008	19,087	30,011	18,762	175	61,035	0.605
2009	20,376	30,740	21,222	151	72,489	0.674
2010	12,711	29,761	15,877	27	58,376	0.538
2011	18,558	31,675	35,014	289	121,219	1.094
Means	**20,170**	**27,470**	**17,865**	**257**	**68,631**	**0.539**

Table A2. Total number of adult tule returns to Spring Creek NFH and estimated age structure by return year.

Return Year	Age-2	Age-3	Age-4	Age-5	Total Adults
2008	956	32,912	810	0	34,678
2009	11,988	8,463	5,008	228	25,687
2010	4,856	43,835	1,444	0	50,135
2011	4,049	14,618	2,108	34	20,809
2012	1,912	20,852	4,321	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
Means	**5,402**	**20,382**	**2,986**	**65**	**28,835**

Table A3. Total number of adult URB returns to Little White Salmon NFH and estimated age structure by return year.

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total Adults
2008	652	1,164	2,526	1,096	6	5,444
2009	1,156	961	1,942	706	10	4,775
2010	1,021	5,675	3,009	2,263	34	12,002
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
Means	**523**	**3,908**	**6,514**	**1,700**	**31**	**12,676**

Table A4. Catch data for the 2018 sampling efforts on the White Salmon River conducted by USFWS personnel from the CRFWCO as part of the URB-Tule hybridization study. Personnel sampled at four locations: Northwestern Lake Park (45.778611, -121.517298), Old Raceways (45.748371, -121.521276), a bank accessible site off State Route 141 known as the "PO Trail" (45.740587, -121.523554), and at a boat-accessible island (Left Island) near the River mouth (45.734449, -121.522623). Personnel utilized beach seines, electrofishing, minnow traps, and dip nets in an effort to catch and sample fin tissue from juvenile fall Chinook. An inclined-plane trap in being designed for use in 2019 and 2020 due to the low number of juvenile Chinook captured using methods in 2018.

Date of Collection	Species – Common and Scientific name	Number Encountered	Mortality? (Y/N)	Specific Location (e.g., reach location, reservoir name, etc.)	Sampling Method
10-Apr-18	Sculpin sp. (Cottidae)	6	N	Northwestern Lake	Electrofishing
10-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	2	N	Northwestern Lake	Electrofishing
10-Apr-18	Rainbow/Steelhead Trout (O.mykiss)	1	N	Northwestern Lake	Electrofishing
11-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	4	N	Northwestern Lake	Minnow Trap
11-Apr-18	Sculpin sp. (Cottidae)	1	N	Northwestern Lake	Minnow Trap
10-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	2	N	Raceways (Arnett Rd)	Electrofishing
10-Apr-18	Coho Salmon (O.kisutch)	3	N	Raceways (Arnett Rd)	Electrofishing
11-Apr-18	Rainbow/Steelhead Trout (O.mykiss)	6	N	Raceways (Arnett Rd)	Minnow Trap
11-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	5	N	Raceways (Arnett Rd)	Minnow Trap
10-Apr-18	Coho Salmon (O.kisutch)	13	N	PO Trail	Electrofishing
10-Apr-18	Coho Salmon (O.kisutch)	1	Y	PO Trail	Electrofishing
10-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	2	N	PO Trail	Electrofishing
10-Apr-18	Coho Salmon (O.kisutch)	1	N	PO Trail	Beach Seine
11-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	N	PO Trail	Minnow Trap
11-Apr-18	Sculpin sp. (Cottidae)	1	N	PO Trail	Minnow Trap
17-Apr-18	Rainbow/Steelhead Trout (O.mykiss)	1	N	Northwestern Lake	Electrofishing
17-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	2	N	Northwestern Lake	Electrofishing

17-Apr-18	Coho Salmon (O.kisutch)	1	N	Northwestern Lake	Beach Seine
18-Apr-18	Sculpin sp. (Cottidae)	1	N	Northwestern Lake	Minnow Trap
18-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	N	Northwestern Lake	Minnow Trap
18-Apr-18	Cutthroat Trout (O.clarkii)	1	N	Northwestern Lake	Minnow Trap
17-Apr-18	Coho Salmon (O.kisutch)	1	N	Raceways (Arnett Rd)	Electrofishing
18-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	4	N	Raceways (Arnett Rd)	Minnow Trap
18-Apr-18	Rainbow/Steelhead Trout (O.mykiss)	3	N	Raceways (Arnett Rd)	Minnow Trap
17-Apr-18	Sculpin sp. (Cottidae)	2	N	PO Trail	Beach Seine
18-Apr-18	Sculpin sp. (Cottidae)	2	N	PO Trail	Minnow Trap
18-Apr-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	N	PO Trail	Minnow Trap
1-May-18	Sculpin sp. (Cottidae)	19	N	Northwestern Lake	Electrofishing
1-May-18	Coho Salmon (O.kisutch)	2	N	Northwestern Lake	Electrofishing
2-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	N	Northwestern Lake	Minnow Trap
1-May-18	Coho Salmon (O.kisutch)	3	N	Raceways (Arnett Rd)	Electrofishing
1-May-18	Spring Chinook Salmon (O.tshawytscha)	1	N	Raceways (Arnett Rd)	Electrofishing
1-May-18	Coho Salmon (O.kisutch)	20	N	PO Trail	Dip Net
1-May-18	Coho Salmon (O.kisutch)	4	N	PO Trail	Beach Seine
1-May-18	Fall Chinook Salmon (O.tshawytscha)	1	N	PO Trail	Beach Seine
2-May-18	Rainbow/Steelhead Trout (O.mykiss)	1	N	PO Trail	Minnow Trap
2-May-18	Coho Salmon (O.kisutch)	6	N	PO Trail	Minnow Trap
2-May-18	Sculpin sp. (Cottidae)	2	N	PO Trail	Minnow Trap
8-May-18	Coho Salmon (O.kisutch)	1	N	Northwestern Lake	Electrofishing
8-May-18	Sculpin sp. (Cottidae)	4	N	Northwestern Lake	Electrofishing
9-May-18	Sculpin sp. (Cottidae)	2	N	Northwestern Lake	Minnow Trap
8-May-18	Coho Salmon (O.kisutch)	7	N	Raceways (Arnett Rd)	Electrofishing
9-May-18	Spring Chinook Salmon (O.tshawytscha)	1	N	Raceways (Arnett Rd)	Minnow Trap
9-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	2	N	Raceways (Arnett Rd)	Minnow Trap
9-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	Y	Raceways (Arnett Rd)	Minnow Trap
8-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	N	PO Trail	Electrofishing
8-May-18	Sculpin sp. (Cottidae)	18	N	PO Trail	Electrofishing
8-May-18	Coho Salmon (O.kisutch)	39	N	PO Trail	Electrofishing
8-May-18	Coho Salmon (O.kisutch)	1	Y	PO Trail	Electrofishing
22-May-18	Coho Salmon (O.kisutch)	1	N	Northwestern Lake	Electrofishing
22-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	3	N	Northwestern Lake	Electrofishing
22-May-18	Sculpin sp. (Cottidae)	11	N	Northwestern Lake	Electrofishing
23-May-18	Sculpin sp. (Cottidae)	3	N	Northwestern Lake	Minnow Trap
22-May-18	Coho Salmon (O.kisutch)	4	N	Raceways (Arnett Rd)	Electrofishing
22-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	1	N	Raceways (Arnett Rd)	Electrofishing

22-May-18	Fall Chinook Salmon (O.tshawytscha)	1	N	Raceways (Arnett Rd)	Electrofishing
23-May-18	Cutthroat/Rainbow/Steelhead Trout (O.clarkii, O.mykiss)	4	N	Raceways (Arnett Rd)	Minnow Trap
23-May-18	Fall Chinook Salmon (O.tshawytscha)	1	N	Raceways (Arnett Rd)	Minnow Trap
23-May-18	Coho Salmon (O.kisutch)	1	N	Raceways (Arnett Rd)	Minnow Trap
23-May-18	Sculpin sp. (Cottidae)	1	N	Raceways (Arnett Rd)	Minnow Trap
22-May-18	Fall Chinook Salmon (O.tshawytscha)	2	N	PO Trail	Beach Seine
22-May-18	Coho Salmon (O.kisutch)	8	N	PO Trail	Dip Net
23-May-18	Coho Salmon (O.kisutch)	25	N	PO Trail	Minnow Trap
23-May-18	Sculpin sp. (Cottidae)	1	N	PO Trail	Minnow Trap
31-May-18	Fall Chinook Salmon (O.tshawytscha)	2	N	Left Island Near River Mouth	Beach Seine
31-May-18	Steelhead Trout (O.mykiss)	2	N	Left Island Near River Mouth	Beach Seine
31-May-18	Coho Salmon (O.kisutch)	35	N	Left Island Near River Mouth	Dip Net

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