U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office

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

*FY 2016 Annual Report*

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***On the cover:*** *Adult tule fall Chinook Salmon (Oncorhynchus tshawytscha) at Spring Creek National Fish Hatchery. Juvenile tule fall Chinook reared and released annually from the facility provide future harvest and broodstock opportunities as part of the John Day/The Dalles Dam Mitigation Program funded by the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service stock photograph by Lance Koudele.*

**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

## 2016 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 includes freshwater and saltwater harvests, returns to the hatcheries, and fish 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 11.7 million juvenile tules into the Columbia River, and contributed a mean of 78,458 adult tules (including 50,469 for harvest) annually to the JDTD program TAP goal. Since 2007, Little White Salmon NFH has annually released a mean of 3.9M 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 19,902 adult upriver brights (including 9,608 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 meeting their mitigation obligations. Additional monitoring and evaluation projects for both facilities are being developed to determine the success and longevity of the programs in meeting their mitigation goals 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 25 miles upstream of The Dalles, leading to further loss of spawning habitat and decreased production of fall Chinook Salmon (*Oncorhynchus tshawytscha*) in the mainstem of the Columbia River.

In 1978, Congress authorized the John Day/The Dalles Dam Mitigation (JDTD) program which aimed to offset the inundation of spawning habitat and reduced fall Chinook Salmon production due to construction of the John Day and The Dalles Dams (Fig. 1; USACE 2013). Mitigation included financial settlements to the Yakima, Warm Springs, Umatilla, and Nez Perce native tribes 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 quota, 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 for broodstock, and those observed on the spawning grounds. Additionally, 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 quotas were "In Kind" goals set when considering the impact that both The Dalles and John Day Dams had on 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 (current and proposed) state, tribal, and federally-operated hatcheries.

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 eggs to the state-operated Bonneville Hatchery to support the Umatilla/Yakima River program, and URB juveniles to the Yakima River-Prosser Hatchery 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.

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

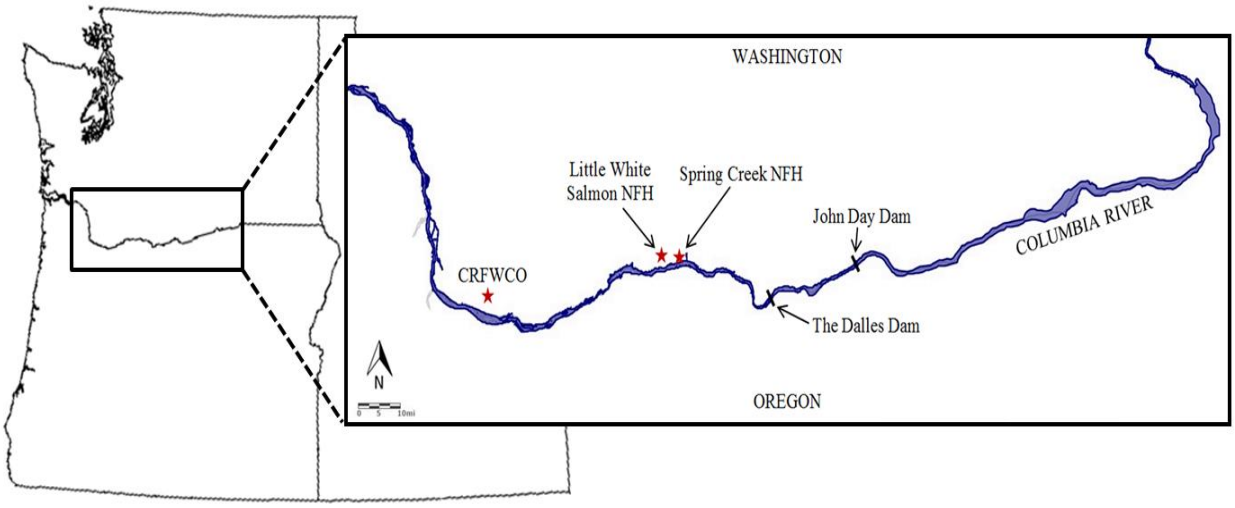


**Figure 1. Spring Creek and Little White Salmon NFHs are located on the Washington side of the Columbia River (purple) downstream of the John Day and The Dalles Dams. Monitoring and evaluation of the fall Chinook production programs at these facilities is conducted by staff at the Columbia River Fish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

mandate implemented in fiscal year (FY) 2005 requiring all production fish from federal facilities (except those 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 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 FY 2016, the U.S. Fish and Wildlife Service (USFWS) requested funding from the USACE in the amount of $3,815,706 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 Biological Opinion. The purpose of this report is to summarize the results of the monitoring and evaluation programs using data downloaded from the Columbia River Information System (CRiS) for the previous ten years, compare to data for FY 2016, discuss long-term trends, and identify any special studies or proposed changes to the fall Chinook production programs at Spring Creek and Little White Salmon NFHs.

# 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 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 the 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. Broodstock for the tule program originated from the White Salmon River located approximately 1 mile upstream of the hatchery. The lower Columbia River Chinook Salmon, White Salmon River tule stock is one of several in the Columbia River basin that is currently 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 adult returns of hatchery-reared tule 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, and genetic anomalies. Hatchery staff monitor these objectives to make sure the facilities are meeting their production levels, and determine whether alternative rearing and release practices are needed to improve on-station survival when warranted.

*b) Juvenile Mass Marking and Release Data*

Funds requested from the USACE for FY 2016 included production costs to meet annual release goals, operational marking costs, and equipment maintenance at Spring Creek NFH. Traditionally, the goal for the facility was to annually release 15.1M juvenile tule into the Columbia River in March, April, and May. Beginning in FY 2009, reprogramming at the facility changed the production level goal to 10.5M tule being released in April and May. The actual number of juvenile tule annually released is recorded by hatchery personnel, and has varied by release year (Table 1) with 10,167,948 being released in April and May of FY 2016.

Spring Creek NFH has mean juvenile size goals of 90-120 fish/lb for the April release and 60-80 fish/lb for the May release. Since release year 2007, the mean size of juveniles released in April and May are 113.64 and 86.91 fish/lb, respectively. Ninety-two percent (~9.7M) of the annual production is mass marked with an adipose fin-clip only (AD ONLY). The remaining fish are marked with CWTs with 4% (~400K) being adipose fin-clipped (AD) and marked with CWTs, and 4% (~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 2007 are presented below (Table 1). Coded-wire tag codes are stored in the USFWS CRiS database at the CRFWCO.

**Table 1. Annual release dates, mass marking information, number of juveniles released, and mean juvenile size at release in March (M), April (A), and May (My) 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) |
|---|---|---|---|---|---|---|
| 2007 | 5- ,9-Mar, 12-, 17-, 23-Apr, 1-May | 450,144 | 450,204 | 14,572,213 | 15,472,561 | M: 139.67<br>A: 84.29<br>My: 74.24 |
| 2008 | 5-, 6-Mar, 10-Apr, 2-May | 450,998 | 450,998 | 13,997,274 | 14,899,270 | M: 145.23<br>A: 79.77<br>My: 65.45 |
| 2009 | 13-Apr, 1-May | 359,866 | 359,967 | 10,513,263 | 11,233,096[1] | A: 144.36<br>My: 90.95 |
| 2010 | 12-Apr, 10-May | 404,033 | 405,808 | 9,940,720 | 10,750,561 | A: 111.26<br>My: 75.64 |
| 2011 | 12-Apr, 4-May | 404,613 | 404,508 | 10,052,171 | 10,861,292 | A: 112.11<br>My: 88.68 |
| 2012 | 11-, 13-Apr, 1-May | 413,775 | 404,212 | 10,260,717 | 11,078,704 | A: 123.87<br>My: 98.32 |
| 2013 | 11-Apr, 2-May | 406,511 | 406,117 | 10,430,058 | 11,242,686 | A: 99.00<br>My: 78.72 |
| 2014 | 11-Apr, 6-May | 406,574 | 404,679 | 9,943,229 | 10,754,482 | A: 121.83<br>My: 87.80 |
| 2015 | 13-Apr, 1-May | 393,924 | 393,339 | 9,628,371 | 10,415,634 | A: 147.59<br>My: 105.44 |
| 2016 | 11-Apr, 9-May | 401,711 | 402,179 | 9,364,058 | 10,167,948 | A: 112.30<br>My: 89.55 |

[1]***Reprogramming occurred in FY 2009 reducing 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*

Beginning with brood year 2007, 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. Travel times and detection rates to BONN are estimated annually (Table 2). The mean travel time to BONN since release year 2008 when fish were first PIT tagged was 2.00 days. Detection data is also used in conjunction with open population, Cormack-Jolly-Seber (CJS) models in the program, MARK (v. 6.1; White and Burnham 1999), to estimate post-release juvenile survival. The CJS model has a basic structure of $\boldsymbol{Capture = Juvenile\ Survival}\ (\boldsymbol{\phi_t}) * \boldsymbol{Encounter\ Probability}\ (\boldsymbol{p_t})$ where (t) refers to time. Using detection data from PTAGIS, the estimate (± standard error) for the probability of a juvenile tule released from Spring Creek NFH being detected at BONN in 2015 was 0.06 (± 0.01). Juvenile survival to BONN was estimated as 0.98 (± 0.12). In 2016, the probability of a juvenile tule released from Spring Creek NFH being detected at BONN was 0.05 (± <0.01), and estimated survival to BONN was 1.00 (± <0.01). The number of PIT tag detections downstream of BONN was too low to estimate survival and encounter probabilities.

**Table 2. The number of juvenile tule PIT tagged in a given release year and travel times to BONN following release from Spring Creek NFH.**

| Release Year | # PIT Tagged | # Detected at BONN | % Detected | Travel Times (Days) | | |
|---|---|---|---|---|---|---|
| | | | | Min | Mean | Max |
| 2008 | 14,086 | 946 | 6.72 | 1.00 | 3.47 | 105.00 |
| 2009 | 14,897 | 840 | 5.64 | 1.00 | 2.39 | 62.00 |
| 2010 | 14,142 | 1,277 | 9.03 | 0.50 | 2.57 | 42.00 |
| 2011 | 14,939 | 922 | 6.17 | 0.50 | 1.37 | 20.00 |
| 2012 | 14,944 | 668 | 4.47 | 0.50 | 1.02 | 24.00 |
| 2013 | 14,953 | 825 | 5.52 | 0.50 | 1.89 | 38.00 |
| 2014 | 14,975 | 757 | 5.06 | 0.50 | 1.70 | 37.00 |
| 2015 | 14,933 | 788 | 5.28 | 1.00 | 2.51 | 54.00 |
| 2016 | 14,975 | 779 | 5.20 | 0.50 | 1.11 | 9.00 |
| **Means** | **14,760** | **867** | **5.90** | **0.67** | **2.00** | **43.44** |

### *1.4) Adult Returns, Harvest Data, and Smolt-to-Adult Survival*

Based on coded-wire tag recovery data from brood years 1990 to 2004, Spring Creek NFH has a mean smolt-to-adult survival of 0.47%. Therefore, the 10.5M juvenile release goal is expected to contribute an estimated 49,592 adult Chinook towards the TAP goal of 107,000 adults with 28,000 supplied for harvest. Adult returns to Spring Creek NFH are estimated by

hatchery staff. Coded-wire tag recoveries maintained in the Regional Mark Information System (RMIS) database are used for estimating the number of harvested adults (Table 3) and number present on the spawning grounds (Pastor 2004; Pastor 2016). At Spring Creek NFH, fluctuations have been observed in the number of hatchery returns, harvested adults, and estimated adults on the spawning grounds for brood years 2000 to 2010 (Table 3). Data beyond brood year 2010 was not included in this report given that adults from those brood years may still return to the hatchery. The Spring Creek NFH tule program has contributed a mean of 78,458 adults since brood year 2000.

**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. Adult returns are used to estimate smolt-to-adult survival rates.**

| Brood Year | Hatchery Returns | Columbia River Harvest | Ocean Harvest | Spawning Grounds | Total # of Adults | Smolt-to-Adult Survival (%) |
|---|---|---|---|---|---|---|
| 2000 | 39,000 | 32,376 | 42,600 | 4,200 | 118,176 | 1.118 |
| 2001 | 68,208 | 42,325 | 66,246 | 4,479 | 181,258 | 1.125 |
| 2002 | 18,703 | 12,448 | 12,516 | 740 | 44,407 | 0.295 |
| 2003 | 8,309 | 8,110 | 7,073 | 406 | 23,898 | 0.163 |
| 2004 | 3,037 | 4,452 | 2,593 | 329 | 10,411 | 0.072 |
| 2005 | 37,852 | 41,451 | 19,360 | 140 | 98,803 | 0.648 |
| 2006 | 11,617 | 12,493 | 4,415 | 0 | 28,525 | 0.184 |
| 2007 | 56,468 | 68,333 | 41,303 | 520 | 166,624 | 1.118 |
| 2008 | 21,174 | 27,924 | 20,009 | 175 | 69,282 | 0.617 |
| 2009 | 20,980 | 30,019 | 22,343 | 151 | 73,493 | 0.688 |
| 2010 | 11,366 | 21,600 | 14,946 | 28 | 47,940 | 0.447 |
| **Means** | **26,974** | **27,412** | **23,057** | **1,015** | **78,458** | **0.589** |

Monitoring adult returns to the hatchery provides information on sex ratios, length information, and age structure. Aging is determined by USFWS staff using scales and CWT sampling. Approximately 68% of adult tules return to the facility at 3 years of age (Age-3; Table 4), but 16% of fish return at Age-2 as sexually mature males ("jacks") and sexually-mature females ("jills"). The majority of females (99%) return at Age-3 or Age-4 as opposed to the 89% of males that return at Age-2 or Age-3. Less than 1% of adults return at Age-5.

**Table 4. Adult returns by age and sex based on scale sampling and CWT recoveries for adult tule returning to Spring Creek NFH. Estimates don't include fish whose sex could not be determined at time of sampling. Aging for 2016 has not been finalized.**

| Return | Age-2 | | Age-3 | | Age-4 | | Age-5 | | Total |
|---|---|---|---|---|---|---|---|---|---|
| Year | Male | Female | Male | Female | Male | Female | Male | Female | Adults |
| 2005 | 2,268 | 46 | 7,174 | 9,247 | 4,165 | 10,964 | 93 | 334 | 34,291 |
| 2006 | 733 | 24 | 3,099 | 3,851 | 1,064 | 1,828 | 24 | 122 | 10,745 |
| 2007 | 8,284 | 19 | 1,361 | 2,304 | 781 | 1,379 | 36 | 36 | 14,200 |
| 2008 | 956 | 0 | 14,344 | 18,568 | 319 | 491 | 0 | 0 | 34,678 |
| 2009 | 11,893 | 95 | 5,527 | 2,936 | 1,819 | 3,189 | 70 | 158 | 25,687 |
| 2010 | 4,770 | 86 | 14,073 | 29,762 | 1,272 | 172 | 0 | 0 | 50,135 |
| 2011 | 4,049 | 0 | 6,478 | 8,140 | 501 | 1,607 | 0 | 34 | 20,809 |
| 2012 | 1,862 | 50 | 9,367 | 11,485 | 1,863 | 2,458 | 0 | 50 | 27,135 |
| 2013 | 2,827 | 0 | 6,403 | 6,212 | 943 | 2,235 | 0 | 29 | 18,649 |
| 2014 | 9,989 | 39 | 7,770 | 10,451 | 1,018 | 2,415 | 0 | 119 | 31,801 |
| 2015 | 2,637 | 101 | 11,737 | 24,415 | 1,385 | 3,818 | 66 | 0 | 44,159 |
| **Means** | **4,570** | **42** | **7,939** | **11,579** | **1,375** | **2,778** | **26** | **80** | **28,390** |

### *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 were 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, 2016 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, 2016 memorandum). Data from the spawning surveys is accessible on the Salmon Conservation Reporting Engine (SCoRE) website operated by WDFW.

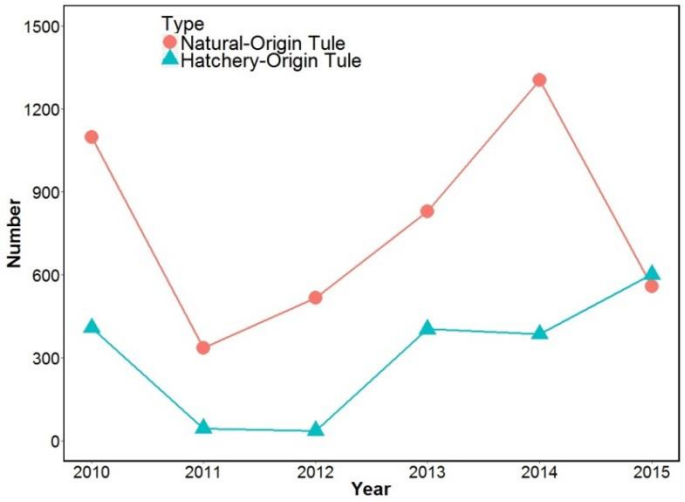


**Figure 3. Escapement estimates of natural-origin and hatchery-origin tule spawning in the White Salmon River during annual spawning surveys. Data belongs to WDFW, and was accessed from the SCoRE website.**

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 2015 (Fig. 3), pHOS estimates range from 6.51 to 51.90% with a mean pHOS of 25.44%. However, WDFW personnel have cited poor visibility in the river during the fall Chinook surveys, precluding the

ability to determine the definitive number of hatchery-origin spawners in the river using spawning survey data alone. 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 2010-2015 is (Pearson's) r = 0.59.

# 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 river kilometer 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 the Klickitat Hatchery URB Program and Willard NFH URB program as well as the rearing and release of spring-run Chinook. 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 and Release Data*

USACE funds support production costs to meet annual release goals, operational juvenile marking, transfer of eggs and juveniles to other facilities, and equipment maintenance at Little White Salmon NFH. 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 FY 2009 to a release goal of 4.5M juvenile URBs. 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) with 3,964,636 juveniles being released in July in FY 2016.

Little White Salmon NFH has a mean juvenile size goal of 70-90 fish/lb at the time of release. Since release year 2007, the mean size of juveniles released from the facility is 83.2 fish/lb. Approximately ninety-one percent (~4.1M) of the annual production released into the Little White Salmon River is mass marked with an adipose fin-clip only (AD ONLY). The remaining fish are CWT with 4.4% (~200K) being adipose fin-clipped and CWT, and 4.4% (~200K) being CWT only (DIT fish). The actual numbers of juveniles that have been mass marked and tagged by USFWS crews since 2007 are presented below (Table 5).

**Table 5. Annual release dates, mass marking 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) |
|---|---|---|---|---|---|---|
| 2007 | 28-Jun | 198,516 | 198,480 | 1,664,928 | 2,061,924 | 77.05 |
| 2008 | 3-Jul | 199,717 | 199,740 | 1,602,303 | 2,001,760 | 96.00 |
| 2009 | 18-Jun, 25-Jun | 369,483 | 199,795 | 4,116,629 | 4,685,907[1] | 77.08 |
| 2010 | 17-Jun, 24-Jun | 370,800 | 199,928 | 3,980,531 | 4,551,259 | 84.96 |
| 2011 | 23-Jun | 369,410 | 199,994 | 3,906,464 | 4,475,868 | 86.80 |
| 2012 | 26-Jun, 3-Jul | 575,616 | 200,205 | 3,793,608 | 4,569,429 | 87.10 |
| 2013 | 2-Jul | 368,615 | 199,212 | 3,853,751 | 4,421,578 | 65.80 |
| 2014 | 1-Jul, 2-Jul | 269,125 | 100,000 | 4,037,267 | 4,406,392 | 89.50 |
| 2015 | 2-Jul | 199,913 | 199,993 | 3,572,620 | 3,972,526 | 82.44 |
| 2016 | 11-Jul | 199,964 | 200,072 | 3,564,636 | 3,964,672 | 85.30 |

[1]***The annual release goal was increased from 2.05M to 4.5M juvenile URBs in FY 2009.***

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 200,000 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 2007 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 program. These egg and juvenile transfer programs are planned through FY 2017, 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 |
|---|---|---|---|---|
| 2007 | 4/3, 4/4 | 1,075,021 | 200,084 | 1,275,105 |
| 2008 | 4/22 | 98,615[1] | 199,810[1] | 298,425[1] |
| 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 |

[1]***Low egg takes in brood year 2007 prevented the Little White Salmon NFH URB program from meeting the juvenile URB transfer goal.***

### *2.3) Off-Station Juvenile Survival*

*a) PIT Tagging Program: Juvenile Survival and Migration Time*

PIT tagging of juvenile production fish began with brood year 2007 with 25,000 juvenile URBs being PIT tagged by USFWS crews. Beginning in brood year 2012 (release year 2013), the number of juveniles that were PIT tagged was decreased to 15,000 to estimate juvenile migration time and survival through the Columbia River basin (Table 7). In FY 2016, 14,957 were PIT tagged prior to release from Little White Salmon NFH. Juvenile URBs are typically detected at BONN, approximately 30km downstream from the confluence of the Little White Salmon and Columbia Rivers. Travel times to BONN vary annually due to environmental conditions in the mainstem, but the mean travel time for juvenile URBs to reach BONN is 18.76 days. Using detection data from PTAGIS, the estimated probability of a juvenile URB released

**Table 7. The number of juvenile URBs PIT tagged in a given release year and travel times to BONN following release from Little White Salmon NFH.**

| Release Year | # PIT Tagged | # Detected at BONN | % Detected | Travel Times (Days) | | |
|---|---|---|---|---|---|---|
| | | | | Min | Mean | Max |
| 2008 | 24,888 | 2,650 | 10.65 | 1.00 | 19.22 | 139.00 |
| 2009 | 24,951 | 2,340 | 9.38 | 9.00 | 31.44 | 154.00 |
| 2010 | 24,958 | 2,245 | 9.00 | 1.00 | 25.75 | 149.00 |
| 2011 | 24,879 | 1,193 | 11.97 | 2.00 | 20.23 | 126.00 |
| 2012 | 25,173 | 1,140 | 4.57 | 0.50 | 16.03 | 127.00 |
| 2013 | 14,961[1] | 1,978 | 13.22 | 0.50 | 14.52 | 143.00 |
| 2014 | 14,931 | 1,787 | 11.97 | 1.00 | 19.18 | 137.00 |
| 2015 | 14,963 | 1,194 | 7.98 | 1.00 | 11.24 | 44.00 |
| 2016 | 14,957 | 1,646* | 11.00* | 2.00* | 11.25* | 38.00* |
| **Means** | **20,518** | **1,797** | **9.97** | **2.00** | **18.76** | **117.44** |

[1]***The number of juveniles to be PIT tagged was decreased in FY 2013 from 25K to 15K juveniles.***
****Current estimates as of 8/29/2016***

from Little White Salmon NFH in 2015 being encountered at BONN was 0.17 (± 0.02). Juvenile survival to BONN was estimated as 0.48 (± 0.06). In 2016, the probability of a juvenile URB released from Little White Salmon NFH being detected at BONN was 0.20 (± 0.09), and estimated survival to BONN was 0.55 (± 0.25) for all detections up to August 29, 2016. Similar to juveniles released from Spring Creek NFH, the number of PIT tag detections downstream of BONN was too low to estimate reliable survival and encounter probabilities.

### *2.4) Adult Returns, Harvest Data, and Smolt-to-Adult Survival*

At Little White Salmon NFH, the mean smolt-to-adult survival rate is 0.32% based on brood years 1990 to 2004. With the 4.5M juvenile URBs released annually, the facility is expected to contribute 14,382 adult fish (5,900 for harvest) to the TAP goal of 107,000. Hatchery personnel estimate the number of adult returns to the facility. Coded-wire tag recovery data from the RMIS database is used to estimate the number of harvested adults and number present on the spawning grounds. Annual fluctuations have been observed in the estimated number of adults that are harvested, returned to the hatchery, and are present on the spawning grounds for brood years 2000 to 2010 (Table 8). Data beyond brood year 2010 was not included in this report given that adults from those brood years may still return to the hatchery. The Little White Salmon NFH URB program has contributed a mean of 19,902 total adults since brood year 2000.

**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 | Columbia River Harvest | Ocean Harvest | Spawning Ground | Total # of Adults | Smolt-to-Adult Survival (%) |
|---|---|---|---|---|---|---|
| 2000 | 910 | 1,279 | 2,490 | 1,730 | 6,409 | 0.331 |
| 2001 | 1,350 | 1,440 | 1,490 | 1,650 | 5,930 | 0.286 |
| 2002 | 352 | 748 | 924 | 814 | 2,838 | 0.136 |
| 2003 | 1,600 | 530 | 980 | 360 | 3,470 | 0.171 |
| 2004 | 1,774 | 323 | 1,185 | 70 | 3,352 | 0.176 |
| 2005 | 6,912 | 2,856 | 3,234 | 174 | 13,176 | 0.731 |
| 2006 | 6,868 | 2,233 | 1,777 | 613 | 11,491 | 0.557 |
| 2007 | 14,804 | 6,303 | 4,406 | 1,043 | 26,556 | 1.328 |
| 2008 | 8,132 | 5,020 | 4,841 | 1,813 | 19,806 | 0.423 |
| 2009 | 18,292 | 13,765 | 9,987 | 9,747 | 51,791 | 1.143 |
| 2010 | 27,818 | 17,372 | 22,506 | 6,406 | 74,102 | 1.658 |
| **Means** | **8,074** | **4,715** | **4,893** | **2,220** | **19,902** | **0.631** |

Aging of the adult returns is conducted by USFWS crews using scales and CWT sampling. The majority (51%) of adult URBs return to the facility at Age-4 (Table 9), but 32% return at Age-3. Nearly 33% of females return at Age-4 and Age-5 while 56% of males return at Age-3 and Age-4. Approximately 4.4% of males return as jacks at Age-2. A rare number of females have returned as jills at Age-2. Less than 1% of all adults return at Age-6.

**Table 9. Age and sex (males (M) and females (F)) of adult returns to Little White Salmon NFH since 2005. Estimates don't include fish whose sex could not be determined at time of sampling. Aging for 2016 returns has not been completed.**

| Return | Age-2 | | Age-3 | | Age-4 | | Age-5 | | Age-6 | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | M | F | M | F | M | F | M | F | M | F | Adults |
| 2005 | 39 | 0 | 208 | 10 | 6,325 | 740 | 138 | 249 | 15 | 34 | 7,758 |
| 2006 | 283 | 0 | 323 | 50 | 301 | 317 | 225 | 644 | 19 | 22 | 2,184 |
| 2007 | 156 | 0 | 475 | 68 | 871 | 460 | 121 | 125 | 17 | 17 | 2,310 |
| 2008 | 652 | 0 | 1,153 | 11 | 1,305 | 1,221 | 365 | 731 | 0 | 6 | 5,444 |
| 2009 | 1,156 | 0 | 863 | 98 | 917 | 1,025 | 170 | 536 | 5 | 5 | 4,775 |
| 2010 | 1,010 | 11 | 5,344 | 331 | 1,561 | 1,448 | 861 | 1,402 | 11 | 23 | 12,002 |
| 2011 | 268 | 0 | 1,267 | 68 | 1,753 | 1,327 | 192 | 402 | 0 | 26 | 5,303 |
| 2012 | 587 | 0 | 4,202 | 349 | 1,202 | 1,568 | 308 | 921 | 0 | 12 | 9,149 |
| 2013 | 374 | 0 | 14,553 | 1,091 | 10,496 | 7,277 | 409 | 1,092 | 0 | 73 | 35,365 |
| 2014 | 658 | 0 | 1,450 | 30 | 4,548 | 12,475 | 692 | 1,671 | 0 | 0 | 21,524 |
| 2015 | 64 | 0 | 4,827 | 722 | 1,913 | 1,661 | 817 | 2,143 | 0 | 13 | 12,160 |
| **Means** | **477** | **1** | **3,151** | **257** | **2,836** | **2,684** | **391** | **901** | **6** | **21** | **10,725** |

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, 2016 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 60.08%. However, WDFW personnel have cited poor visibility in the river during the fall Chinook surveys, precluding the ability to determine the definitive number of hatchery-origin spawners in the river using spawning survey data alone. 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) $r = -0.02$.

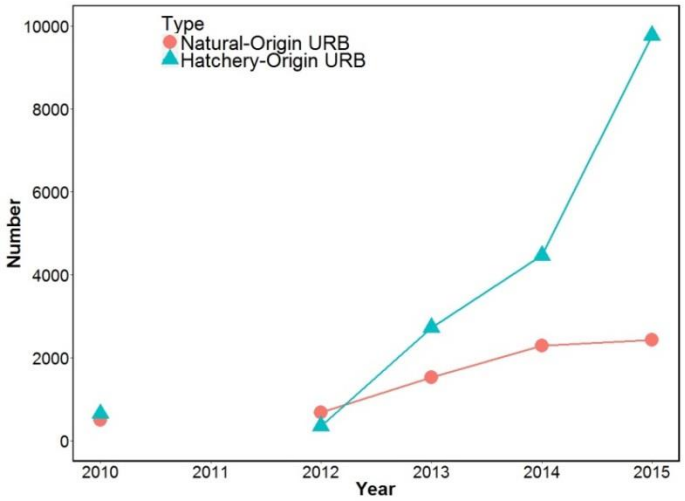


**Figure 5. Escapement estimates of natural-origin and hatchery-origin URBs in the White Salmon River during annual spawning surveys. 2011 escapement estimates were unavailable due to the breach of Condit Dam. Data belongs to WDFW, and was accessed from the SCoRE website.**

*b) Genetic Introgression of URB and Tule 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 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, the 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 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.

*c) Juvenile Downstream Migration and Survival Comparisons to Willard NFH*

Willard NFH is located on the Little White Salmon River approximately 6.5 kilometers upstream of Little White Salmon NFH. The facility began rearing URBs in 2014 using funds provided by the Mitchell Act and administered by the NMFS. Juvenile release metrics from Willard NFH provide a useful comparison to the Little White Salmon NFH URB program. Broodstock for the Willard NFH URB program is provided by Little White Salmon NFH given that a barrier prevents adults from migrating upriver to the Willard facility. In 2015, the facility

released 1.8M juvenile URBs into the Little White Salmon River. Nearly 15,000 of the juveniles were PIT tagged to track their downstream migration through the Little White Salmon River and the Columbia River basin to the Pacific Ocean. A report summarizing comparisons of the two programs was completed at the CRFWCO in July of 2016 (Dammerman 2016).

## Summaries and Program Recommendations

*a) Spring Creek NFH Tule Program*

Since 2007, the tule juvenile production program has exceeded the annual juvenile release goal of 10.5M juveniles by an average 4% except in 2015 and 2016. In the past two years, the number of juveniles released has been below the annual release goal by 1-3%. 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 a mean travel time to BONN of 2.0 days. Despite low detection rates at BONN, the estimated survival of juvenile tule released from Spring Creek NFH migrating to BONN has been 98% or higher for the past two years which may be attributed to swift downstream migration. Low (<6.0%) juvenile encounter probabilities may result from juveniles passing over the spillway, and not being detected by the numerous arrays at BONN.

Mass marking efforts of juveniles has provided reliable adult return information and smolt-to-adult survival rates. Since brood year 2000, the mean smolt-to-adult survival rate for the facility is 0.59% 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 greater since brood year 2007. Through juvenile releases, the program has produced a mean of 78,458 adults since brood year 2000 with a mean of 50,469 being harvested in sport, tribal, and commercial fisheries. Since reprogramming in FY 2009, the program has produced a mean of 60,717 adults through annual juvenile releases. Collectively, these results indicate that the program is successfully meeting contribution levels to the TAP goal agreed upon by USACE and *U.S. v. Oregon* parties.

Since 2005, annual adult returns to the facility have ranged from 10,745 to 50,135 adults (Table 4) providing adequate numbers to satisfy broodstock needs. Aging of adult returns to the facility indicate that the mean proportion of Age-2 returns is low compared to the number of Age-3 and Age-4 fish, but a large number of males return as jacks. Jacks are utilized as broodstock at the facility and naturally occur at reduced rates in wild populations of Chinook, Coho, and Sockeye Salmon (Berejikian et al. 2010). However, 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. Aging all adults at the facility also allows managers to make informed decisions when selecting broodstock as adults return to the hatchery.

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 increasing since 2012. Additionally, a mean pHOS of 25.4% since 2010 suggests that stray rates are high. However, biologists are incapable of determining 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 slight correlation between the number of adult returns to Spring Creek NFH and the number of hatchery-origin tule on the spawning grounds (r = 0.59), 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 2.3% below the release goal, but has met the juvenile size at release goals every year since reprogramming in FY 2009. Additionally, the facility has successfully provided URB juveniles on an annual basis to the Yakima River-Prosser Hatchery program for the Yakama Nation. PIT tagging of juvenile URBs released from Little White Salmon NFH indicate that juveniles reach BONN in a mean of 18.76 days post-release. However, some individuals take up to 154 days to reach BONN indicating that juveniles are either 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. Encounter probabilities at BONN for the past 2 years range from 17-20% as juvenile survival to BONN ranges from 48-50%. Environmental conditions within the mainstem of the Columbia River as well as a higher predation rate due to a longer duration above BONN may be two of the reasons juvenile URBs released from Little White Salmon NFH have lower estimates survival in comparison to juvenile tule released from Spring Creek NFH.

Since brood year 2000, the mean smolt-to-adult survival rate for the facility is 0.63% which is greater than the 0.32% rate used for mitigation planning for the program. The mean smolt-to-adult survival rate since reprogramming in 2009 is 1.15%. Since brood year 2000, the URB program has produced a mean of 19,902 adults which includes 9,608 adults for harvest by sport, tribal, and commercial fishermen. Additionally, since doubling the number of URB juveniles being annually released from the facility in 2009, the program has produced a mean of 62,947 adults. Collectively, the program has been successfully meeting contribution levels to the TAP goal agreed upon by USACE and *U.S. v. Oregon* parties. The number of annual adult returns to the facility has ranged from 2,310 to 35,365 adults since 2005 (Table 9). Since reprogramming in 2009, the number of adult returns has increased providing adequate numbers to satisfy broodstock needs. Aging of adult returns indicate that females are returning at a later age than males, typically migrating to the facility at Age-4 and Age-5. Less than 5% of males return as jacks at Age-2, and only a total of 11 females have returned to the facility at Age-2 since 2005. Aging assists managers in selecting adults for broodstock as adults return to the facility.

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 60.1%. 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. Currently, there is no relationship between the number of adult returns to Little White Salmon NFH and the number of hatchery-origin URBs on the spawning grounds (r = -0.02).

*c) 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 meeting 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 should be 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. **Quantifying the number of hatchery-origin spawners from both Spring Creek and Little White Salmon NFHs present in the White Salmon River and additional watersheds.** 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. Given the close geographic proximity of both facilities to the White Salmon River, escapement of hatchery-origin fish to the White Salmon River spawning grounds may be a common occurrence for adults from both facilities. Coordinating with WDFW personnel and developing a monitoring project during fall spawning would be beneficial to determine whether hatchery practices (including juvenile production levels, ladder operations, etc…) at both Spring Creek and Little White Salmon NFHs are contributing to adult straying. Understanding the effect of hatchery-origin fish on the ESA-listed tule stock in the White Salmon River is imperative for complying with federal regulations regarding ESA-listed species. Additionally, fish from Spring Creek and Little White Salmon NFH have been detected in other watersheds (Pastor 2004). Personnel at the CRFWCO plan to parse out individual spawning ground recoveries reported to RMIS in order to monitor the proportion of hatchery fish that are straying to tributaries of the Columbia River including the White Salmon River.
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 jack 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). Studies examining feed ration amount and feed types during critical growth periods would be beneficial to determine whether hatchery practices (including high feeding rates to meet size at release goals) are influencing the number of jacks returning to Spring Creek NFH.
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 2016, the maximum travel time to BONN for juvenile tule released from Spring Creek NFH was 9 days which was less than half of the max travel time observed in previous years. For juveniles URBs released from Little White Salmon NFH, mean and max travel times in 2015 were lower than all previous release years, and appears to be lower for 2016 even though some URBs may not have migrated downstream yet. Elevated temperatures in the mainstem of the Columbia River in June and July of 2015 may have influenced juvenile downstream migration; however, knowledge on how environmental covariates at the time of release influence juvenile post-release movement is

lacking. Studies utilizing PIT tag detections, downstream migration data calculated at the CRFWCO, 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. These datasets can be utilized in conjunction with environmental covariates (ocean and freshwater) to develop improved forecasting tools for predicting the number of adult returns to the facilities. 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.

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