

Monitoring and Evaluation of Mitchell Act-Funded National Fish Hatcheries in the Columbia River Gorge Complex - 2020 Annual Report

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The Mitchell Act was authorized by Congress in 1938 to provide funds for hatchery programs and fish passage facilities to mitigate for declining salmon populations due to irrigation diversions, water pollution, logging, and hydropower development in the Columbia River Basin. Funds are distributed to treaty tribes, states, and federal agencies from the National Oceanic and Atmospheric Administration (NOAA) Fisheries. For National Fish Hatcheries (NFHs) in the Columbia River Gorge Complex, Mitchell Act funds are utilized by four facilities (Carson, Eagle Creek, Little White Salmon, and Willard NFHs) for rearing programs that produce Coho, fall Chinook, and spring Chinook salmon for commercial, tribal, and recreational harvest opportunities. Additionally, funds support egg and juvenile transfer programs, the collection of broodstock, maintenance of facilities, and monitoring and evaluation (M&E) of the programs by the Columbia River Fish and Wildlife Conservation Office. In this report, results from the M&E programs conducted at each of the four facilities over the past ten years is discussed including broodstock need, juvenile production levels, size at release data, marking and tagging information, detection rates at Bonneville Dam, juvenile survival, adult returns and smolt-to-adult survival rates inferred from coded-wire tag recoveries, adult age structures, and special studies which are supported by Mitchell Act funds. Recommendations for future studies are also discussed.

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Introduction

In 1938, Congress passed the Mitchell Act to mitigate for declining anadromous fish populations and spawning habitat loss due to irrigation diversions, water pollution, logging, and hydropower development in the Columbia River (NPCC 2008). Mitchell Act funds were used by federal agencies to install fish passage facilities and establish hatchery programs that would provide tribal, recreational, and commercial harvest opportunities in the Pacific Ocean and Columbia River. In 1946, the act was amended to allow funds to be distributed to state agencies for development of salmon resources. In 1947, the Columbia River Fisheries Development Program was established to coordinate the use of Mitchell Act funds in the Columbia River Basin. Presently, the National Oceanic and Atmospheric Administration (NOAA) Fisheries directs funding to agencies in Oregon, Idaho, Washington, treaty tribes, and the U.S. Fish and Wildlife Service (USFWS) for the operation and maintenance of facilities funded by the Mitchell Act (USFWS 2006).

Mitchell Act funds currently support rearing programs at four of the six National Fish Hatcheries (NFHs) in the Columbia River Gorge Complex (Fig. 1). At Carson and Little White Salmon NFHs, Mitchell Act funds support yearling spring Chinook programs. At Eagle Creek NFH, funds are utilized for the rearing, release, and transfer of yearling Coho salmon. Lastly, funds support a sub-yearling upriver bright (URB) fall Chinook program at Willard NFH. The hatchery programs are operated to be in compliance with the Endangered Species Act (NMFS 2007, NMFS 2017; USFWS 2015) consistent with the 2008-2017 and 2018-2027 *United States v. Oregon* Management Agreements. Monitoring and evaluation (M&E) of these four programs is conducted by the Columbia River Fish and Wildlife Conservation Office (CRFWCO) located in Vancouver, Washington. The purpose of this report is to summarize results of the M&E

programs conducted at each of the facilities over the past ten years, discuss whether facilities are meeting objectives outlined in their Hatchery and Genetic Management Plans (HGMPs), and describe special studies being conducted which have been supported by Mitchell Act funds.

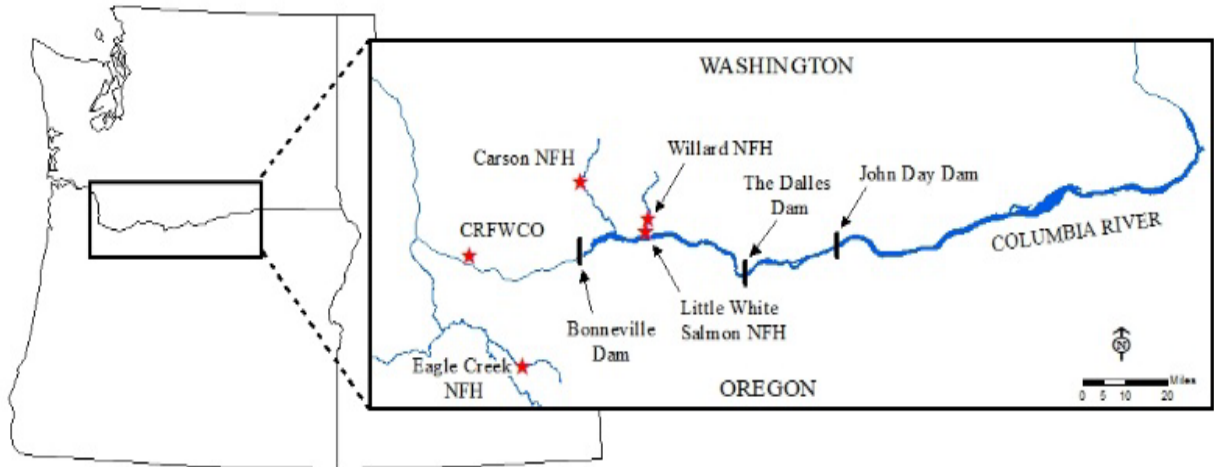


Figure 1. The Columbia River (blue) and the four Mitchell Act Funded NFHs of the Columbia River Gorge Complex: Willard, Little White Salmon, Eagle Creek, and Carson.

*For previous Columbia River Fish and Wildlife Program Office reports, please see:
<https://www.fws.gov/columbiariver/publications.html>*

Carson NFH: Spring Chinook Program

Carson NFH (Fig. 2) is located at the confluence of Tyee Creek and the Wind River in Skamania County, Washington, approximately 14 miles north of the Columbia River (Fig. 1). This facility became operational in December of 1937, and currently operates as part of the Columbia River Fisheries Development Program with funding through the Mitchell Act for the spring Chinook rearing program. The spring Chinook program was initiated in 1955 as mitigation for fish losses in the Columbia River Basin due to hydropower development and operation in the mainstem. Current broodstock need for the program is 1,500 adults to meet production demands for on-station release and transfers. Broodstock is provided by adult returns of hatchery-reared spring Chinook to the facility.



Figure 2. Aerial photograph of Carson NFH located along the Wind River near Carson, WA. U.S. Fish and Wildlife Service stock photograph

On-Station Juvenile Production

a) Egg-to-Smolt Survival

Survival objectives during the early life stages are important M&E metrics for determining whether the hatchery is equipped to meet mitigation goals funded by the Mitchell Act.

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 Marking, Tagging, and Release Data

Funds distributed from NOAA Fisheries as part of the Mitchell Act are used to meet annual juvenile release goals, process adult returns, for costs associated with PIT tagging, and for equipment maintenance. The facility has an annual release goal of 1,170,000 yearling spring Chinook salmon into the Wind River. Fish released contribute to sport, commercial, and tribal fisheries while also providing for adequate escapement for hatchery production. The actual number of juveniles produced at Carson NFH has varied by release year (Table 1) with a mean of 1,155,492 juveniles being annually released since release year (RY) 2011 which is within 1.2% of the release goal.

Carson NFH has a mean juvenile size goal of 18 fish/lb for an April release of their yearling spring Chinook into the Wind River. Since RY 2011, the facility has achieved a mean juvenile size of 19.7 fish/lb at the time of release. Approximately 8% of the total number of juveniles

released are adipose-clipped (AD) and coded-wire tagged (CWT). The remaining 92% of the juveniles released from the facility are AD only. The actual number of juveniles that are mass-marked annually are presented below (Table 1). CWT codes are stored in the USFWS Columbia River Information System (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 juvenile size at release in April for juvenile spring Chinook released from Carson NFH into the Wind River (Data retrieved from CRiS SR80S File: 8/7/2020).

Release Year	Release Dates	AD + CWT	AD Only	Total Released	Mean Size (Fish/lb)
2011	11, 13, 14-Apr	138,758	920,013	1,058,771	17.5
2012	16-Apr	139,276	987,089	1,126,365	18.4
2013	17-Apr	138,802	985,240	1,124,042	18.7
2014*	16-Apr	135,778	991,234	1,127,012	18.3
2015	15-Apr	73,976	1,084,413	1,158,389	17.4
2016	12-Apr	71,295	1,108,476	1,179,771	25.5
2017	10-Apr	60,524	1,203,811	1,264,335	22.1
2018	10-Apr	79,492	1,113,709	1,193,201	19.8
2019	10-Apr	83,588	1,167,820	1,251,408	19.9
2020	10-Apr	85,983	985,644	1,071,627	19.0
Mean		100,747	1,054,745	1,155,492	19.7

c) Transfer Data

The facility also annually transfers approximately 250,000 yearling spring Chinook (Table 2) to the Confederated Tribes of the Umatilla Indian Reservation for reintroduction of spring Chinook to the Walla Walla River.

* In 2014, a special study to evaluate the effects of PIT tagging on post-release survival ended, thus reducing the number of fish both CWT and Adipose marked

Table 2. Annual transfer dates, marking and tagging information, and total number of yearling spring Chinook transferred to the Walla Walla River from Carson NFH (Data retrieved from CRiS SR80S File: 8/7/2020).

Transfer Year	Transfer Dates	Transfer Location	AD + CWT	AD Only	Total Transferred
2011	11, 12-Apr	Walla Walla	50,163	182,191	232,354
2012	2, 3-Apr	Walla Walla	49,872	199,322	249,194
2013	1, 2, 3-Apr	Walla Walla	50,041	198,906	248,947
2014	31-Mar, 1-Apr	Walla Walla	49,710	198,445	248,155
2015	30, 31-Mar	Walla Walla	50,099	197,488	247,587
2016	29-Mar	Walla Walla	48,393	192,366	240,759
2017	28-Mar	Walla Walla	49,878	199,353	249,231
2018	28-Mar	Walla Walla	49,060	197,988	247,048
2019	27-Mar	Walla Walla	49,585	198,073	247,658
2020	9-Apr	Walla Walla	48,483	200,367	248,850
Mean			49,528	196,450	245,978

Off-Station Juvenile Migration and Survival

The smolt-to-adult survival rate goal is 0.5%

a) PIT Tagging Program

PIT tagging provides real-time tracking data as fish migrate from the Wind River to the Columbia River, over Bonneville Dam (BONN), and to the Pacific Ocean. All data is stored in a regional database called the Columbia Basin PIT Tag Information System (PTAGIS) which is utilized by staff at CRFWCO to estimate juvenile post-release migration and survival, track adult returns, and estimate stray rates. Before RY 2011, approximately 15,000 juvenile spring Chinook were annually tagged with passive integrated transponder (PIT) tags just prior to release from Carson NFH (Table 3). An additional 5,000 juveniles are PIT tagged each year prior their transfer to the Confederated Tribes of the Umatilla Indian Reservation for reintroduction into the Walla Walla River. Tagging rates increased to nearly 30,000 for four years (RYs 2011-2014) before returning to 15,000 juveniles per year beginning in RY 2015. Financial support for PIT tagging juveniles at Carson NFH has been provided by Bonneville Power Administration (as part of a comparative survival study), the USFWS, and Mitchell Act funds.

The facility has tagged a mean 20,667 juveniles annually since RY 2011. 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. A mean of 2,148 PIT tagged juveniles have been detected at BONN for a mean detection rate of 10.5%. Mean juvenile travel time to BONN after release is approximately 13 days with some juveniles spending up to 237 days between the facility and BONN before migrating downstream. However, the majority of fish (90th percentile) pass over BONN within 24 days after release.

Table 3. The number of juvenile spring Chinook PIT tagged in a given release year and travel times to Bonneville (BONN) following release from Carson NFH (Data retrieved from PTAGIS: 9/14/2020).

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Mean	Median	Range	50th	75th	90th
2011	29,548	2,856	9.7	18	20	(1 - 99)	20	28	31
2012	29,479	2,563	8.7	11	8	(0.5 - 74)	8	18	26
2013	29,580	3,574	12.1	16	15	(1.5 - 43)	15	20	24
2014	29,399	2,873	9.8	16	17	(1.5 - 57)	17	23	28
2015	14,734	2,263	15.4	15	17	(1 - 47)	17	20	21
2016	14,019	1,043	7.4	10	9	(1 - 44)	9	14	19
2017	14,967	1,137	7.6	11	9	(1 - 45)	9	17	24
2018	14,987	1,461	9.7	10	8	(1 - 49)	8	17	24
2019	14,973	1,570	10.5	10	8	(1 - 50)	8	14	19
2020	14,981	2,138	14.3	12	10	(1.5 - 36)	10	18	20
Mean	20,667	2,148	10.5	13	12		12	19	24

b) Juvenile Survival

PIT tag detection histories are also used to estimate the apparent juvenile survival from hatchery release downstream to Bonneville Dam. A PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated in order to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged fish to estimate the detection probability at Bonneville Dam and estimate the apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 4, Figure 3). As a note in the model, the term “apparent survival” is used to indicate a tagged fish that is alive, a “mortality” is considered a fish that never migrated past Bonneville Dam.

Since release year 2011, median Spring Chinook survival from release at Carson NFH to Bonneville Dam averaged 0.79 (95% CI = 0.65 - 0.93).

Table 4. Carson NFH juvenile Spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals (Data retrieved from PTAGIS: 9/16/2020).

Release Year	Median Survival	95% Lower	95% Upper
2011	0.70	0.60	0.81
2012	0.89	0.77	0.98
2013	0.85	0.76	0.94
2014	0.75	0.67	0.89
2015	0.70	0.64	0.76
2016	0.82	0.64	1.00
2017	0.83	0.57	0.98
2018	0.79	0.58	0.98
2019	0.79	0.58	0.98
2020	0.83	0.65	0.99
Mean	0.79	0.65	0.93

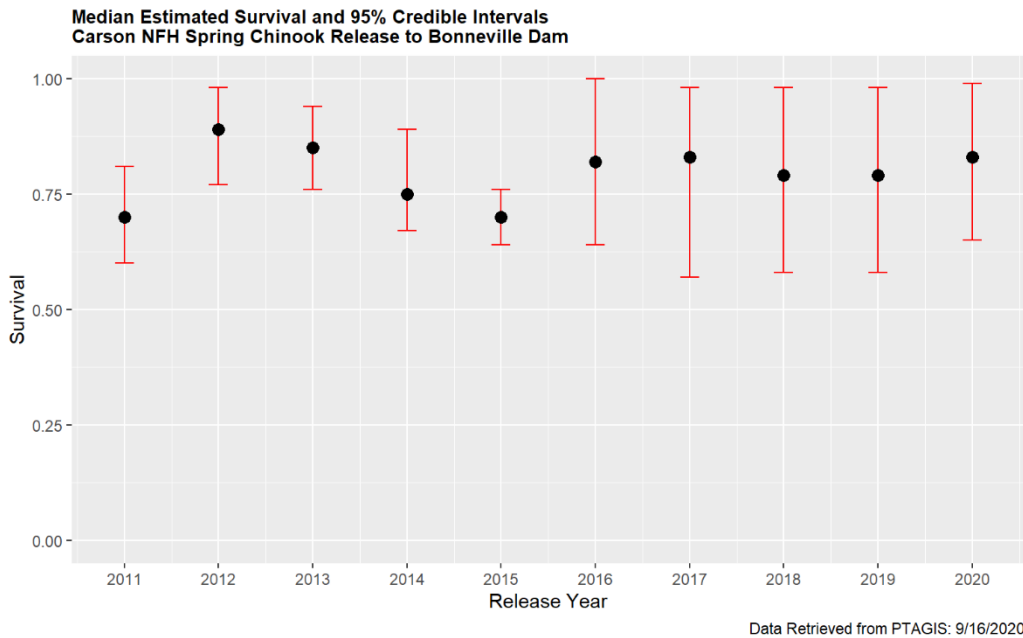


Figure 3. Carson NFH juvenile Spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals

c) Adult Returns, Harvest Data, and Smolt-to-Adult Survival

Adult returns to Carson NFH are estimated by hatchery personnel and the marking and biosampling crew from the CRFWCO. CWT recoveries maintained in the RMIS database are used to estimate the number of harvested adults and spawning ground recoveries (Table 5). At Carson NFH, the number of hatchery returns and harvested adults has fluctuated since brood

year (BY) 2004. Collectively, the facility has produced a mean of 6,663 adults annually since BY 2004 resulting in a mean smolt-to-adult survival rate of 0.55% which exceeds the 10-year average goal of 0.5% set in the facility’s Hatchery and Genetic Management Plan (HGMP; USFWS 2004a).

Table 5. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery expansion data from RMIS for spring Chinook released from Carson NFH. Adult returns are used to estimate smolt-to-adult survival rates (Data retrieved from CRiS Stock Assessment Report: 10/13/2020).

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2004	1,648	4,904	0	0	6,552	0.54
2005	1,967	3,272	0	0	5,239	0.45
2006	6,156	9,710	0	0	15,866	1.19
2007	3,176	2,309	57	0	5,542	0.46
2008	1,909	5,506	0	0	7,415	0.58
2009	1,725	846	0	0	2,571	0.24
2010	2,800	2,289	0	0	5,089	0.45
2011	4,144	3,459	0	5	7,608	0.68
2012	3,341	3,763	0	0	7,104	0.63
2013	2,007	1,525	16	96	3,644	0.31
Mean	2,887	3,758	7	10	6,663	0.55

An average 232 CWTs have been recovered each year at Carson NFH since 2010 (Table 6). The Carson NFH Spring Chinook program accounts for 99.1 percent of all recoveries; Spring Chinook from other programs include Little White Salmon NFH (0.5%), Willard NFH (0.3%), and the Nez Perce Tribal Hatchery (0.1%).

Table 6. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Carson NFH 2010 - 2019, tag recoveries for 2020 are not yet complete. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. (Data retrieved from RMIS: 8/7/2020).

Return Year	CWT Recoveries	Hatchery Origin	% of Total Return
2010	233	Carson NFH	99.6
	1	Willard NFH	0.4
2011	316	Carson NFH	98.1
	4	L White Salmon NFH	1.2
	2	Nez Perce Tribal Hatchery	0.6
2012	148	Carson NFH	98.7
	2	Willard NFH	1.3
2013	426	Carson NFH	100.0
2014	560	Carson NFH	98.9
	2	L White Salmon NFH	0.4
	4	Willard NFH	0.7
2015	270	Carson NFH	99.3
	2	L White Salmon NFH	0.7
2016	144	Carson NFH	99.3
	1	L White Salmon NFH	0.7
2017	107	Carson NFH	99.1
	1	L White Salmon NFH	0.9
2018	50	Carson NFH	98.0
	1	L White Salmon NFH	2.0
2019	49	Carson NFH	98.0
	1	L White Salmon NFH	2.0
Mean	232		

Since Return Year 2011, Spring Chinook jacks (Age 3) and adults (Ages 4 and 5) PIT tagged and released from Carson NFH returned to Bonneville Dam as early as Mar-23 and as late as Jul-30 with the average median passage date May-04 (Table 7). Returns to the Carson NFH Hatchery ladder were detected as early as Apr-30 and as late as Aug-13 with the average median May-29. Actual returns to the hatchery average 30% of the Bonneville Expansion.

Table 7. Median Bonneville Dam passage date and Hatchery Ladder Detections of Carson NFH PIT tagged Spring Chinook jacks (Age 3) and adults (Ages 4 and 5). Total returns for Return Year 2020 are not yet complete (Data retrieved from PTAGIS: 8/18/2020).

Return Year	Bonneville Detections					Hatchery Ladder Detections					Hatchery Count	Hatchery Count/ Bonn Exp.
	Median	First	Last	Total	Bonneville Expansion (95% CI)	Median	First	Last	Total	Ladder Expansion (95% CI)		
2011	May-03	Apr-19	Jun-12	229	18,799 (15,658 – 23,365)	-	-	-	-	--	3,095	16 (13 -20) %
2012	May-09	Apr-13	May-20	130	10,802 (8,608 – 14,168)	Jun-10	May-24	Aug-06	21	1,739 (1,031 – 5,348)	1,612	15 (11 – 19) %
2013	May-01	Apr-03	Jun-07	96	3,672 (2,569 – 4,500)	May-19	May-05	Aug-04	27	1,022 (620 – 5,345)	1,913	52 (43 - 74) %
2014	Apr-30	Mar-26	Jul-21	178	6,789 (5,568 – 8,138)	May-30	May-07	Jul-24	43	1,640 (1,156 – 4,172)	2,416	36 (30 - 43) %
2015	Apr-23	Mar-23	May-28	306	11,634 (10,128 – 13,816)	May-22	Apr-30	Jun-18	50	1,901 (1,389 – 2,977)	2,841	24 (21 - 28) %
2016	May-01	Apr-02	Jul-01	181	7,055 (5,741 – 8,319)	Jun-01	May-08	Aug-13	33	1,264 (881 – 3,288)	1,318	19 (16 - 23) %
2017	May-16	May-01	Jul-04	58	4,490 (3,260 – 5,643)	May-31	May-24	Jun-06	9	708 (375 – 1,543)	1,596	36 (28 - 49) %
2018	May-09	Apr-24	Jun-12	32	2,682 (1,704 – 3,638)	May-25	May-20	Jun-07	8	668 (264 – 7,815)	1,042	39 (29 - 61) %
2019	May-07	Apr-17	Jul-30	29	2,444 (1,435 – 3,257)	May-31	May-21	Aug-01	11	929 (477 – 5,082)	742	30 (23 - 52) %
2020	May-02	Mar-28	May-26	35	2,800 (1,809 – 3,718)	Jun-05	May-02	Jun-12	7	557 (272 – 1,382)	-	-
Mean	May-04	Apr-09	Jun-18	127	7,117	May-29	May-12	Jul-10	23	1,159	1,842	30%

d) Age Structure

Monitoring adult returns to the hatchery provides information on sex ratios, length information, and age structure. Aging is determined by USFWS staff through CWT recoveries and scale sampling. Since Return Year 2011, approximately 89% of adults have returned to the facility at Age-4 (Table 8). Additionally, almost 6% have returned as jacks at Age-3, and 5% have returned at Age-5. No CWT recoveries or scale samples from Age-2 or Age-6 returns have been documented. The facility has a mean of 1,842 adult returns each year.

Table 8. Age structure of adult spring Chinook returns to Carson NFH based on scale analysis (and the proportion of the total return). Adults referred to as Age-2 are in their first year at migration, Age-3 (jacks) are in their second, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Aging for Return Year 2020 has not yet been completed (Data retrieved from CRiS AGECOMP: 8/18/2020).

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2011	0	176 (6%)	2,734 (88%)	185 (6%)	0	3,095
2012	0	26 (2%)	1,437 (89%)	149 (9%)	0	1,612
2013	0	223 (12%)	1,507 (79%)	183 (10%)	0	1,913
2014	0	199 (8%)	2,126 (88%)	91 (4%)	0	2,416
2015	0	138 (5%)	2,671 (94%)	32 (1%)	0	2,841
2016	0	40 (3%)	1,174 (89%)	104 (8%)	0	1,318
2017	0	76 (5%)	1,468 (92%)	52 (3%)	0	1,596
2018	0	55 (5%)	973 (93%)	14 (1%)	0	1,042
2019	0	73 (10%)	656 (88%)	13 (2%)	0	742
2020	-	-	-	-	-	-
Mean	0	112 (6%)	1,638 (89%)	91 (5%)	0	1,842

Special Studies

Staff at the CRFWCO conducted a study (brood years 2009-2012) evaluating the effects of PIT tagging on post-release survival (USFWS 2013). The last year of adult sampling for the study was conducted at the hatchery in 2017. Reporting and publication of findings from the study are planned in the upcoming years. No other special studies as part of the M&E program are currently being conducted. However, the hatchery staff continually monitor the Bacterial Kidney Disease (BKD) issues with their broodstock, and cull eggs from females with high occurrences of BKD.

Additionally, hatchery staff continue to be included in the CRFWCO in discussions about the monitoring and potential eradication of Brook Trout from Tye Springs. In 2019, CRFWCO and hatchery staff conducted a multi-day mark-recapture in Tye Springs to estimate Brook Trout abundance. The Brook Trout abundance estimate was used to develop a decision model to assess the feasibility of using the Trojan Y Chromosome approach to eradicate Brook Trout in Tye Springs (Schill et al. 2016). In October 2020, a total of 600 YY-male Brook Trout were stocked

into Tyee Springs. The stocked YY males will be monitored to measure dispersion, migration (through the hatchery bypass channel), survival and spawning success (Poirier et al. 2020).

Eagle Creek NFH: Coho Program

Eagle Creek NFH (Fig. 4) is located at river kilometer (rkm) 16 on Eagle Creek, a tributary of the Clackamas River near Estacada, Oregon. The Clackamas River connects with the Willamette River which then flows into the Columbia River at rkm 163 (Fig. 1). The hatchery became operational in 1956 with the primary role of mitigating for habitat loss due to operation of BONN by supporting commercial and recreational fisheries as authorized under the Mitchell Act. Currently, the facility annually rears and releases yearling Coho salmon into Eagle Creek and assists with the Confederated Tribes and Bands of the Yakama Nation and Nez Perce Tribes' reintroduction efforts by providing yearling Coho salmon for these programs. Current broodstock need for Coho reared at Eagle Creek NFH is a minimum of 1,600 adult returns to the facility and eyed egg transfers to the facility to meet juvenile production and transfer demands. Additionally, the facility propagates winter-run steelhead and spring Chinook under an agreement with the Oregon Department of Fish and Wildlife (ODFW). The ODFW steelhead and spring Chinook programs are not included in this report.



Figure 4. Aerial photograph of Eagle Creek NFH located on Eagle Creek, a tributary of the Clackamas River near Estacada, Oregon. U.S. Fish and Wildlife Service stock photograph

On-Station Juvenile Production

a) Egg-to-Smolt Survival

Survival objectives during the early life stages are important M&E metrics for determining whether the hatchery is equipped to meet mitigation goals being funded by the Mitchell Act.

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. In September 2020, nearby wildfires in the Eagle Creek Basin required the temporary evacuation of staff from the facility. While there was no fish mortality from this event, future wildfires and evacuations could be extended and significantly impact fish survival.

b) Juvenile Marking, Tagging, and Release Data

There is a cost share between Bonneville Power Administration and Mitchell Act funds for the Eagle Creek NFH Coho program. Bonneville Power Administration funds the Confederated Tribes and Bands of the Yakama Nation Coho program at Eagle Creek including all PIT tagging and marking. Mitchell Act funds support juvenile production costs including the PIT tagging and transfer of juveniles to other facilities and programs. Prior to RY 2009, the facility was rearing and releasing 500,000 juvenile Coho into Eagle Creek annually. However, production goals were changed to 350,000 juvenile Coho on-station releases beginning with RY 2009 (BY 2007) in order to reduce ecological risks (USFWS 2007). The actual number of juvenile Coho released into Eagle Creek has varied by release year (Table 9) with an annual mean of 351,987 juveniles released since RY 2011 which is within 0.6% of the release goal.

Eagle Creek NFH has a mean juvenile size goal of 12 fish/lb according to the most recent HGMP for a mid-April release of their yearling Coho salmon (USFWS 2004b). In recent years, a maximum size of 15 fish/lb and a preferred size of 18 fish/lb has been targeted to reduce excessive jack rates with high body fat percentages. Since RY 2011, the facility has achieved a mean juvenile size of 18 fish/lb at the time of release. Approximately 6.5% of the total number of juveniles that are released from the facility are AD and CWT. Another 6.5% is CWT only (Double Index Tagged, DIT fish) which is used to assess the impact of fishing pressures on wild populations. The remaining 86% of the juvenile Coho releases are AD only. The actual number of juveniles that are marked and tagged varies each year (Table 9). All CWT codes are stored in the USFWS CRiS database at the CRFWCO and reported annually to RMIS.

Table 9. Annual release dates, marking and tagging information, total number of juveniles released, and mean juvenile size for Coho released from Eagle Creek NFH (Data retrieved from CRiS SR80S File: 8/18/2020).

Release Year	Release Dates	AD + CWT	CWT (DIT)	AD Only	Total Released	Mean Size (Fish/lb)
2011	11-Apr	24,850	24,834	272,207	321,891	15.8
2012	1-May	24,534	24,312	296,154	345,000	16.8
2013	18-Apr	25,006	23,656	333,907	382,569	16.7
2014	16-Apr	24,084	22,594	321,314	367,992	16.0
2015	3-Apr	14,905	23,654	292,674	331,233	16.6
2016	30-Mar	23,515	23,326	261,815	308,656	15.8
2017	11-Apr	24,301	21,603	298,312	344,216	18.7
2018	7-Apr	24,513	24,416	364,297	413,226	19.9
2019	26-Mar	23,694	23,589	297,810	345,093	21.1
2020	24-Mar	22,718	22,316	314,963	359,997	23.0
Mean		23,212	23,430	305,345	351,987	18.0

c) Transfer Data

The facility also has transfer goals of 500,000 yearlings to the Confederated Tribes and Bands of the Yakama Nation for reintroduction efforts in the Yakima River region, and 550,000 yearlings to the Nez Perce Tribe for reintroduction efforts in the Clearwater River region. These transferred fish are marked and/or tagged by staff at the CRFWCO prior to transfer, but any release information after transfer would be reported to RMIS from the Confederated Tribes and Bands of the Yakama Nation or Nez Perce Tribe. Eagle Creek NFH will continue to support these reintroduction programs until transfers are no longer needed.

Off-Station Juvenile Migration and Survival

The smolt-to-adult survival rate goal is 2%

a) PIT Tagging Program

At Eagle Creek NFH, no PIT tagging of the on-station juvenile releases is conducted given that juveniles migrate to the Pacific Ocean through the Clackamas, Willamette, and Columbia Rivers without passing over any major PIT tag detection locations. However, Mitchell Act funds are used to PIT tag Coho at Eagle Creek NFH for the Nez Perce Tribe and purchase an additional 5,000 PIT tags for the Nez Perce Tribe to tag Coho at Kooskia NFH. Approximately 10,000 juvenile Coho have been PIT tagged annually just prior to transfer to the Nez Perce Tribe program since RY 2013 (Table 10).

Table 10. Tagging dates and number of juvenile Coho PIT tagged by the CRFWCO prior to transfer to the Nez Perce Tribe program (Data retrieved from PTAGIS: 8/18/2020).

Release Year	Tag Dates	# PIT Tagged
2013	18, 19, 20-Jan 2013	9,959
2014	14, 15, 16-Jan 2014	9,979
2015	21, 22, 23-Jan 2015	9,986
2016	12, 13, 14-Jan 2016	9,922
2018*	28, 29-Nov 2016	4,992
2018	28, 29-Nov 2017	9,994
2019	27, 28-Nov 2018	9,994
2020	2,3-Dec 2019	9,974
Mean		9,350

b) Adult Returns, Harvest Data, and Smolt-to-Adult Survival

For Coho released from Eagle Creek NFH, the number of hatchery returns, harvested adults, and spawning ground recoveries have fluctuated since BY 2004 (Table 11). Approximately 18% of adults are harvested in the Pacific Ocean as opposed to the 5% harvested in the Columbia River Basin. The facility has produced a mean of 7,623 adults annually since BY 2004 with a smolt-to-adult survival rate of 1.8% which is near the 10-year average goal of 2% set for the Coho program in the HGMP (USFWS 2004b).

* Approximately 5K juveniles PIT tagged given low juvenile numbers

Table 11. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery expansion data from RMIS for Coho released from Eagle Creek NFH. Adult returns are used to estimate smolt-to-adult survival rates (Data retrieved from CRiS Stock Assessment: 10/13/2020).

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2004	10,145	634	3,418	73	14,270	3.1
2005	3,399	339	444	2	4,184	0.8
2006	11,425	1,530	5,243	55	18,253	3.6
2007	1,005	87	204	24	1,320	0.4
2008	1,418	123	146	26	1,713	0.5
2009	873	168	132	0	1,173	0.4
2010	3,372	81	442	0	3,895	1.1
2011	14,899	2,667	3,908	0	21,474	5.6
2012	2,955	392	643	0	3,990	1.1
2013	4,878	745	318	21	5,962	1.8
Mean	5,437	677	1,490	20	7,623	1.8

c) Age Structure

Aging of adult Coho returns to Eagle Creek NFH are determined using CWT recoveries and scale sampling as noted for Carson NFH. However, the vast majority (~94%) of adult Coho return as Age-3 fish with a small proportion (~6%) of fish returning as jacks at Age-2 (Table 12). Zero Age-4, Age-5, or Age-6 returns have been documented. The facility has an annual mean of 4,396 adult returns to the facility since Return Year 2011.

Table 12. Age structure of adult coho returns to Eagle Creek NFH based on scale analysis (and the proportion of the total return). Adults referred to as Age-2 (jacks) are in their first year at migration, Age-3 are in their second, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Aging for return year 2020 has not yet been completed (Data retrieved from CRiS AGECOMP: 8/18/2020).

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2011	60 (3%)	2,130 (97%)	0	0	0	2,190
2012	214 (16%)	1,132 (84%)	0	0	0	1,346
2013	522 (13%)	3,382 (87%)	0	0	0	3,904
2014	257 (2%)	14,413 (98%)	0	0	0	14,670
2015	310 (14%)	1,931 (86%)	0	0	0	2,241
2016	278 (9%)	2,935 (91%)	0	0	0	3,213
2017	181 (4%)	4,308 (96%)	0	0	0	4,489
2018	235 (6%)	3,543 (94%)	0	0	0	3,778
2019	129 (3%)	3,605 (97%)	0	0	0	3,734
2020	-	-	-	-	-	-
Mean	243 (6%)	4,153 (94%)	0	0	0	4,396

Special Studies

No special studies as part of the Coho M&E program are currently being conducted at Eagle Creek NFH. From 2005 through 2015, the USFWS conducted multiple year evaluations investigating the ecological and genetic interactions of hatchery and wild steelhead in Eagle Creek (Kavanagh et al. 2009, 2017). Brignon (2017) is an example of a recent publication from these evaluations.

Little White Salmon NFH: Spring Chinook Program

Little White Salmon NFH (Fig. 5) 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 is the oldest NFH in the Pacific Region (Fig. 1) becoming operational in 1898 to support the commercial fishing industry. In the late 1930s, the facility began receiving Mitchell Act funds to mitigate for habitat loss due to the completion of BONN. Mitchell Act funds are currently used for the annual production and PIT tagging of spring Chinook salmon into the Little White Salmon River as well as the transfer of URB fall Chinook eggs to Willard NFH and

the Confederated Tribes and Bands of the Yakama Nation's Klickitat Hatchery. Additionally, the facility has an URB fall Chinook program with funding from the U.S. Army Corps of Engineers as part of the John Day/The Dalles Dam Mitigation (JDTD) Program. Broodstock need for the spring Chinook program at Little White Salmon NFH is a minimum of 1,000 adults. Currently, the broodstock need is met through adult returns to the facility.



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

On-Station Juvenile Production

a) Egg-to-Smolt Survival

Survival objectives during the early life stages are important M&E metrics for determining whether the hatchery is equipped to meet mitigation goals being funded by the Mitchell Act. 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 Marking, Tagging, and Release Data

Funds received from NOAA Fisheries under the Mitchell Act are used to cover juvenile production and PIT tagging expenses, general facility maintenance costs, processing of adult returns, and egg transfer requests. The program has an annual juvenile release goal of 1,000,000 yearling spring Chinook. Since RY 2011, the program has produced an annual mean of 1,064,070 yearling spring Chinook that were released into the Little White Salmon River in mid-April which is within 6.4% of the release goal (Table 13). From 2010 to 2014, a proportion of

the programs juvenile production was reared and released at Willard NFH into the Little White Salmon River.

Approximately 10% of juveniles are AD and CWT. The remaining 90% of fish are AD only just prior to release (Table 13). All CWT codes are stored in the CRiS database and reported to RMIS. Since RY 2011, the facility has achieved a mean juvenile size of 16.7 fish/lb which is near the program’s goal of 15 fish/lb at release listed in the HGMP (USFWS 2004c).

Table 13. Annual release dates, marking and tagging information, total number of juveniles released, and mean juvenile size for spring Chinook reared at Little White Salmon (LWS) NFH or Willard (WI) NFH, and released into the Little White Salmon River (Data retrieved from CRiS SR80S File: 8/18/2020).

Release Year	Release Site	Release Dates	AD + CWT	AD Only	Total Released	Mean Size (Fish/lb)
2011	LWS	14-Apr	67,861	532,872	600,733	15.3
2011	WI	14-Apr	74,062	325,891	399,953	15.4
2012	LWS	19-Apr	74,304	684,857	759,161	15
2012	WI	19-Apr	24,677	221,827	246,504	15.4
2013	LWS	18-Apr	73,511	652,214	725,725	15.3
2013	WI	18-Apr	24,266	271,816	296,082	15.5
2014	LWS	17-Apr	73,487	802,166	875,653	15.3
2014	WI	17-Apr	9,738	112,997	122,735	16.5
2015	LWS	16-Apr	73,946	925,259	999,205	14.8
2016	LWS	14-Apr	73,539	1,250,120	1,323,659	14.9
2017	LWS	12-Apr	74,475	1,008,064	1,082,539	15.8
2018*	LWS	10-Apr	76,336	1,001,798	1,078,134	21.4
2019*	LWS	11-Apr	108,839	932,258	1,041,097	19
2020*	LWS	13-Apr	89,646	999,874	1,089,520	18.8
Annual Means	LWS/WI	Mid-Apr	91,869	972,201	1,064,070	16.7

c) Transfer Data

Little White Salmon NFH does not transfer any spring Chinook yearlings as part of the Mitchell Act funded program; however, the facility does use Mitchell Act funds to transfer surplus eggs to other spring Chinook programs like Carson NFH, as well as approximately 2.2 million URB fall Chinook eggs to Willard NFH to support their Mitchell Act funded program, and up to 5 million URB fall Chinook eggs to the Confederated Tribes and Bands of the Yakama Nation to support their Klickitat Hatchery program.

* Beginning with RY 2018, the LWS SCS program is aiming to shift production to 20 fish/lb. A portion of fish will still be reared to 15 fish/lb (target goal) to monitor differences in downstream migration and/or returns

Off-Station Juvenile Migration and Survival

The smolt-to-adult survival rate goal is 0.2%

a) PIT Tagging Program

Since RY 2011, an annual mean of 14,760 yearling spring Chinook have been PIT tagged at either Little White Salmon NFH or Willard NFH as part of the Little White Salmon NFH spring Chinook program (Table 14). Approximately 13.1% of PIT tagged yearling spring Chinook released from Little White Salmon NFH and 9.4% released from Willard NFH have been detected annually at BONN. On average, yearlings took approximately 13 days after release from Little White Salmon NFH and 24 days after release from Willard NFH to be detected at BONN. The majority of yearlings (90th percentile) released from Little White Salmon NFH passed over BONN within 23 days after release versus 32 days after release from Willard NFH.

Table 14. The number of juvenile spring Chinook PIT tagged in a given release year (RY) at Little White Salmon (LWS) and Willard (WI) NFHs, and travel times to Bonneville Dam (BONN) following release into the Little White Salmon River (Data retrieved from PTAGIS: 9/14/2020).

Release Year	Release Site	# PIT Tagged	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2011	LWS	7,482	854	11.4	17	(1 - 108)	18	28	31
2011	WI	5,495	417	7.6	26	(2.5 - 84)	29	32	34
2012	LWS	11,959	1,003	8.4	11	(1 - 40)	7	18	24
2012	WI	2,960	273	9.2	25	(4 - 63)	26	29	33
2013	LWS	10,480	1,273	12.1	13	(1 - 41)	13	17	20
2013	WI	4,492	475	10.6	22	(4.5 - 66)	22	25	28
2014	LWS	11,991	1,325	11	13	(0.5 - 39)	12	20	24
2014	WI	2,989	302	10.1	23	(3.5 - 44)	24	28	31
2015	LWS	14,945	2,840	19	14	(0.5 - 44)	15	18	20
2016	LWS	14,974	2,097	14	11	(0.5 - 51)	11	15	19
2017	LWS	14,964	2,413	16.1	14	(0.5 - 40)	15	18	23
2018	LWS	14,935	1,418	9.5	12	(0.5 - 37)	10	19	24
2019	LWS	14,968	1,961	13.1	14	(1 - 46)	13	19	25
2020	LWS	14,964	2,413	16.1	14	(0.5 -40)	15	18	23
Mean	LWS	14,760	1,760	13.1	13		13	19	23
	WI	14,760	367	9.4	24		25	28	32

b) Juvenile Survival

PIT tag detection histories are also used to estimate the apparent juvenile survival from hatchery release downstream to Bonneville Dam. A PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner

collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated in order to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged fish to estimate the detection probability at Bonneville Dam and estimate the apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 15, Figure 6). As a note in the model, the term “apparent survival” is used to indicate a tagged fish that is alive, a “mortality” is considered a fish that never migrated past Bonneville Dam.

Since release year 2011, median Spring Chinook survival from release at Little White Salmon NFH (or Willard NFH) to Bonneville Dam averaged 0.82 (95% CI = 0.67 - 0.94).

Table 15. Little White Salmon NFH juvenile Spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals (Data retrieved from PTAGIS: 9/16/2020).

Release Year	Median Survival	95% Lower	95% Upper
2011	0.68	0.55	0.89
2012	0.91	0.75	0.99
2013	0.94	0.81	0.99
2014	0.87	0.74	0.98
2015	0.84	0.77	0.91
2016	0.93	0.79	1.00
2017	0.88	0.68	0.99
2018	0.78	0.57	0.97
2019	0.61	0.48	0.74
2020	0.81	0.60	0.99
Mean	0.82	0.67	0.94

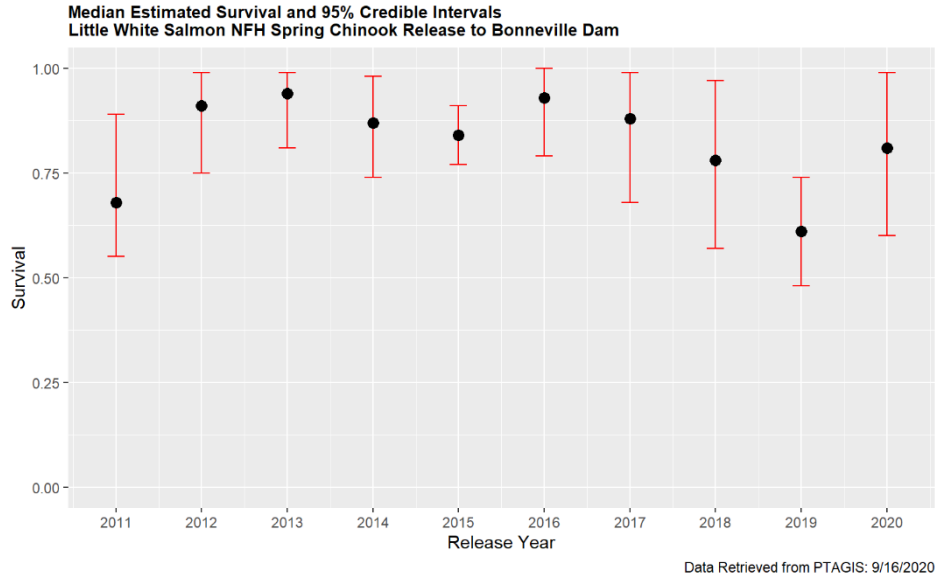


Figure 6. Little White Salmon NFH juvenile Spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals

c) Adult Returns, Harvest Data, and Smolt-to-Adult Survival

The number of adult returns to the facility were estimated annually by hatchery personnel and the marking and biosampling crew from the CRFWCO. CWT recoveries obtained from RMIS are used to estimate the number of harvested adults and adults recovered on the spawning grounds. Since BY 2004, the number of adult hatchery returns has varied from 1,328 to 5,379 adults (Table 16). Approximately 45% of adult returns are harvested in the Columbia River with less than 1% on average being harvested in the ocean and less than 4% being observed on the spawning grounds. The facility has produced a mean of 7,151 adult spring Chinook since BY 2004 with a smolt-to-adult survival rate of 0.85% which is greater than the 0.2% rate set in the HGMP (USFWS 2004c).

As part of the Little White Mitchell Act program, additional spring Chinook (BYs 2007 - 2012) were reared and released from Willard NFH with a goal of 1.0 million on-site releases. Since BY 2007, spring Chinook released at Willard NFH have produced an average of 1,475 adults with a smolt-to-adult survival rate of 0.44% which is also greater than the 0.2% rate set in the HGMP.

Table 16. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery expansion data from RMIS for spring Chinook released from Little White Salmon (LWS) and Willard (WI) NFHs. Adult returns are used to estimate smolt-to-adult survival (Data retrieved from CRiS Stock Assessment: 8/18/2020).

Brood Year	Release Site	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2004	LWS	2,440	2,576	0	10	5,026	0.50
2005	LWS	2,408	4,624	0	8	7,040	0.70
2006	LWS	4,768	14,408	0	240	19,416	2.08
2007	LWS	1,328	1,840	0	712	3,880	0.66
	WI	510	1,116	0	534	2,160	0.51
2008	LWS	1,784	1,480	0	8	3,272	0.56
	WI	780	1,494	0	60	2,334	0.55
2009	LWS	1,710	576	0	0	2,286	0.38
	WI	460	260	0	5	725	0.19
2010	LWS	2,430	2,390	0	1,390	6,210	0.82
	WI	240	580	0	0	820	0.33
2011	LWS	5,008	5,020	0	0	10,028	1.38
	WI	900	480	0	0	1,380	0.47
2012	LWS	4,256	708	0	216	5,180	0.52
	WI	351	78	0	0	429	0.35
2013	LWS	5,379	2,947	38	809	9,173	0.92
Mean	LWS	3,151	3,657	4	339	7,151	0.85
	WI	707	668	0	100	1,475	0.44

An average 322 CWTs have been recovered each year at Little White Salmon NFH since 2009 (Table 17). The Little White Salmon NFH Spring Chinook program accounts for 86 percent of all recoveries; Spring Chinook from other programs include Carson NFH (9.7%), Willard NFH (4.2%), Kooski and Leavenworth NFHs account for (0.1%).

Table 17. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Little White Salmon NFH, tag recoveries for 2020 are not yet complete. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. (Data retrieved from RMIS: 8/18/2020).

Return Year	CWT Recoveries	Hatchery Origin	% of Total Return
2009	323	L. White Salmon NFH	90
	37	Carson NFH	10
	1	Leavenworth NFH	< 1
2010	493	L. White Salmon NFH	92
	42	Carson NFH	8
2011	176	L. White Salmon NFH	90
	15	Carson NFH	8
	2	Kooski NFH	1
	2	Willard NFH	1
2012	326	L. White Salmon NFH	93
	23	Carson NFH	7
2013	119	L. White Salmon NFH	61
	12	Carson NFH	6
2014	63	Willard NFH	33
	192	L. White Salmon NFH	84
	20	Carson NFH	9
	18	Willard NFH	8
2015	429	L. White Salmon NFH	65
	167	Carson NFH	25
	65	Willard NFH	10
2016	1	Carson NFH	< 1
	281	L. White Salmon NFH	> 99
2017	356	L. White Salmon NFH	100
2018	191	L. White Salmon NFH	92
	16	Carson NFH	8
2019	160	L. White Salmon NFH	94
	10	Carson NFH	6
Mean	322		

Since Return Year 2011, Spring Chinook adults (Ages 3, 4 and 5) PIT tagged and released from Little White Salmon NFH returned to Bonneville Dam as early as Apr-08 and as late as Jul-26 with the average median passage date May-04 (Table 18). Returns to the Little White Salmon NFH Hatchery ladder were detected as early as Apr-27 and as late as Sep-28 with the average median May-14. Actual returns to the hatchery average 68% of the Bonneville Expansion.

Table 18. Median Bonneville Dam (BONN) passage date and Hatchery Ladder Detection date of Little White Salmon NFH PIT tagged Spring Chinook adults (Ages 3, 4 and 5). Detections of spring Chinook from other programs (i.e., Carson and Willard NFHs) are *not* included. Total returns for Return Year 2020 are not yet complete (Data retrieved from PTAGIS 8/18/2020).

Return Year	BONN Detections					Hatchery Ladder Detections					Hatchery Count	Hatchery Count/ BONN exp
	Median	First	Last	Total	BONN Expansion (95% CI)	Median	First	Last	Total	Ladder Expansion (95% CI)		
2011	May-03	Apr-15	Jun-12	97	7,353 (5,511 – 9,491)	May-11	May-11	Jun-16	9	644 (269 – 2,125)	1,768	24 (19 - 32) %
2012	May-08	Apr-20	May-17	36	2,827 (1,754 – 4,661)	May-15	May-15	May-29	13	1,021 (513 – 8,008)	2,891	102 (62 - 165) %
2013	May-03	Apr-08	May-26	40	3,086 (1,843 – 4,572)	May-16	Apr-28	Sep-28	22	1,692 (869 – 7,231)	3,678	119 (80 - 200) %
2014	May-01	Apr-12	Jul-25	110	7,095 (5,566 – 9,239)	May-14	May-04	Jun-29	33	2,128 (1,436 – 4,213)	2,967	42 (32 - 53) %
2015	Apr-25	Apr-10	Jun-01	158	10,939 (8,927 – 12,334)	May-27	Apr-27	Jun-08	54	3,739 (2,684 – 6,683)	7,786	71 (63 - 87) %
2016	May-03	Apr-16	May-20	87	6,297 (4,691 – 8,312)	May-09	May-08	May-29	30	2,172 (1,390 – 3,877)	5,423	86 (65 - 116) %
2017	May-20	Apr-21	Jul-26	79	5,528 (3,999 – 8,507)	May-20	May-09	Sep-12	35	2,454 (1,559 – 7,131)	4,404	80 (52 - 110) %
2018	May-07	Apr-21	Jun-05	99	8,568 (6,710 – 11,043)	May-12	May-06	Jun-24	20	1,725 (1,048 – 3,780)	3,748	44 (34 - 56) %
2019	May-02	Apr-20	May-22	82	5,975 (4,396 – 6,962)	May-13	May-03	Aug-22	37	2,674 (1,864 – 4,814)	2,806	47 (40 - 64) %
2020	Apr-30	Apr-12	May-27	26	1,874 (1,110 – 2,613)	May-10	May-04	Jun-21	14	1,008 (525 – 7,270)	-	-
Mean	May-04	Apr-15	Jun-08	81	5,954	May-14	May-5	Jul-10	27	1,926	3,941	68 (50 -98) %

d) Age Structure

Similar to Carson and Eagle Creek NFHs, aging of adult returns to Little White Salmon NFH are determined using CWT recoveries and scale sampling. On average, the majority (~89%) of spring Chinook return to Little White Salmon NFH as Age-4 adults (Table 19). Approximately 3% return as jacks at Age-3 and 8% of adults return to the facility at Age-5. For RYs 2011-20, no Age-2 or Age-6 adults have been documented. The facility has a mean of 3,941 adult returns each year.

Table 19. Age structure of adult spring Chinook returns to Little White Salmon NFH based on scale analysis (and the proportion of the total return). Adults referred to as Age-2 are in their first year at migration, Age-3 (jacks) are in their second, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Aging for Return Year 2020 has not yet been completed (Data retrieved from CRiS 8/19/2020).

Return Year	Age-2	Age-3	Age-4	Age-5	Age-6	Total # Adults
2011	0	34 (2%)	1,589 (90%)	145 (8%)	0	1,768
2012	0	24 (1%)	2,485 (86%)	382 (13%)	0	2,891
2013	0	88 (2%)	2,732 (75%)	854 (23%)	0	3,674
2014	0	67 (2%)	2,773 (94%)	127 (4%)	0	2,967
2015	0	183 (2%)	7,270 (94%)	333 (4%)	0	7,786
2016	0	116 (3%)	3,832 (87%)	456 (10%)	0	4,404
2017	0	404 (7%)	4,748 (88%)	271 (5%)	0	5,423
2018	0	83 (2%)	3,574 (96%)	91 (2%)	0	3,748
2019	0	69 (2%)	2,529 (91%)	208 (7%)	0	2,806
2020	-	-	-	-	-	-
Mean	0	119 (3%)	3,504 (89%)	319 (8%)	0	3,941

Special Studies

Little White Salmon NFH is considering a change in size at release from 15 fish/lb to 20 fish/lb. Altering the fish/lb goal could free up space, reduce food costs, and allow for other rearing opportunities. Based on literature review, a change from 15 fish/lb to 20 fish/lb may not significantly affect juvenile smolting rates, adult return rates, straying, or the age structure of adult returns. However, differences in juvenile travel time may be observed since larger smolts (15 fish/lb) typically migrate downstream at faster rates.

From 2018 to 2020, two release groups targeted different average release sizes for monitoring and comparison (Table 20). The majority of spring Chinook were reared at 20 fish/lb and one raceway targeted fish at 15 fish/lb. In 2018, chronic low mortality BKD in the raceway with the 15 fish/lb target, medicated feed was administered, and fish only reached 17 fish/lb before release. Approximately 14% of the 15 fish/lb target and 12.7% of the 20 fish/lb target were detected at BONN. On average, the 15 fish/lb target took approximately 14 days and the 20 fish/lb target took 13 days after release for detection at BONN. The majority (90th percentile) of both 15 and 20 fish/lb targets passed over BONN within 24 days after release.

Table 20. Release date, total number, and travel times to Bonneville Dam following release into the Little White Salmon River of juvenile spring Chinook released at 15 fish/lb and 20 fish/lb targets (Data retrieved from PTAGIS 9/14/2020).

Release Year	Release Date	Size (fish/lb)	# PIT Tagged	# Detected	% Detected	Mean	Range	50th	75th	90th
2018	10-Apr	17	2,197	233	10.6	13	(0.5 - 37)	14	21	25
		20	12,738	1,185	9.3	11	(0.5 - 33)	10	19	23
2019	11-Apr	15	2,196	274	12.5	14	(1 - 46)	13	17	23
		20	12,772	1,687	13.2	14	(1 - 43)	13	19	25
2020	13-Apr	21	12,865	2,017	15.7	14	(0.5 - 40)	14	18	24
		16.5	2,099	396	18.9	15	(0.5 - 35)	16	19	23
Mean		16	2,164	301	14	14		14	19	24
		20	12,792	1,630	12.7	13		12	19	24

Willard NFH: Upriver Bright Fall Chinook Program

Willard NFH (Fig. 7) is located on the Little White Salmon River approximately 6.5 rkm upstream of Little White Salmon NFH (Fig. 1). Mitchell Act funds are cost shared with Bonneville Power Administration to fund Willard NFH’s Coho program and the Confederated Tribes and Bands of the Yakama Nation Coho program. In 2013, Willard also began rearing URB fall Chinook with funding from the Mitchell Act. The purpose of the URB fall Chinook program at Willard NFH is to provide adults for harvest as mitigation for hydropower development on the mainstem of the Columbia River. A natural waterfall above Little White Salmon NFH prevents all adults from passing upstream to Willard NFH so broodstock need is provided by hatchery returns to Little White Salmon NFH. The current broodstock needed to meet Willard NFH’s juvenile release goal is a minimum of 500 females or approximately 2.2 million eggs and is set by the USFWS. Little White Salmon NFH successfully fulfilled this broodstock need from BY 2013 to BY 2017. In BY 2018, the program received half of their need (1,069,895 green eggs) due to low adult returns to Little White Salmon NFH which in turn needed to supplement their own program with eggs from Washington State Hatcheries (Priest Rapids and Ringold).



Figure 7. Willard NFH is located on the Little White Salmon River near Willard, WA. U.S. Fish and Wildlife Service stock photograph by Cheri Anderson

On-Station Juvenile Production

a) Egg-to-Smolt Survival

Survival objectives during the early life stages are important M&E metrics for determining whether the hatchery is equipped to meet mitigation goals being funded by the Mitchell Act. 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 Marking, Tagging, and Release Data

Mitchell Act funds support juvenile production and PIT tagging costs as well as facility maintenance. The URB fall Chinook program has a release goal of 2,000,000 juvenile fall Chinook. Since RY 2014, Willard NFH has produced a mean of 1,735,360 sub-yearling, URB fall Chinook and released into the Little White Salmon River in mid to late July which is within 13.2% of the release goal (Table 21). Approximately 6% of these juveniles were AD and CWT, and another 6% were CWT only (DIT fish). The remaining 88% of juveniles were AD only prior to release. In March and April 2020, marking was temporarily suspended due to COVID-19. Because of health and safety precautions and time constraints, it was necessary to reduce the number of fish marked with AD only to 50% prior to release. All CWT codes used are stored in the USFWS CRiS database at the CRFWCO and reported to RMIS. Since RY 2014, the facility

has achieved a mean juvenile size of 88.8 fish/lb, near the program’s goal of 70-90 fish/lb at release listed in the HGMP (USFWS 2004d).

Table 21. Annual release dates, mass marking information, total number of juveniles released, and mean juvenile size for upriver bright fall Chinook released from Willard (WI) NFH and Little White Salmon/Drano Lake (LWS) NFH (Data retrieved from CRiS 9/15/2020)

Release Year	Release Dates	Release Location	AD + CWT	CWT (DIT)	AD Only	No Mark, No CWT	Total Released	Mean Size (Fish/lb)
2014	28-Jul	WI	99,960	99,965	1,673,335	-	1,873,260	94.4
2015	1-Jul	WI	100,029	100,038	1,603,197	-	1,803,264	81.8
2016	11-Jul	WI	100,039	100,083	1,360,690	-	1,560,812	101.5
2017	12-Jul	WI	98,058	100,068	1,684,890	-	1,883,016	96.5
2018	10-Jul	WI	49,691	49,749	858,267	-	957,707	81.5
2018*	10-Jul	LWS	50,009	50,011	903,599	-	1,003,619	79.6
2019	10-Jul	WI	49,802	50,022	328,323	-	428,147	82
	10-Jul	LWS	49,917	50,011	331,391	-	431,319	85
2020	6, 7, 8-Jul	WI	50,065	50,138	509,039	446,495	1,055,737	85
2020†	7-Jul	LWS	50,015	50,068	508,946	541,609	1,150,638	81
Mean	Mid-Jul	WI & LWS	99,627	99,951	1,535,782	-	1,735,360	88.8

Off-Station Juvenile Migration and Survival

a) PIT Tagging Program

PIT tagging of juvenile URB fall Chinook prior to release allows CRFWCO staff to monitor juvenile post-release migration time and survival as juveniles migrate to the Columbia River and over BONN to the Pacific Ocean. PIT tag data is also used to determine the timing of adult returns and potential stray rates. PIT tagging of juvenile URB fall Chinook began at Willard NFH in RY 2015. Since then, the facility has annually PIT tagged a mean of 14,934 juveniles (Table 22). Approximately 6.9% of PIT tagged juveniles released at Willard NFH have been detected at BONN and 13.9% of fish released at Little White Salmon NFH/Drano Lake were detected; an average 7.9% of fish have been detected annually. On average, juveniles released at Willard NFH take approximately 16 days to reach BONN with the majority of juveniles (90th percentile) passing over BONN within 23 days after release. Juveniles released at Little White Salmon NFH/Drano Lake required approximately 14 days to reach BONN with the majority of

* Due to low adult returns at Little White NFH in 2018, Willard received half of their need (1,069,895 green eggs) for production.

† Marking was temporarily suspended in March and April 2020 Due to COVID-19. Prior to release, the number of fish marked with AD only was reduced to 50%.

juveniles (90th percentile) passing over BONN within 19 days after release. Overall, juveniles take approximately 15 days to reach BONN with the majority of juveniles (90th percentile) passing over BONN within 22 days after release. Some individuals have spent up to 89 days between Willard NFH and BONN before migrating downstream.

Predation and passage within the Little White Salmon River between Willard and Little White Salmon NFHs may be contribute to low detection rates. Beginning in 2018, a strategy to address this concern was carried out by trucking half of the juveniles down to Little White Salmon NFH/Drano Lake for release. In 2018, the first truckload was released at Little White Salmon NFH, due to low water concerns, the remaining truckloads were released 1 km downstream at Drano Lake (future releases will take place at Little White NFH or Drano Lake depending on water conditions). The detection rate for Juvenile URB fall Chinook migrating over BONN was 150% greater for fish trucked down and released at Little White Salmon NFH/Drano Lake (mean = 13.9%) than for fish released on station at Willard NFH (mean = 6.9%).

Table 22. The number of juvenile upriver bright fall Chinook PIT tagged at Willard NFH in a given release year and travel times to BONN following release from Little White Salmon/Drano Lake (LWS) and Willard (WI) NFHs (Data retrieved from PTAGIS 9/14/2020)

Release Year	Release Site	# PIT Tagged	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2015	WI	14,934	434	2.9	21	(5.5 - 287)	18	24	31
2016	WI	14,958	579	3.9	14	(2.5 - 114)	13	15	17
2017	WI	14,895	680	4.6	11	(1.5 - 103)	9	14	17
2018	WI	7,489	750	10	12	(3.5 - 116)	11	13	18
	LWS	7,483	1,246	16.7	11	(1 - 42)	11	12	14
2019	WI	7,478	516	6.9	20	(3 - 303)	17	23	30
	LWS	7,479	849	11.4	15	(3 - 68)	13	17	22
2020	WI	7,422	989	13.3	16	(2.5 - 56)	16	18	23
	LWS	7,466	1,016	13.6	15	(5 - 56)	15	18	21
Mean	WI	14,934	658	6.9	16		14	18	23
	LWS	14,934	1,037	13.9	14		13	16	19

b) Juvenile Survival

PIT tag detections can be used to estimate apparent juvenile survival after release downstream to Bonneville Dam. A PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated in order to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged

fish after passing downstream of Bonneville Dam to estimate Bonneville Dam's detection probability. This probability of detection at Bonneville Dam is then used to estimate apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 23, Figure 8). As a note in the model, the term "apparent survival" is used to indicate a tagged fish that is alive, a "mortality" is considered a fish that never migrated past Bonneville Dam. In 2020, no fish were detected at any in-river detection systems downstream of Bonneville Dam and we were unable to generate encounter histories. We will however, be able to back-calculate juvenile survival from the 2020 release based on adult returns in future years

Since release year 2015, median survival of Willard NFH URB fall Chinook released at Little White Salmon NFH or Willard NFH to Bonneville Dam averaged 0.3 (95% CI = 0.22 - 0.44). Beginning in release year 2018 (brood year 2017), half of the PIT tagged URB fall Chinook were released at Willard NFH while the other half were released at Little White Salmon NFH/Drano lake (see Special Studies section for survival differences).

Table 23. Willard NFH juvenile upriver bright fall Chinook survival from release to Bonneville Dam. Release year is one year after brood year. Estimates are median survival and lower and upper credible intervals. Survival was not calculated for the 2020 release due to lack of in-river detections downstream of Bonneville Dam. (Data retrieved from PTAGIS: 9/16/2020)

Release Year	Median Survival	95% Lower	95% Upper
2015	0.23	0.15	0.37
2016	0.23	0.16	0.38
2017	0.18	0.12	0.29
2018	0.47	0.39	0.55
2019	0.40	0.27	0.63
2020	-	-	-
Mean	0.30	0.22	0.44

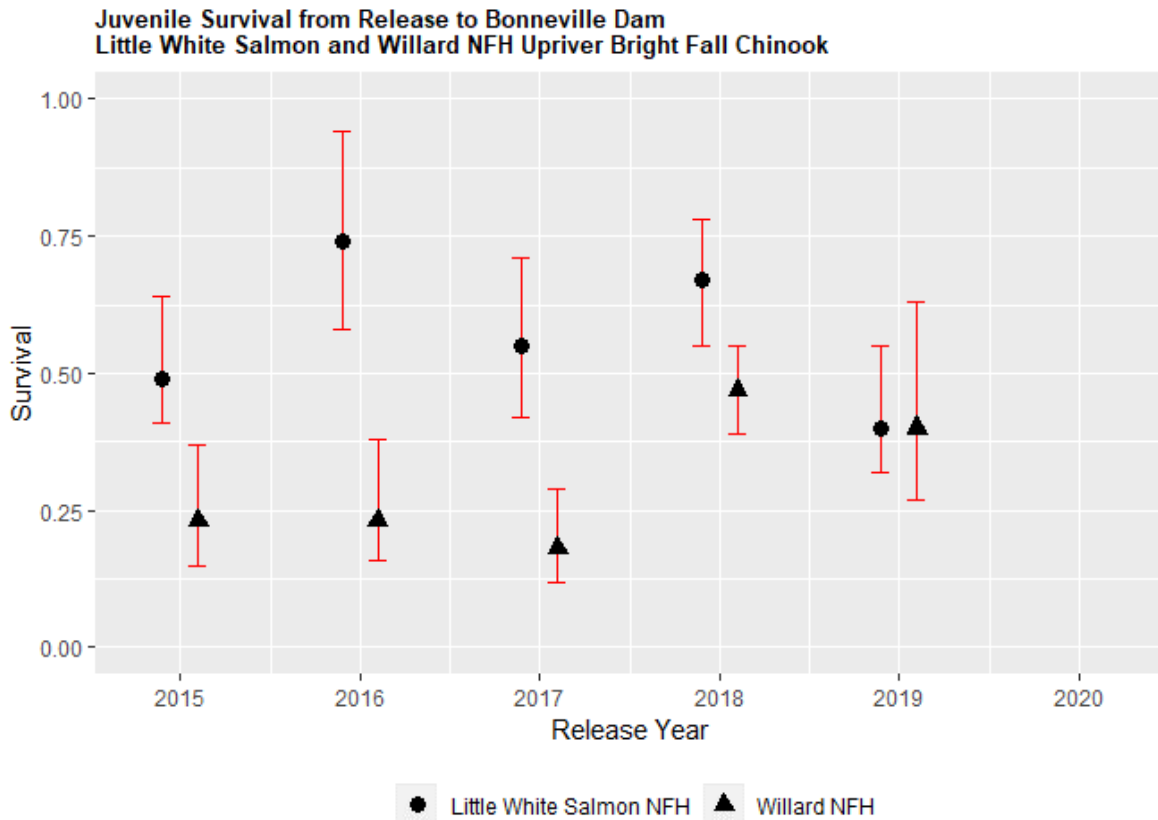


Figure 8. Estimated apparent survival of Willard and Little White Salmon NFH (Dammerman 2020) upriver bright fall Chinook (+/- 95% credible intervals)

c) Adult Returns, Harvest Data, and Smolt-to-Adult Survival

Juveniles released from Willard NFH in 2015 are expected to begin returning as adults to Little White Salmon NFH in fall 2017. On average, 8 adults (Ages 3 and 4) were detected at Bonneville Dam and/or the Little White Salmon Hatchery Ladder since 2017 (Table 24). By 2022, all fish will have reached the end of their lifespan (6 years) and stock assessment will be completed. Coded wire tag recoveries will be monitored to determine whether the Willard NFH program is meeting the smolt-to-adult survival rate of 0.32% set in the HGMP (USFWS 2004d), and successfully contributing to the 10-year average goal of 2,680 adults that the program is expected to provide for harvest.

Table 24. PIT tagged adult upriver bright fall Chinook reared at Willard NFH and detected at Bonneville Dam or the Little White Salmon NFH Hatchery Adult Ladder (Data retrieved from CRiS: 9/21/2020).

Return Year	Age 2 (Jack)	Age 3	Age 4	Age 5
2017	0	0	0	0
2018	0	1	7	0
2019	1	2	5	0
2020	2	8	7	0
Mean	1	3	5	0

d) Age Structure

Adults returning to Little White Salmon NFH will be sorted and processed at Little White Salmon NFH. Aging of these fish will be reported in the John Day/The Dalles Dam Mitigation Program report.

Special Studies

Based on the PIT tag detection data and juvenile survival estimates, URB fall Chinook released from Willard NFH had lower estimated apparent survival downstream to Bonneville Dam compared to the Little White Salmon NFH URB fall Chinook program (Figure 8). Residualism, predation, or other causes of mortality within the Little White Salmon River between the hatchery and Drano Lake may account for the low apparent survival to Bonneville Dam. A 2017 feeding study was conducted at the hatchery to investigate whether the hatchery releases were precocially maturing and residualizing within the Little White Salmon river. Few precocial fish were found in the hatchery population during the study, and rationing feed during the March to May period appeared to not be a factor influencing precociousness in the Willard program.

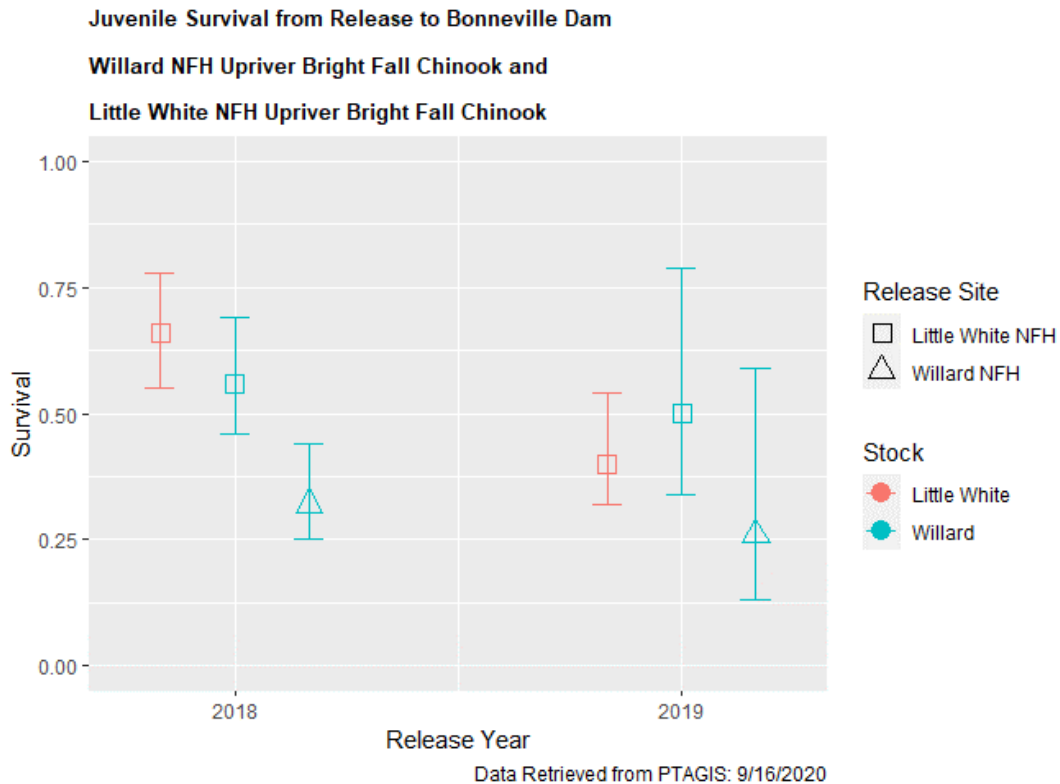
Starting with the brood year 2017 release in 2018, Willard NFH investigated trucking a portion of their release downstream to Little White Salmon NFH and Drano Lake. The objective of the study was to assess whether the low apparent juvenile survival of the Willard program was due to factors in the Little White Salmon River, between the hatchery release site and Little White Salmon NFH. For brood years 2017-2019 (release years 2018-2020) a portion of the hatchery production was trucked downstream to the Little White Salmon River at Little White NFH.

Differential PIT tagging and coded-wire tagging was conducted, and juvenile survival and subsequent adult returns will be monitored. For both release years 2018 and 2019, the juveniles trucked downstream had a higher apparent survival to Bonneville Dam than those released from the hatchery, with a median estimated survival of 32% for hatchery release vs 56% for trucked release in 2018, and 26% for hatchery release and 50% for trucked release in 2019 (Table 25, Figure 9). Juvenile survival of the trucked fish was similar to the estimated survival of the Little White Salmon NFH URB fall Chinook program. Release year 2020 will be monitored to see if the trend holds. Additionally, adult returns will be monitored to see if juvenile survival translates into adult survival, as well as if differences in stray rates of adult returns are found.

Table 25. Willard NFH juvenile upriver bright fall Chinook survival to Bonneville Dam from release at Willard NFH or trucked to Little White NFH. Release year is one year after brood year. Estimates are median survival and lower and upper credible intervals (Data retrieved from CRiS: 9/21/2020)

Release Year	Stock	Release Site	Median Survival	95% Lower	95% Upper
2018	Willard	Willard NFH	0.32	0.25	0.44
	Willard	Little White NFH	0.56	0.46	0.69
	Little White	Little White NFH	0.66	0.55	0.78
2019	Willard	Willard NFH	0.26	0.13	0.59
	Willard	Little White NFH	0.50	0.34	0.79
	Little White	Little White NFH	0.40	0.32	0.54

Figure 9. Willard NFH juvenile upriver bright (URB) fall Chinook survival to Bonneville Dam from release at Willard NFH or trucked to Little White NFH compared to Little White Salmon URB Fall Chinook survival to Bonneville Dam from release at Little White NFH. Release year is one year after brood year. Estimates are median survival and lower and upper credible intervals



Precocial Juvenile Monitoring

The Mitchell Act Program Biological Opinion (NMFS 2017) requires all Mitchell Act funded hatchery programs to monitor the rates of precocity in their hatchery releases. Specifically, the Biological Opinion requires:

- “The incidental take through ecological interactions relating specifically to residualization shall have been exceeded if the percent of yearling releases that are determined to be precocially mature exceeds 5% in any one year, or if the 5-year average exceeds 3% at any time. Section 2.8.1 Amount and Extent of Take (p. 415)”
- “Terms and Conditions # 5 b) NMFS shall require funding grantees to report to NMFS the estimated proportion of precocial male smolts released annually from each program.”

Our sampling for precocial fish included sixty fish from each program’s on station release, sampled within 2-8 weeks of their scheduled release date (Table 26). Fish were netted from the front, middle, and end of representative raceways (i.e. about 10 fish/raceway; not all raceways were sampled). During the fish health exams (lethal), the size of the gonads (i.e. testes present/not present) were also observed. Our sampling rate was based on statistics. If zero fish are precocial out of a 60 fish sample, then the precocial rate probability is less than 5% with a 95% C.I. If one fish is precocial out of a sample of 100, the probability is still <5% precocial rate with a 95% C.I. (Table 27). No precocial fish were observed during the fish health exams at any facility in 2020.

Table 26. Fish examined for precocity before release. The precocial rate is less than 5% with a 95% C.I. at all hatcheries

Sample Years	Hatchery	Sample Size	# Precocial
2018 - 2020	Carson NFH	60	0
2018 - 2020	Eagle Creek NFH	60	0
2018 - 2020	Little White Salmon NFH	60	0
2018 - 2020	Willard NFH	60	0

Table 27. Analysis of the probability that the precocial rate is less than 5% with a 95% C.I.

Sample Size	p_0.25	p_0.20	p_0.15	p_0.10	p_0.05	p_0.01
30	0	-	-	-	-	-
40	0	0	0	-	-	-
50	0	0	0	0	-	-
60	1	1	0	0	0	-
70	1	1	1	0	0	-
80	2	1	1	1	0	-
90	2	2	1	1	0	0
100	2	2	2	1	1	0

Summaries and Future Studies

Collectively, the four facilities in the Columbia River Gorge Complex with programs funded through the Mitchell Act are sufficiently meeting objectives identified in their respective HGMPs. Based on the 10-year-averages, Carson, Eagle Creek, and Little White Salmon have reached their production goals set under *U.S. v. Oregon* agreements. All but the Willard NFH URB fall Chinook program have remained within 7% of their target release number and successfully collected enough eggs or produced enough juveniles to either meet or be close to meeting their transfer goals to other programs or facilities in most years. Additionally, the programs at Carson, Eagle Creek, and Little White Salmon NFHs have been close to or exceeded their 10-year-average, smolt-to-adult survival rate goals as outlined in their respective HGMPs. In most of the past 10 years, all programs have produced enough adult returns to sufficiently meet their on-station broodstock needs except the Carson spring Chinook program in 2016 and 2018-2020, the Eagle Creek Coho program in 2012, and the Willard URB fall Chinook program in 2018. Based on the age structure of adult returns, jack rates at the facilities are low (i.e. ranging from 3-7%) which indicates the majority of adults produced by these Mitchell Act-funded programs are large, mature adults; therefore, all programs are producing adults that contribute to harvest opportunities.

a) Notable Trends

Little White Salmon NFH is evaluating a change in size at release of spring Chinook from 15 fish/lb to 20 fish/lb. Altering the fish/lb goal could free up space, reduce food costs, and allow for other rearing opportunities. Based on literature review, a change from 15 fish/lb to 20 fish/lb may not significantly affect juvenile smolting rates, adult return rates, straying, or the age structure of adult returns. However, we may see differences in juvenile travel time since larger smolts (15 fish/lb) typically migrate downstream at faster rates. Between 2018 and 2020, the average migration time to BONN for larger smolts (16 fish/lb) was 14 days which is a slightly longer average time than the mean migration time of smaller fish (20 fish/lb) which was 13 days. Additional monitoring will evaluate smolt-to-adult survival rates and mean travel time while accounting for results that may be facility and/or stock dependent.

As part of NOAA’s recent Biological Opinion (NMFS 2017), quantification of precocity (early sexual maturation) rates at facilities with Mitchell Act funded programs is required as an additional monitoring metric. At Carson, Little White Salmon, Eagle Creek, and Willard NFHs, jack rates are quantified through monitoring of adult returns. A protocol involving internally examining juvenile fish from each program just prior to release was developed to create a standardized method for documenting precocity at each facility. No precocial fish have been observed during the fish health exams at any facility since monitoring began in 2018.

b) Future M&E Studies

Additional PIT tag detection data for the fish reared at Carson, Little White Salmon, and Willard NFHs can provide insight on minijack rates and precocity but has not been actively monitored. Therefore, a future objective for the M&E program is to develop a standardized protocol for quantifying minijack rates in order to accurately predict and monitor precocial male maturation at each of the facilities. Monitoring of PIT tag releases will be used to estimate the number of mini-jack/precocial fish either a) migrating back upstream over BONN during the year of release, or b) returning to the hatchery during the year of release.

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Data used in this report was downloaded from CRiS maintained at the CRFWCO, RMIS, and PTAGIS. Hatchery personnel at Carson, Eagle Creek, Little White Salmon, and Willard NFHs collected data on release dates, adult returns, and annual number of juveniles released from the facilities. Marking and biosampling crews from the USFWS documented the number of adult returns as well as adipose fin-clipped, coded-wire tagged, and PIT-tagged juveniles prior to release. Funding for M&E of these hatchery programs was provided by the USFWS and funds from the Mitchell Act distributed by NOAA Fisheries.

Disclaimer:

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service. The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

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