

Monitoring and Evaluation of Mitchell Act-Funded National Fish Hatcheries in the Columbia River Gorge Complex - 2023 Annual Report

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

February 26, 2024

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 twelve 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.

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.

The correct citation for this report is:

Silver B.P., T. Gilmore, S. Lazzini, K. Beard, J. Baker, D. Hand, J. Rivera, J. Voeltz. 2024. Monitoring and Evaluation of Mitchell Act-Funded National Fish Hatcheries in the Columbia River Gorge Complex, 2023 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, WA. 54 pps.

Table of Contents

Introduction	5
Carson NFH: Spring Chinook Program	6
On-Station Juvenile Production	7
a) Egg-to-Smolt Survival	7
b) Juvenile Marking, Tagging, and Release Data.....	7
c) Transfer Data	9
Off-Station Juvenile Migration and Survival	10
a) PIT Tagging Program	10
b) Juvenile Survival.....	11
c) Adult Returns, Harvest Data, and Smolt-to-Adult Survival	13
d) Age Structure	17
Special Studies.....	18
Eagle Creek NFH: Coho Program	19
On-Station Juvenile Production	20
a) Egg-to-Smolt Survival	20
b) Juvenile Marking, Tagging, and Release Data.....	20
c) Transfer Data	21
Off-Station Juvenile Migration and Survival	23
a) PIT Tagging Program	23
b) Adult Returns, Harvest Data, and Smolt-to-Adult Survival	23
c) Age Structure.....	24
Special Studies.....	26
Little White Salmon NFH: Spring Chinook Program	26
On-Station Juvenile Production	27
a) Egg-to-Smolt Survival	27
b) Juvenile Marking, Tagging, and Release Data.....	28
c) Transfer Data	29
Off-Station Juvenile Migration and Survival	30
a) PIT Tagging Program	30
b) Juvenile Survival.....	31
c) Adult Returns, Harvest Data, and Smolt-to-Adult Survival	33
d) Age Structure	37
Special Studies.....	38

Willard NFH: Upriver Bright Fall Chinook Program	38
On-Station Juvenile Production	39
a) Egg-to-Smolt Survival	39
b) Juvenile Marking, Tagging, and Release Data.....	40
Off-Station Juvenile Migration and Survival	42
a) PIT Tagging Program	42
b) Juvenile Survival.....	43
c) Adult Returns, Harvest Data, and Smolt-to-Adult Survival.....	45
d) Age Structure	46
Special Studies.....	46
Precocial Juvenile Monitoring.....	49
Summaries and Future Studies.....	50
Acknowledgements	51
Appendix A: Other Species Handled	52
Appendix B: Annual Hatchery Notes	52
Carson NFH: Spring Chinook	52
Eagle Creek NFH: Coho.....	52
Little White Salmon NFH: Spring Chinook	52
Willard NFH: Upriver Brights.....	52
References	53

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 2016; NMFS 2017; USFWS 2015) and consistent with the production tables in the 2018-2027 *United States v. Oregon* Management Agreement. 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 twelve 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.

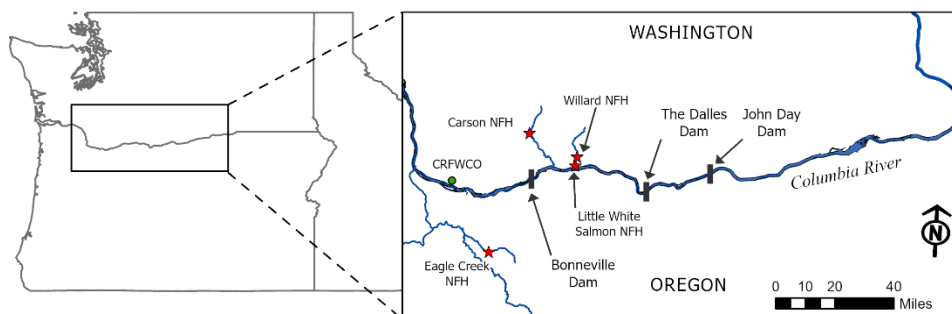


Figure 1. The Columbia River (blue) and the four Mitchell Act funded NFHs of the Columbia River Gorge Complex: Willard, Little White Salmon, Eagle Creek, and Carson.

For previous Columbia River Fish and Wildlife Program Office reports, please see:
<https://www.fws.gov/office/columbia-river-fish-and-wildlife-conservation/reports>

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.

In Brood Year (BY) 2021, the facility increased its annual release goal from 1,170,000 to 1,420,000 yearling spring Chinook salmon into the Wind River contingent upon filling production needs for CTUIR's Walla Walla Hatchery program. This increase of 250,000 yearlings is a result of a change in transfer responsibilities to the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) from yearlings to gametes for CTUIR's new Walla Walla Hatchery. Also beginning in BY 2021, production was increased by an additional 100,000 spring Chinook to benefit Southern Resident Killer Whales (SRKW) for a total on-station release target of 1,520,000. In addition to the on-station release, Carson also provides 250,000 eyed SCS eggs to the WDFW for the Touche River Program.

Broodstock need for the spring Chinook program at Carson NFH is a minimum of 1,800 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. Beginning in 2021, broodstock goals were adjusted to spawn an additional 100 females to supplement SRKW production.



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. Throughout the rearing cycle, the hatchery has a maximum Flow Index < 1.0 and Density Index < 0.25 to minimize disease risk (USFWS 2004a). 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. 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 1,197,553 juveniles being annually released since release year (RY) 2012. The mean release for years 2012-2022 was 1,170,593 which is within 0.05% of the 1.17 million release goal; the 2023 release was 1,494,123 which included the production increase of BY 21 as well as smolts produced for SRKW.

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 2012, the facility has achieved a mean juvenile size of 20.4 fish/lb at the time of release. All juvenile fish released from the facility are adipose-clipped (AD), and 87,500 (approximately 8%) also receive a coded-wire tag (CWT). 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 data, 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. Brood year is two years before release year. Data retrieved from CRiS SR80s File: 11/6/2023

Release Year	Release Dates	River Water Temperature at Release (°C)	AD + CWT	AD Only	Total Released	Mean Size (Fish/lb)
2012	16-Apr	5.7	139,276	987,089	1,126,365	18.4
2013	17-Apr	6.1	138,802	985,240	1,124,042	18.7
2014*	16-Apr	6.7	135,778	991,234	1,127,012	18.3
2015	15-Apr	5.5	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	4.7	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	5.0	83,588	1,167,820	1,251,408	19.9
2020	10-Apr	8.0	85,983	985,644	1,071,627	19.0
2021†	12-Apr	6.6	79,342	1,138,029	1,217,371	18.6
2022	12-Apr	4.8	84,090	1,078,907	1,162,997	22.8
2023‡	11-Apr	6.7	87,015	1,407,108	1,494,123	24.5
Average		6.0	93,263	1,104,290	1,197,553	20.4

*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.

†In 2021, there is a marking/release discrepancy for tag code 05-45-91. CRFWCO marking records indicate 50,024 fish were CWT tagged, Carson NFH's records indicate they released 42,996 CWT tagged fish. After discussions with the hatchery and review of the CRiS files, we were still unable to identify the cause for the tagged fish release 7,028 lower than the initial tagging number. The total number of AD+CWT in 2021 includes the 42,996 CWT tagged fish from Carson NFH's release records and the CRiS database, not the marking record.

‡ RY23 reflects the BY21 increased release goal from 1.17M to 1.42M. Also in 2023, approximately 87,500 juveniles were lost due to predation before release.

c) Transfer Data

The facility also transferred approximately 250,000 yearling spring Chinook to the CTUIR for reintroduction of spring Chinook to the Walla Walla River each year until 2022 (Table 2). In 2021, a spring Chinook hatchery was completed at the site of an existing adult holding and spawning facility on the South Fork Walla Walla River near Milton-Freewater in Umatilla County, Oregon. The hatchery is managed and operated by the CTUIR. Beginning with BY 2021, Carson NFH shifted from transferring yearlings to providing approximately 250,000 gametes (eyed eggs) for the hatchery to incubate and rear if needed. Any release information after transfer would be reported to RMIS from the CTUIR.

Since 2018, 250,000 spring Chinook gametes have been provided to the Washington Department of Fish and Wildlife’s Lyons Ferry Hatchery for eventual smolt release into the Touchet River per the *United States v. Oregon* agreement. As per *United States v. Oregon* agreement, spring Chinook transfers will be filled from Carson NFH. In low return years to Carson NFH, Little White Salmon NFH will be the secondary source to assist in transfers agreed to as per *United States v. Oregon*. Carson NFH will continue to support these reintroduction programs until transfers are no longer needed.

Table 2. Annual transfer dates, marking and tagging information, and total number of spring Chinook (yearling and gametes) transferred to the Walla Walla River from Carson NFH (* fulfilled by Little White Salmon NFH). Data retrieved from CRiS SR80s File: 11/28/2023

Transfer Year	Transfer Dates	Transfer Location	AD + CWT	AD Only	Gametes	Total Yearlings Transferred
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
2021	2-Apr	Walla Walla	48,236	197,266	-	245,502
2021	19, 26-Aug	Walla Walla	-	-	350,000	-
2022	25-Mar	Walla Walla	49,781	199,396	-	249,177
2022	18-Aug	Walla Walla	-	-	370,000	-
2023*	2-Oct	Walla Walla	-	-	344,000	-
Average			49,376	198,088	354,667	247,464

Off-Station Juvenile Migration and Survival

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

a) PIT Tagging Program

PIT tagging provides tracking data in real-time 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 the Columbia Basin PIT Tag Information System (PTAGIS) regional database. Staff at CRFWCO use this database 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. 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 (Table 3). 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 an average 18,432 juveniles annually since RY 2012. 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. An average 2,025 PIT tagged juveniles have been detected annually at BONN for an average detection rate of 11.2%. Juvenile travel time to BONN after release is approximately 13 days with some juveniles spending up to 74 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 Dam (BONN) following release from Carson NFH. Data retrieved from PTAGIS: 11/6/2023

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Mean	Median	Range	75th	90th
2012	29,479	2,563	8.7	11	8	(0.5 - 74)	18	26
2013	29,580	3,574	12.1	16	15	(1.5 - 43)	20	24
2014	29,399	2,873	9.8	16	17	(1.5 - 57)	23	28
2015	14,734	2,263	15.4	15	17	(1 - 47)	20	21
2016	14,019	1,043	7.4	10	9	(1 - 44)	14	19
2017	14,967	1,137	7.6	11	9	(1 - 45)	17	24
2018	14,987	1,461	9.7	10	8	(1 - 49)	17	24
2019	14,973	1,570	10.5	10	8	(1 - 50)	14	19
2020	14,981	2,138	14.3	12	10	(1.5 - 36)	18	20
2021	14,995	1,986	13.2	10	9	(1.5 - 38)	13	19
2022	14,986	1,798	12.0	19	19	(1.5 - 49)	24	33
2023	14,082	1,898	13.5	16	17	(1 - 55)	22	26
Average	18,432	2,025	11.2	13	12		18	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 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, a 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). The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years. This is due to the addition of adult returns to the detection histories (as “downstream of Bonneville” detections), which in turn decreases the variance. Since recent years do not have adult returns, or at least not the full age complement of adult returns, the more recent estimates have larger variances. In subsequent years, as more adults from a brood year return, the variance of the estimates should decrease. 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. Improvements to PIT tag antennas at Bonneville Dam and installation of additional interrogation sites in the Columbia

River Estuary will increase the likelihood of juvenile detections, thus improving survival estimates.

Since release year 2011, median spring Chinook survival from release at Carson NFH to Bonneville Dam averaged 0.78.

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. Survival is not calculated for the 2023 release due to lack of in-river detections downstream of Bonneville Dam at this time. Data retrieved from PTAGIS: 12/11/2023

Release Year	Median Survival	95% Lower	95% Upper
2011	0.70	0.60	0.81
2012	0.88	0.76	1.00
2013	0.86	0.76	0.96
2014	0.80	0.70	0.90
2015	0.71	0.65	0.77
2016	0.78	0.63	1.00
2017	0.96	0.75	1.00
2018	0.87	0.66	1.00
2019	0.54	0.44	0.67
2020	0.90	0.78	1.00
2021	0.80	0.66	1.00
2022	0.61	0.48	0.80
Average	0.78		

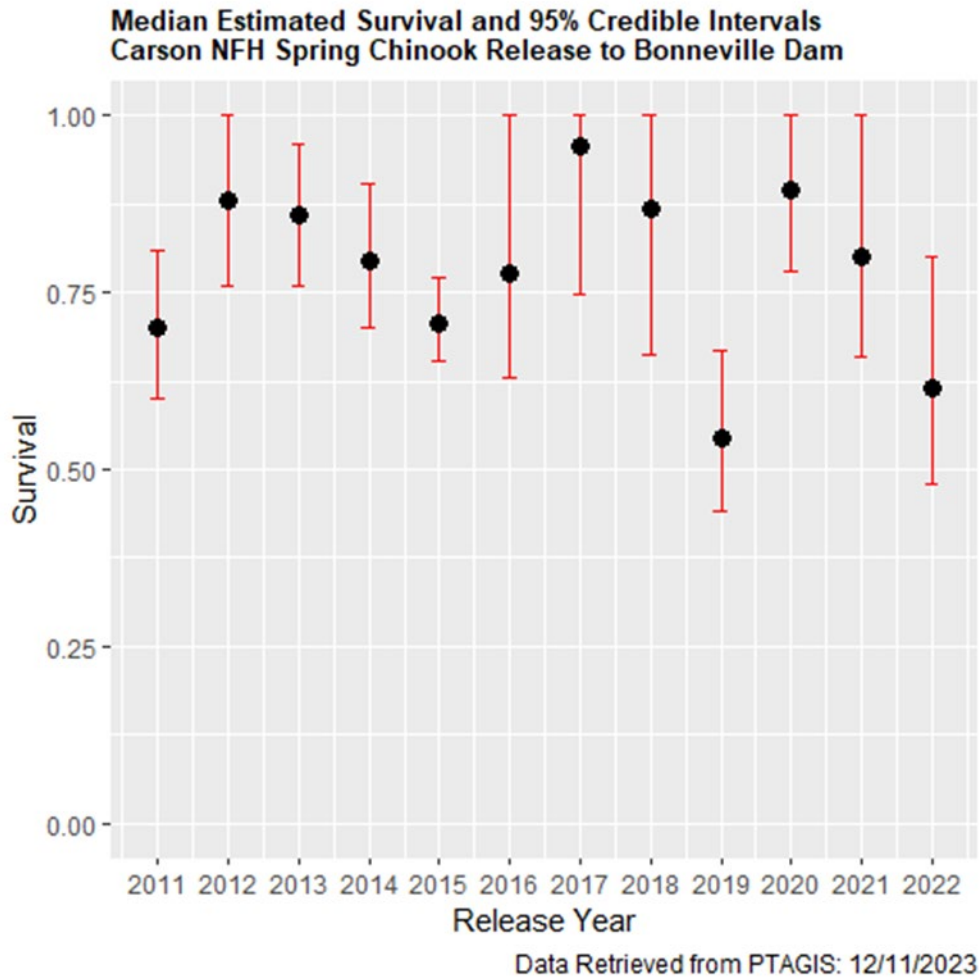


Figure 3. Carson NFH juvenile spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals

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) 2005. Collectively, the facility has produced an average 5,808 adults annually from BY 2005 to BY 2016 resulting in an average smolt-to-adult survival rate of 0.48% which is near the 10-year average goal of 0.5% set in the facility’s Hatchery and Genetic Management Plan (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 (rounded to the nearest one-hundredth). Complete return data for brood years 2017 and 2018 are not yet available and not included in the average. Data downloaded from RMIS TS1-Rec Report: 1/3/2024

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
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	3,454	0	5	7,603	0.68
2012	3,341	3,763	0	0	7,104	0.63
2013	2,007	1,525	16	96	3,644	0.31
2014	1,490	1,487	9	0	2,986	0.25
2015	3,968	407	0	0	4,375	0.35
2016	1,569	696	0	0	2,265	0.19
2017	2,838	646	0	0	3,484	0.28
2018	3,795	3,291	9	126	7,221	0.67
Average	2,854	2,939	7	8	5,808	0.48

An average 143 CWTs have been recovered each year at Carson NFH since 2012 (Table 6). The Carson NFH spring Chinook program accounts for 99.2 percent of all recoveries; spring Chinook from other programs include Little White Salmon NFH (<0.6%) and Willard NFH (<0.2).

Table 6. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Carson NFH 2012 - 2023. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from CRiS CWT Recovery Report: 1/4/2024

Return Year	CWT Recoveries	Hatchery Origin	% of Total CWT Return
2012	94	Carson NFH	98.7
	1	Willard NFH	1.3
2013	213	Carson NFH	100.0
2014	280	Carson NFH	98.9
	1	L White Salmon NFH	0.4
	2	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
2020	52	Carson NFH	100.0
2021	163	Carson NFH	93.0
	1	L White Salmon NFH	7.0
2022	171	Carson NFH	99.0
	1	L White Salmon NFH	1.0
2023	105	Carson NFH	98.0
	2	L White Salmon NFH	2.0
Average	143		

Since Return Year 2012, spring Chinook jacks (Age 3 fish, the majority of which are male; all Chinook Age-3 fish will be referred to as “jacks” regardless of sex in this report) 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 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 32% 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). No Carson NFH ladder data in 2023 due to equipment malfunction. Data retrieved from PTAGIS: 11/6/2023

Return Year	Bonneville Median Passage Date	Bonneville First Detection Date	Bonneville Last Detection Date	Bonneville # of Fish Detected	Bonneville Expansion	Hatchery Ladder Median Passage Date	Hatchery Ladder First Detection Date	Hatchery Ladder Last Detection Date	Hatchery Ladder # of Fish Detected	Ladder Expansion	Actual Return
2012	May-09	Apr-13	May-20	130	10,802	Jun-10	May-24	Aug-06	21	1,739	1,612
2013	May-01	Apr-03	Jun-07	96	3,672	May-19	May-05	Aug-04	27	1,022	1,913
2014	Apr-30	Mar-26	Jul-21	178	6,789	May-30	May-07	Jul-24	43	1,640	2,416
2015	Apr-23	Mar-23	May-28	306	11,634	May-22	Apr-30	Jun-18	50	1,901	2,841
2016	May-01	Apr-02	Jul-01	181	7,055	Jun-01	May-08	Aug-13	33	1,264	1,318
2017	May-16	May-01	Jul-04	58	4,490	May-31	May-24	Jun-06	9	708	1,596
2018	May-09	Apr-24	Jun-12	32	2,682	May-25	May-20	Jun-07	8	668	1,042
2019	May-07	Apr-17	Jul-30	29	2,444	May-31	May-21	Aug-01	11	929	742
2020	May-02	Mar-28	May-26	35	2,800	Jun-05	May-02	Jun-12	7	557	742
2021	May-04	Apr-19	Jul-18	62	5,081	May-17	May-10	Jun-05	24	1,969	2,744
2022	May-03	Mar-24	May-30	144	10,339	Jun-11	Jun-07	Jun-27	15	654	2,351
2023	May-12	Apr-02	Jun-01	74	5,975	-	-	-	-	-	1,843
Average	May-04	Apr-07	Jun-18	110	6,147	May-29	May-14	Jul-06	23	1,187	1,763

d) Age Structure

Monitoring adult returns (> Age-2) 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 2012, approximately 90% of adults have returned to the facility at Age-4 (Table 8: return year; Table 9: brood year). Additionally, almost 6% have returned as jacks at Age-3, and 4% have returned at Age-5. No CWT recoveries or scale samples from Age-6 returns have been documented. The facility has an average 1,763 adult returns each year.

Table 8. Age structure of adult spring Chinook returns to Carson NFH based on scale analysis and the estimated proportion of the total return (%) by return year. Adults referred to as Age-3 (jacks) are in their second year at migration, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Data retrieved from CRiS AGECOMP Report: 11/6/2023

Return Year	Age-3	Age-3 Proportion (%)	Age-4	Age-4 Proportion (%)	Age-5	Age-5 Proportion (%)	Age-6	Age-6 Proportion (%)	Total # Adults
2012	26	2	1,437	89	149	9	0	0	1,612
2013	224	12	1,506	79	183	10	0	0	1,913
2014	198	8	2,124	88	94	4	0	0	2,416
2015	139	5	2,670	94	32	1	0	0	2,841
2016	41	3	1,173	89	104	8	0	0	1,318
2017	77	5	1,467	92	52	3	0	0	1,596
2018	56	5	973	93	13	1	0	0	1,042
2019	74	10	655	88	13	2	0	0	742
2020	15	2	716	96	11	1	0	0	742
2021	180	7	2,535	92	29	1	0	0	2,744
2022	115	5	2,194	93	42	2	0	0	2,351
2023	98	5	1,709	93	36	2	0	0	1,843
Average	104	6	1,597	90	63	4	0	0	1,763

Table 9. Age structure of adult spring Chinook returns to Carson NFH based on scale analysis and the estimated proportion of the total return (%) by brood year. Adults referred to as Age-3 (jacks) are in their second year at migration, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Returns for brood years 2018 - 2020 are not yet complete. Data retrieved from CRiS AGECOMP Report: 11/6/2023

Brood Year	Age-3	Age-3 Proportion (%)	Age-4	Age-4 Proportion (%)	Age-5	Age-5 Proportion (%)	Age-6	Age-6 Proportion (%)	Total # Adults
2006	412	9	4,114	87	186	4	0	0	4,712
2007	196	6	2,733	89	149	5	0	0	3,078
2008	176	10	1,437	80	183	10	0	0	1,796
2009	26	2	1,506	93	94	6	0	0	1,626
2010	224	9	2,124	89	32	1	0	0	2,380
2011	198	7	2,670	90	104	3	0	0	2,972
2012	139	10	1,173	86	52	4	0	0	1,364
2013	41	3	1,467	96	13	1	0	0	1,521
2014	77	7	973	92	13	1	0	0	1,063
2015	56	8	655	91	11	2	0	0	722
2016	74	9	716	87	29	4	0	0	819
2017	15	1	2,535	98	42	2	0	0	2,592
2018	180	-	2,194	-	36	-	-	-	-
2019	115	-	1,709	-	-	-	-	-	-
2020	98	-	-	-	-	-	-	-	-
Average	135	7	1,858	90	73	4	0	0	2,054

Special Studies

Staff at the CRFWCO conducted a study (brood years 2009-2012) evaluating the effects of PIT tagging on post-release survival (Brignon et al., 2011). 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 discussions about the monitoring and potential eradication of Brook Trout from Tyee Springs. In 2019, CRFWCO and hatchery staff conducted a multi-day mark-recapture in Tyee 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 Tyee Springs (Schill et al. 2016). Since 2020, CRFWCO staff have removed 6,740 brook trout from

Tyee Springs and stocked 924 adipose clipped YY-male brook trout and 5,594 adipose clipped and PIT tagged YY-male brook trout (J. Poirier, personal communication, October 3, 2023).

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.

The facility has propagated winter-run steelhead and spring Chinook under a Memorandum of Agreement (MOA) with the Oregon Department of Fish and Wildlife (ODFW). Due to the need to complete critical deferred maintenance infrastructure projects at the hatchery, the USFWS was unable to extend the MOA for ODFW fish production at Eagle Creek NFH and it expired in May 2021. Discontinuing the MOA with ODFW will terminate rearing winter steelhead and spring Chinook at Eagle Creek NFH for release into Eagle Creek. In fall of 2018, ODFW moved the release location of their spring Chinook program back to the Clackamas state fish hatchery.



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. Throughout the rearing cycle, the hatchery has a maximum Flow Index < 1.5 and Density Index < 0.54 to minimize disease risk (USFWS 2004b). 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

b) Juvenile Marking, Tagging, and Release Data

There is a cost share between Bonneville Power Administration and Mitchell Act for the Eagle Creek NFH Coho program. Bonneville Power Administration funds the Confederated Tribes and Bands of the Yakama Nation Coho PIT tagging and marking program at Eagle Creek; Mitchell Act funds support juvenile production 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 10) with an average 354,605 juveniles released annually since RY 2012 which is within 1.3% 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 preferred size of 15 fish/lb has been targeted to reduce excessive jack rates (Coho Age 2 fish, the majority of which are male; all Coho Age-2 fish will be referred to as “jacks” regardless of sex in this report) with high body fat percentages. Since RY 2012, the facility has achieved a mean juvenile size of 18.4 fish/lb at the time of release. Of the juvenile fish released from the facility, 25,000 (approximately 7%) are AD and CWT marked. Another 25,000 (approximately 7%) are 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 10). All CWT codes are stored in the USFWS CRiS database at the CRFWCO and reported annually to RMIS.

Table 10. Annual release data, marking and tagging information, total number of juveniles released, and mean juvenile size for Coho released from Eagle Creek NFH. Brood year is two years before release year. Data retrieved from CRiS SR80s File: 11/6/2023

Release Year	Release Dates	River Water Temperature at Release (°C)	AD + CWT	CWT (DIT)	AD Only	No Mark, No CWT	Total Released	Mean Size (Fish/lb)
2012	1-May	-	24,534	24,312	295,402	752	345,000	16.8
2013	18-Apr	-	25,006	23,656	332,557	1,350	382,569	16.7
2014	16-Apr	-	24,084	22,594	320,145	1,169	367,992	16.0
2015	3-Apr	6.0	14,905	23,654	292,447	227	331,233	16.6
2016	30-Mar	6.6	23,515	23,326	261,628	187	308,656	15.8
2017	11-Apr	5.9	24,301	21,603	298,312	0	344,216	18.7
2018	7-Apr	5.9	24,513	24,416	364,297	97	413,323	19.9
2019	26-Mar	5.3	23,694	23,589	297,626	184	345,093	21.1
2020	24-Mar	4.3	22,718	22,316	313,658	1,305	359,997	23.0
2021	20-Mar	4.5	24,117	23,893	310,972	333	359,315	22.0
2022	13-Apr	4.2	48,433	23,852	270,073	683	343,041	17.5
2023	18-Apr	4.9	23,034	23,063	306,770	1,955	354,822	17.3
Average		5.3	25,238	23,356	305,324	687	354,605	18.4

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 (Table 11). Until BY22, these transferred fish have marked and/or tagged by CRFWCO staff (30K AD/CWT, 30K DIT, 10K PIT) prior to transfer. Release information after transfer is reported to RMIS by the Confederated Tribes and Bands of the Yakama Nation or Nez Perce Tribe. Beginning with BY23, these fish will no longer be tagged at Eagle Creek NFH. Eagle Creek NFH will continue to support these reintroduction programs until transfers are no longer needed.

For BY22, the Yakama transfer changed from a 500k early run stock to a 180k early run and a 300k late run. This was to be a three-year pilot program to bring late run coho back to the Yakama Basin. The late run stock came from Ringold Hatchery, a Type N Coho facility and incubated at Prosser Hatchery until passing a health inspection and reaching the eye-up stage. The eyed eggs were then transferred to Eagle Creek NFH to be hatched, reared, marked, and tagged before returning to Prosser Hatchery for acclimation and release as yearlings. Due to poor egg quality and low survival post transfer, the Yakama program has reverted to the 500k early run stock as in the past.

In BY23, over uncertainties regarding Mitchell Act operational funding, the Nez Perce Tribe moved their production to Dworshak NFH. USFWS is working with partners to find funding to utilize the space vacated by NPT.

Table 11. Number of juvenile Coho transferred to the Nez Perce Tribe and Yakama Nation programs. Data retrieved from CRiS SR80s: 11/6/2023

Transfer Year	Transfer Date	Transfer To	Total Transferred	Mean Size (Fish/lb)
2012	3/6/2012	Nez Perce	540,703	19.6
	3/13/2012	Yakama	377,817	24
2013	3/4/2013	Nez Perce	523,181	19.8
	3/11/2013	Yakama	435,444	19.7
2014	3/3/2014	Nez Perce	479,090	19.1
	3/11/2014	Yakama	498,098	19.1
2015	3/2/2015	Nez Perce	556,364	19.1
	3/9/2015	Yakama	511,776	18.1
2016	3/12/2016	Nez Perce	510,155	19.4
	3/9/2016	Yakama	495,102	18.8
2017	3/10/2017	Nez Perce	252,830	21.1
	3/7/2017	Yakama	312,677	21.3
2018	2/28/2018	Nez Perce	603,295	25.2
	3/5/2018	Yakama	600,134	28
2019	2/27/2019	Nez Perce	558,470	22.2
	3/11/2019	Yakama	779,152	24.66
2020	3/3/2020	Nez Perce	506,998	23
	3/10/2020	Yakama	499,585	24
2021	3/2/2021	Nez Perce	615,736	24.2
	3/8/2021	Yakama	534,042	24
2022	3/2/2022	Nez Perce	555,633	22.1
	3/7/2022	Yakama	505,345	22
2023	3/2/2023	Nez Perce	581,559	22.8
	3/7/2023	Yakama	537,473	24.3
Average		Nez Perce	523,668	21.5
		Yakama	507,220	22.3

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 2012 (Table 12).

Table 12. 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: 11/6/2023

Release Year	Tag Dates	# PIT Tagged
2012	19, 20-Jan 2012	9,991
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
2017*	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
2021	16, 17, 18-Nov 2020	9,987
2022	15, 16-Nov 2021	9,996
2023	21, 22-Nov 2022	9,984
Average		9,563

*Approximately 5K juveniles PIT tagged given low juvenile numbers

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 has fluctuated since BY 2007 (Table 13). Approximately 18% of adults are harvested in the Pacific Ocean as opposed to the 13% harvested in the Columbia River Basin. The facility has produced an average 5,713 adults annually since BY 2007 with a smolt-to-adult survival rate of 1.6%; the 10-year average goal is set at 2% for the Coho program in the HGMP (USFWS 2004b).

Table 13. 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 (rounded to the nearest one-hundredth). Data downloaded from RMIS TS1-Rec Report: 1/3/2024

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
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	57	21,531	5.6
2012	2,955	392	643	0	3,990	1.1
2013	4,878	745	318	21	5,962	1.8
2014	4,016	1,246	1,125	12	6,399	2.1
2015	2,273	718	1,224	0	4,215	1.2
2016	3,906	1,268	1,865	0	7,039	1.7
2017	3,109	326	168	0	3,603	1.0
2018	4,484	979	2,252	0	7,715	2.1
Average	3,932	733	1,036	12	5,713	1.6

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 (~91%) of adult Coho return as Age-3 fish with a small proportion (~9%) of fish returning as jacks at Age-2 (Table 14). Zero returns Age-4 or greater have been documented. The facility has an annual average of 6,147 adult returns to the facility since Return Year 2012.

Table 14. Age structure of adult coho returns to Eagle Creek NFH based on scale analysis and the estimated proportion of the total return (%) by *return year*. 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. Data retrieved from CRiS AGECOMP: 12/18/2023

Return Year	Age-2	Age-2 Proportion (%)	Age-3	Age-3 Proportion (%)	Age-4	Age-4 Proportion (%)	Total # Adults
2012	217	16	1,129	84	0	0	1,346
2013	366	9	3,538	91	0	0	3,904
2014	289	2	15,725	98	0	0	16,014
2015	311	14	1,930	86	0	0	2,241
2016	277	9	2,936	91	0	0	3,213
2017	158	4	4,331	96	0	0	4,489
2018	236	6	3,542	94	0	0	3,778
2019	130	3	3,604	97	0	0	3,734
2020	895	15	5,014	85	0	0	5,909
2021	765	7	9,824	93	0	0	10,589
2022	430	5	8,871	95	14	< 0.01	9,315
2023	1,296	14	7,933	86	0	0	9,229
Average	448	9	5,698	91	1	0	6,147

Table 15. Age structure of adult coho returns to Eagle Creek NFH based on scale analysis and the estimated proportion of the total return (%) by brood year. 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. Returns for brood years 2020 and 2021 are not yet complete. Data retrieved from CRiS AGECOMP: 12/18/2023

Brood Year	Age-2	Age-2 Proportion (%)	Age-3	Age-3 Proportion (%)	Age-4	Age-4 Proportion (%)	Total # Adults
2010	217	6	3,538	94	0	0	3,755
2011	366	2	15,725	98	0	0	16,091
2012	289	13	1,930	87	0	0	2,219
2013	311	10	2,936	90	0	0	3,247
2014	277	6	4,331	94	0	0	4,608
2015	158	4	3,542	96	0	0	3,700
2016	236	6	3,604	94	0	0	3,840
2017	130	3	5,014	97	0	0	5,144
2018	895	8	9,824	92	14	0	10,733
2019	765	8	8,871	92	0	0	9,636
2020	430	-	7,933	-	-	-	-
2021	1,296	-	-	-	-	-	-
Average	448	7	6,113	93	1	0	6,297

Special Studies

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 publication from these evaluations.

A study was conducted in 2021 to examine the morphological variation (i.e., fineness ratio) of hatchery-reared Coho with different levels of predator burden (exposed versus netted). The exposed outer raceways had higher loss than the netted inner raceways based on fish count. However, sizing was relatively similar among the hatchery subgroups; likely due to similar pond loads and feeding amount. Morphology of the hatchery-reared populations were also compared to the wild North Fork Eagle Creek Coho population. The wild population was significantly different from the hatchery population and had greater morphological variation. The majority of adults returned this past year as 3-year-olds. Analysis is pending.

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. Please see https://www.fws.gov/sites/default/files/documents/2022_JDM-Annual-Report_Final_3-29-2023.pdf for more information.

In 2021, the annual release goal into the Little White Salmon River was increased from a 1,000,000 Mitchell Act funded release to an up to 1,650,000 yearling spring Chinook release to accommodate annual SRKW production. These fish will be released in 2023. 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. Starting in BY20, production was increased to benefit SRKW (400,000 in BY20, 650,000 in BY21 and BY22, and 300,000 in BY23). To accommodate the increase in production, 575 females were spawned, an increase of 215 females from 360.



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. Throughout the rearing cycle, the hatchery has a maximum Flow Index < 1.5 and Density Index < 0.25 to minimize disease risk (USFWS 2004c). 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. Since RY 2012, the program has released an annual mean of 1,138,783 yearling spring Chinook into the Little White Salmon River in mid-April (Table 16). The mean release for years 2012-2022 was 1,106,155 which is within 11% of the 1 million release goal; the 2023 release was 1,497,692 which is within 9.2% of the 1.65 million release goal. 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% (100,000) of juveniles are AD and CWT. The remaining 90% of fish are AD only just prior to release (Table 16). All CWT codes are stored in the CRiS database and reported to RMIS. Since RY 2012, the facility has achieved a mean juvenile size of 17.8 fish/lb, the current release goal is 20 fish/lb (see special studies section).

Table 16. Annual release data, 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. Brood year is two years before release year. Data retrieved from CRis SR80s File: 11/6/2023

Release Year	Release Site	Release Dates	River Water Temp. (°C)	AD + CWT	AD Only	Total Released	Mean Size (Fish/lb)
2012	LWS	19-Apr	6.7	74,304	684,857	759,161	15
2012	WI	19-Apr	5.0	24,677	221,827	246,504	15.4
2013	LWS	18-Apr	6.1	73,511	652,214	725,725	15.3
2013	WI	18-Apr	5.0	24,266	271,816	296,082	15.5
2014	LWS	17-Apr	6.1	73,487	802,166	875,653	15.3
2014	WI	17-Apr	5.0	9,738	112,997	122,735	16.5
2015	LWS	16-Apr	7.2	73,946	925,259	999,205	14.8
2016	LWS	14-Apr	6.9	73,539	1,250,120	1,323,659	14.9
2017	LWS	12-Apr	6.3	74,475	1,008,064	1,082,539	15.8
2018*	LWS	10-Apr	7.0	76,336	1,001,798	1,078,134	21.4
2019	LWS	11-Apr	7.1	105,966	935,131	1,041,097	19
2020	LWS	13-Apr	4.3	89,646	999,874	1,089,520	18.8
2021	LWS	12-Apr	4.5	99,270	1,047,838	1,147,108	20.9
2022**	LWS	11-Apr	3.7	58,249	1,322,329	1,380,578	20.6
2023‡	LWS	11-Apr	6.3	99,470	1,398,222	1,497,692	21.4
Annual Averages	LWS/WI	Mid-Apr	5.8	85,907	1,052,876	1,138,783	17.8

*Beginning with RY18, the LWS SCS program shifted production to 20 fish/lb. A portion of fish were reared to 15 fish/lb (target goal) to monitor differences in downstream migration and/or returns until 2020

**380,578 are credited to the SRKW program in RY22

‡ RY23 reflects the BY21 increased release goal from 1M to 1.65M yearling spring Chinook

c) Transfer Data

Little White Salmon NFH does not transfer any spring Chinook yearlings as part of the Mitchell Act funded program. In addition to spring Chinook, approximately 2.2 million URB fall Chinook eggs are provided to Willard NFH to support their Mitchell Act funded program, and 6.3 million URB fall Chinook eggs to the Confederated Tribes and Bands of the Yakama Nation to support their Klickitat Hatchery program.

Little White Salmon NFH has also provided unfertilized or newly fertilized eggs to programs that cannot be filled by Carson NFH due to low returns as part of *United States v. Oregon* agreements (any transfers will be represented in Table 2).

Off-Station Juvenile Migration and Survival

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

a) PIT Tagging Program

Since Release Year 2012, an annual mean of 14,953 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 17), though releases from Willard NFH ceased in 2014. Approximately 13.6% of PIT tagged yearling spring Chinook released from Little White Salmon NFH and 10% released from Willard NFH have been detected annually at BONN. On average, yearlings took approximately 14 days after release from Little White Salmon NFH and 23 days after release from Willard NFH to be detected at BONN with some juveniles spending up to 66 days between the facilities and BONN before migrating downstream. The majority of yearlings (90th percentile) released from Little White Salmon NFH passed over BONN within 24 days after release versus 31 days after release from Willard NFH.

Table 17. 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 BONN following release into the Little White Salmon River. Data retrieved from PTAGIS: 11/6/2023

Release Year	Release Site	# PIT Tagged	# Detected at BONN	% Detected	Mean	Median	Range	75 th	90 th
2012	LWS	11,959	1,003	8.4	11	7	(1 - 40)	18	24
	WI	2,960	273	9.2	25	26	(4 - 63)	29	33
2013	LWS	10,480	1,273	12.1	13	13	(1 - 41)	17	20
	WI	4,492	475	10.6	22	22	(4.5 - 66)	25	28
2014	LWS	11,991	1,325	11	13	12	(0.5 - 39)	20	24
	WI	2,989	302	10.1	23	24	(3.5 - 44)	28	31
2015	LWS	14,945	2,840	19	14	15	(0.5 - 44)	18	20
2016	LWS	14,974	2,097	14	11	11	(0.5 - 51)	15	19
2017	LWS	14,964	2,413	16.1	14	15	(0.5 - 40)	18	23
2018	LWS	14,935	1,418	9.5	12	10	(0.5 - 37)	19	24
2019	LWS	14,968	1,961	13.1	14	13	(1 - 46)	19	25
2020	LWS	14,964	2,413	16.1	14	15	(0.5 - 40)	18	23
2021	LWS	14,983	2,449	16.3	11	10	(1.5 - 37)	18	21
2022	LWS	14,860	1,892	12.7	19	19	(1.5 - 49)	24	32
2023	LWS	14,969	2,204	14.7	19	20	(1.5 - 44)	24	30
Average	LWS	14,953	1,941	13.6	14	13		19	24
	WI		350	10	23	24		27	31

b) Juvenile Survival

PIT tag detection histories are also used to estimate the apparent juvenile survival from hatchery release downstream to Bonneville Dam. A 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 18, Figure 6). The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years as adult returns are added into the detection histories (as “downstream of Bonneville” detections), which in turn decreases the variance. Since recent years do not have adult returns, or at least not the full age complement of adult returns, the more recent estimates have larger variances. In subsequent

years, as more adults from a brood year return, the variance of the estimates should decrease. 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 0.87.

Table 18. 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. Survival is not calculated for the 2023 release due to lack of in-river detections downstream of Bonneville Dam at this time. Data retrieved from PTAGIS: 12/13/2023

Release Year	Median Survival	95% Lower	95% Upper
2011	0.68	0.55	0.89
2012	0.95	0.83	1.00
2013	0.98	0.86	1.00
2014	0.92	0.77	1.00
2015	0.85	0.78	0.91
2016	0.95	0.85	1.00
2017	0.93	0.72	1.00
2018	0.93	0.69	1.00
2019	0.71	0.60	0.89
2020	0.76	0.66	1.00
2021	0.90	0.74	1.00
2022	0.81	0.65	1.00
Average	0.87		

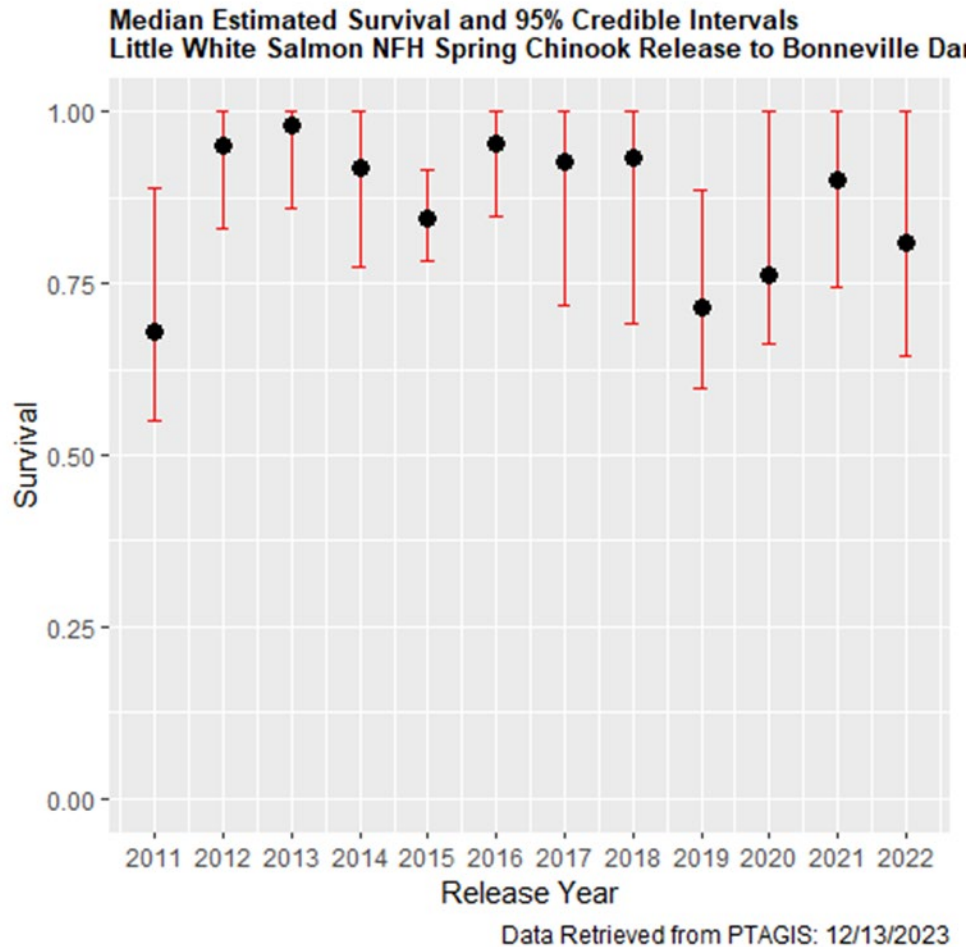


Figure 6. Little White Salmon NFH juvenile spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals

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 2005, the number of adult hatchery returns has varied from 1,328 to 11,962 adults (Table 19). 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 7,579 adult spring Chinook from BY 2005 to BY 2016 with a smolt-to-adult survival rate of 0.84% which is greater than the 0.2% rate set in the HGMP (USFWS 2004c).

As part of the Little White Salmon 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. Spring Chinook released at Willard NFH produced an average of 1,760 adults with a smolt-to-adult survival rate of 0.45% which was also greater than the 0.2% rate set in the HGMP.

Table 19. 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. Eight Brood Year 2007 fish were recovered at a Washington Department of Fish and Wildlife hatchery and are included in the total number of adults. Adult returns are used to estimate smolt-to-adult survival (rounded to the nearest one-hundredth). Complete return data for brood years 2017 - 2018 are not yet available and not included in the average. Data downloaded from RMIS TS1-Rec Report: 1/3/2024

Brood Year	Release Site	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
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	1,832	0	712	3,872	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	1,780	1,494	0	60	3,334	0.78
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
2014	LWS	4,992	3,180	0	276	8,448	0.64
2015	LWS	11,962	1,448	63	189	13,662	1.26
2016	LWS	1,968	388	0	0	2,356	0.22
2017	LWS	1,524	748	40	16	2,328	0.22
2018	LWS	3,528	1,876	28	231	5,663	0.52
Average	LWS	3,999	3,250	8	321	7,579	0.84
	WI	748	862	0	150	1,760	0.45

An average 288 CWTs have been recovered each year at Little White Salmon NFH since 2011 (Table 20). The Little White Salmon NFH spring Chinook program accounts for 83 percent of all recoveries; spring Chinook from other programs include Carson NFH (12.9%), Willard NFH (3.9%), other state and federal fish hatcheries account for < 0.1%).

Table 20. Coded-Wire Tag (CWT) recoveries for all hatchery programs collected at Little White Salmon NFH. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. Data retrieved from CRiS CWT Recovery Report: 1/4/2024

Return Year	CWT Recoveries	Hatchery Origin	% of Total CWT Return
2011	176	L. White Salmon NFH	90.0
	15	Carson NFH	8.0
	2	Kooski NFH	1.0
	2	Willard NFH	1.0
2012	326	L. White Salmon NFH	93.0
	23	Carson NFH	7.0
2013	119	L. White Salmon NFH	61.0
	12	Carson NFH	6.0
	63	Willard NFH	33.0
2014	192	L. White Salmon NFH	84.0
	20	Carson NFH	9.0
	18	Willard NFH	8.0
2015	429	L. White Salmon NFH	65.0
	167	Carson NFH	25.0
	65	Willard NFH	10.0
2016	1	Carson NFH	< 0.0
	281	L. White Salmon NFH	100.0
2017	356	L. White Salmon NFH	100.0
2018	191	L. White Salmon NFH	92.0
	16	Carson NFH	8.0
2019	160	L. White Salmon NFH	94.0
	10	Carson NFH	6.0
2020	117	L. White Salmon NFH	76.0
	33	Carson NFH	22.0
	1	Winthrop NFH	0.6
	1	Sandy	0.6
	1	CEDC Net Pens	0.6
2021	166	L. White Salmon NFH	84.3
	31	Carson NFH	15.7
2022	294	L. White Salmon NFH	69.3
	130	Carson NFH	30.7
2023	304	L. White Salmon NFH	92.0
	26	Carson NFH	8.0
Average	288		

Since Return Year 2012, spring Chinook adults (Ages 3, 4 and 5) PIT tagged and released from Little White Salmon NFH returned to Bonneville Dam as early as Mar-27 and as late as Jul-26 with the average median passage date May-04 (Table 21). 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 79% of the Bonneville Expansion.

Table 21. 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. Number of CWT recoveries are unexpanded and do not reflect sample or tagging rates. Data retrieved from PTAGIS: 12/18/2023

Return Year	BONN Median	BONN First	BONN Last	BONN Total	BONN Expansion	Ladder Median	Ladder First	Ladder Last	Ladder Total	Ladder Expansion	Actual Return
2012	May-08	Apr-20	May-17	36	2,827	May-15	May-15	May-29	13	1,021	2,891
2013	May-03	Apr-08	May-26	40	3,086	May-16	Apr-28	Sep-28	22	1,692	3,678
2014	May-01	Apr-12	Jul-25	110	7,095	May-14	May-04	Jun-29	33	2,128	2,967
2015	Apr-25	Apr-10	Jun-01	158	10,939	May-27	Apr-27	Jun-08	54	3,739	7,786
2016	May-03	Apr-16	May-20	87	6,297	May-09	May-08	May-29	30	2,172	4,404
2017	May-20	Apr-21	Jul-26	79	5,528	May-20	May-09	Sep-12	35	2,454	5,423
2018	May-07	Apr-21	Jun-05	99	8,568	May-12	May-06	Jun-24	20	1,725	3,748
2019	May-02	Apr-20	May-22	82	5,975	May-13	May-03	Aug-22	37	2,674	2,806
2020	Apr-30	Apr-12	May-27	26	1,874	May-10	May-04	Jun-21	14	1,008	2,592
2021	May-02	Apr-20	May-25	51	3,556	May-07	May-02	Aug-22	20	1,394	2,353
2022	May-02	Mar-27	Jun-03	85	6,187	May-04	Apr-30	Jun-22	36	2,625	6,626
2023	May-10	Apr-16	Jun-03	112	8,596	May-21	May-05	Jun-17	35	2,676	4,417
Mean	May-04	Apr-14	Jun-06	80	5,877	May-14	May-04	Jul-12	29	2,109	4,141

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 (~90%) of spring Chinook return to Little White Salmon NFH as Age-4 adults (Table 22). Approximately 3% return as jacks at Age-3 and 7% of adults return to the facility at Age-5. For Return Years 2012-23, no Age-6 adults have been documented. The facility has an average 4,263 adult returns each year.

Table 22. Age structure of adult spring Chinook returns to Little White Salmon NFH based on scale analysis and the estimated proportion of the total return (%) by return year. Adults referred to as Age-3 (jacks) are in their second year at migration, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Data retrieved from CRiS AGECOMP: 12/18/2023

Return Year	Age-3	Age-3 Proportion (%)	Age-4	Age-4 Proportion (%)	Age-5	Age-5 Proportion (%)	Age-6	Age-6 Proportion (%)	Total # Adults
2012	23	1	2,486	86	382	13	0	0	2,891
2013	115	3	2,609	71	950	26	0	0	3,674
2014	68	2	2,772	93	127	4	0	0	2,967
2015	208	2	7,874	93	386	5	0	0	8,468
2016	155	3	4,480	86	551	11	0	0	5,186
2017	430	8	4,719	87	274	5	0	0	5,423
2018	84	2	3,573	95	91	2	0	0	3,748
2019	70	2	2,528	90	208	7	0	0	2,806
2020	49	2	2,464	95	79	3	0	0	2,592
2021	62	3	2,241	95	50	2	0	0	2,353
2022	118	2	6,331	96	177	3	0	0	6,626
2023	63	1	4,127	93	227	5	0	0	4,417
Average	120	3	3,850	90	292	7	0	0	4,263

Table 23. Age structure of adult spring Chinook returns to Little White Salmon NFH based on scale analysis and the estimated proportion of the total return (%) by brood year. Adults referred to as Age-3 (jacks) are in their second year at migration, Age-4 are in their third, Age-5 are in their fourth, and Age-6 are in their fifth. Returns for brood years 2018 - 2020 are not yet complete. Data retrieved from CRiS AGECOMP: 12/18/2023

Brood Year	Age-3	Age-3 Proportion (%)	Age-4	Age-4 Proportion (%)	Age-5	Age-5 Proportion (%)	Age-6	Age-6 Proportion (%)	Total # Adults
2006	344	6	5,181	91	145	3	0	0	5,670
2007	53	3	1,589	79	382	19	0	0	2,024
2008	34	1	2,486	72	950	27	0	0	3,470
2009	23	1	2,609	95	127	5	0	0	2,759
2010	115	4	2,772	85	386	12	0	0	3,273
2011	68	1	7,874	93	551	6	0	0	8,493
2012	208	4	4,480	90	274	6	0	0	4,962
2013	155	3	4,719	95	91	2	0	0	4,965
2014	430	10	3,573	85	208	5	0	0	4,211
2015	84	3	2,528	94	79	3	0	0	2,691
2016	70	3	2,464	95	50	2	0	0	2,584
2017	49	2	2,241	91	177	7	0	0	2,467
2018	62	-	6,331	-	227	-	-	-	-
2019	118	-	4,127	-	-	-	-	-	-
2020	63	-	NA	-	-	-	-	-	-
Average	125	3	3,784	89	281	8	0	0	3,964

Special Studies

Little White Salmon NFH changed size at release from 15 fish/lb to 20 fish/lb in 2018. Altering the fish/lb goal frees up rearing space, reduces feed costs, and allows for other rearing opportunities. From 2018 to 2020, two release groups targeted different average release sizes for monitoring and comparison. The majority (90th percentile) of both 15 and 20 fish/lb targets passed over BONN within 24 days after release. No substantial difference in juvenile travel time were observed (Silver et al., 2021).

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 since 2013 except in 2018. 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. Throughout the rearing cycle, the hatchery has a maximum Flow Index < 1.0 and Density Index < 0.25 to minimize disease risk (USFWS 2004d). 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. In BYs 2019 and 2020, production was increased by 200,000 URB fall Chinook to benefit SRKW. Since RY 2015, Willard NFH has produced a mean of 1,812,697 sub-yearling, URB fall Chinook and released into the Little White Salmon River in mid to late July which is within 9.4% of the release goal of 2 M (Table 24). Approximately 100,000 (6%) of these juveniles were AD and CWT, and another 100,000 (6%) were CWT only (DIT fish). The remaining 83% of juveniles were AD only prior to release. All CWT codes used are stored in the USFWS CRiS database at the CRFWCO and reported to RMIS. Since RY 2015, the facility has achieved a mean juvenile size of 86.1 fish/lb, near the program's goal of 70-90 fish/lb at release listed in the HGMP (USFWS 2004d).

To increase apparent juvenile survival estimates, 100 percent of the Willard NFH brood year 2022 (release year 2023) URB fall Chinook salmon were transported and released at Little White Salmon NFH (J. Baker and D. Hand, USFWS, 2023 memorandum to Willard and Little White Salmon NFH Hatchery Evaluation Teams regarding the Willard NFH Upriver Bright Fall Chinook 2023 Release).

Table 24. Annual release data, 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 SR80s File: 12/18/2023

Release Year	Release Dates	Release Location	River Water Temperature at Release (°C)	AD + CWT	CWT (DIT)	AD Only	No Mark, No CWT	Total Released	Annual Release	Mean Size (Fish/lb)
2015	1-Jul	WI	7.6	100,029	100,038	1,603,197	0	1,803,264	1,803,264	81.8
2016	11-Jul	WI	6.4	99,698	99,462	1,361,075	577	1,560,812	1,560,812	101.5
2017	12-Jul	WI	7.1	97,906	99,687	1,685,042	381	1,883,016	1,883,016	96.5
2018	10-Jul	WI	6	49,691	49,749	857,967	303	957,710	1,911,318	81.5
	10-Jul	LWS	6	50,009	50,011	853,588	0	953,608		79.6
2019	10-Jul	WI	8	49,802	50,022	328,323	0	428,147	859,466	85.2
	10-Jul	LWS	8	49,917	50,011	331,391	0	431,319		82.3
2020	7-Jul	WI	7.2	49,867	50,039	606,900	348,931	1,055,737	2,206,375	85
	7-Jul	LWS	7.2	50,015	49,671	623,681	427,271	1,150,638		81
2021	29-Jun, 1-Jul	WI	7.2	49,781	49,529	1,219,681	495	1,319,486	2,199,356	85
	30-Jun, 1-Jul	LWS	7.2	49,610	48,577	780,239	1,444	879,870		81
2022	5-Jul	WI	8	98,159	48,066	379,246	0	525,471	1,991,761	86.1
	9-Jul	LWS	7.7	103,881	103,888	1,258,521	0	1,466,290		79.9
2023	3, 5, 6-Jul	LWS	7.4	99,574	99,773	1,699,353	204	1,898,904	1,898,904	81.5
Average	Mid-Jul	WI & LWS	7.2	110,882	105,391	1,509,800	86,623		1,812,697	86.1

Due to low adult returns at Little White Salmon NFH in 2018, Willard received half of their need (1,069,895 green eggs) for release in 2019. In 2020, the number of fish marked with AD only was reduced to 50% due to COVID-19 health and safety precautions. In June 2021, an excess 13,472 marked BY 2020 fingerlings were transferred to the Klickitat Tribal Hatchery for release into the Klickitat River as Willard NFH would have exceeded their 2.2M release cap in the BiOp, while the Klickitat Hatchery was under their production target.

Off-Station Juvenile Migration and Survival

The smolt-to-adult survival rate goal is 0.32% returning to Little White Salmon NFH

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 14,941 juveniles (Table 25). Approximately 13.3% of PIT tagged juveniles released at Little White Salmon NFH/Drano Lake have been detected at BONN and 7.4% of fish released at Willard NFH were detected; an average 9.1% of fish have been detected annually. On average, juveniles released at Willard NFH take approximately 15 days to reach BONN with the majority of juveniles (90th percentile) passing over BONN within 22 days after release. Juveniles released at Little White Salmon NFH/Drano Lake required approximately 13 days to reach BONN with the majority of juveniles (90th percentile) passing over BONN within 18 days after release. Overall, juveniles take approximately 14 days to reach BONN with the majority of juveniles (90th percentile) passing over BONN within 20 days after release. Some PIT tags were detected moving downstream between Willard NFH and BONN almost a year later.

Predation and passage within the Little White Salmon River between Willard and Little White Salmon NFHs may 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 took place at Little White Salmon NFH). The detection rate for Juvenile URB fall Chinook migrating over BONN was 1.75 times greater for fish trucked down and released at Little White Salmon NFH/Drano Lake (mean = 13.3%) than for fish released on station at Willard NFH (mean = 7.4%).

Table 25. 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. Brood year is one year before release year. Data retrieved from PTAGIS: 11/30/2023

Release Year	Release Site	# PIT Tagged	# Detected at BONN	% Detected	Mean	Median	Range	75th	90th
2015	WI	14,934	434	2.9	21	18	(5.5 - 287)	24	31
2016	WI	14,958	579	3.9	14	13	(2.5 - 114)	15	17
2017	WI	14,895	680	4.6	11	9	(1.5 - 103)	14	17
2018	WI	7,489	750	10	12	11	(3.5 - 116)	13	18
	LWS	7,483	1,246	16.7	11	11	(1 - 42)	12	14
2019	WI	7,478	516	6.9	20	17	(3 - 303)	23	30
	LWS	7,479	849	11.4	15	13	(3 - 68)	17	22
2020	WI	7,422	989	13.3	16	16	(2.5 - 56)	18	23
	LWS	7,466	1,016	13.6	15	15	(5 - 56)	18	21
2021	WI	7,484	757	10.1	14	14	(3.5 - 41)	16	18
	LWS	7,487	1,135	15.2	11	11	(1.5 - 42)	14	16
2022	WI	7,497	574	7.7	14	12	(2.5 - 50)	16	21
	LWS	7,413	776	10.5	13	11	(4 - 46)	14	18
2023	LWS	14,986	1,888	12.6	11	11	(1 - 40)	13	16
Average	WI	14,941	660	7.4	15	14	-	17	22
	LWS		1,152	13.3	13	12	-	15	18

b) Juvenile Survival

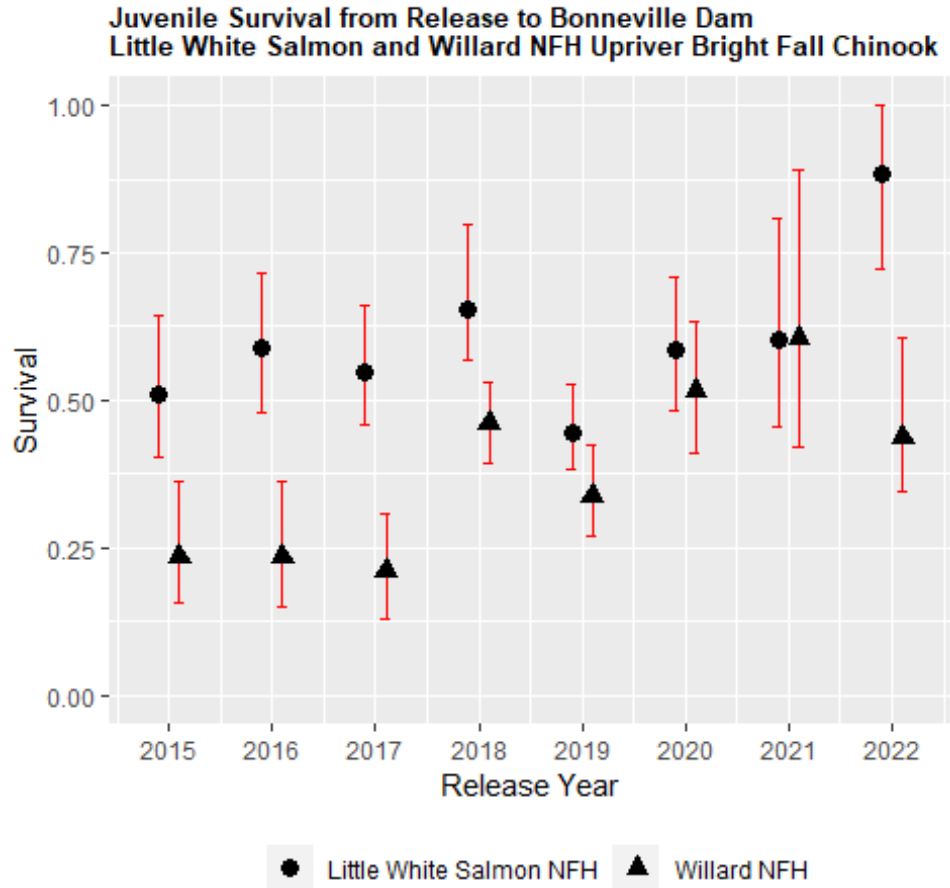
PIT tag detections can be used to estimate apparent juvenile survival after release downstream to Bonneville Dam. Downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing 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 26, 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. The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years, as adult returns are added into the detection histories (as “downstream of Bonneville”

detections), the variance decreases. Since recent years do not have adult returns, or at least not the full age complement of adult returns, the more recent estimates have larger variances. In subsequent years, as more adults from a brood year return, the variance of the estimates should decrease. In 2020, no juvenile fish were detected at any in-river detection systems downstream of Bonneville Dam. Adult returns in recent years have allowed us to back-calculate juvenile survival estimates from the 2020 release.

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 0.38. 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 26. 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 is not calculated for the 2023 release due to lack of in-river detections downstream of Bonneville Dam at this time. Data retrieved from PTAGIS: 12/13/2023

Release Year	Median Survival	95% Lower	95% Upper
2015	0.23	0.16	0.36
2016	0.24	0.15	0.36
2017	0.21	0.13	0.31
2018	0.46	0.40	0.53
2019	0.34	0.27	0.42
2020	0.52	0.41	0.63
2021	0.61	0.42	0.89
2022	0.44	0.35	0.61
Average	0.38		



Data Retrieved from PTAGIS: 12/13/2023

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

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

Juveniles released from Willard NFH in 2015 began returning as adults to LWSNFH in fall 2017 and reached the end of their lifespan (6 years) in 2021. The number of adult returns to LWSNFH are estimated annually by hatchery personnel and the marking and biosampling crew from the CRFWCO. Coded-Wire Tag recoveries obtained from RMIS are used to estimate the number of harvested adults and adults recovered on the spawning grounds. These CWT 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.

From Brood Year 2014 to 2018, an average 585 adults returned to LWSNFH (Table 27). Approximately 25% of adult returns were harvested in the Columbia River, 32% were harvested in the ocean, and 15% were observed on spawning grounds. The facility has produced an average 2,077 adult fall Chinook with a smolt-to-adult survival rate of 0.14%; the goal is a 0.32% survival rate set in the HGMP (USFWS 2004d).

Table 27. 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 URB fall Chinook reared at Willard NFH. Adult returns are used to estimate smolt-to-adult survival (rounded to the nearest one-hundredth). Complete return data for brood years 2017 and 2018 are not yet complete, however the data is included in the average for estimation purposes. Data downloaded from RMIS TS1-Rec Report: 1/4/2024

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2014	248	239	0	10	497	0.03
2015	367	318	318	14	1,017	0.07
2016	556	494	401	156	1,607	0.09
2017	1,223	1,305	1,887	762	5,177	0.27
2018	531	225	701	629	2,086	0.24
Average	585	516	661	314	2,077	0.14

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. https://www.fws.gov/sites/default/files/documents/2022_JDM-Annual-Report_Final_3-29-2023.pdf

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 2017-2021 (release years 2018-2022) a portion of the hatchery production was trucked downstream to the Little White Salmon River at Little White Salmon NFH. Differential PIT tagging and coded-wire tagging was conducted, and juvenile survival and subsequent adult returns will be monitored. For release years 2018 - 2021, the juveniles trucked downstream had a higher apparent survival to Bonneville Dam than those released from the hatchery, with a median estimated survival of 37% for hatchery release vs 59% for trucked

release (Table 28, Figure 9). Juvenile survival of the trucked fish was similar to the estimated survival of the Little White Salmon NFH URB fall Chinook program.

Adult returns are monitored to see if juvenile survival translates into adult survival, as well as if differences in stray rates of adult returns are found. Adult return rates to the Little White Salmon NFH were 2.4 times higher for brood year 2017 URBs released at Drano Lake compared with URBs released at Willard NFH. Similarly for brood year 2018 the adult return rate to the Little White Salmon NFH was 2.3 times higher for Willard NFH URBs released at the Little White Salmon NFH. Overall, the estimated total freshwater return was nearly two times higher for Willard NFH URBs released at Little White Salmon NFH/Drano Lake compared with URBs released at Willard NFH. The estimated number of recoveries on the White Salmon River spawning grounds were similar for brood year 2017 Willard NFH URB releases at Willard NFH (215 fish) and Drano Lake (206 fish). In contrast, URBs reared and released at the Little White Salmon NFH had an estimated 2,144 fish recovered on the White Salmon River spawning grounds for brood year 2017; an approximately 2.5 times higher stray rate compared with Willard NFH releases (J. Baker and D. Hand, USFWS, 2023 memorandum to Willard and Little White Salmon NFH Hatchery Evaluation Teams regarding the Willard NFH Upriver Bright Fall Chinook 2023 Release).

Table 28. Willard NFH juvenile upriver bright fall Chinook survival to Bonneville Dam from release at Willard NFH or trucked to Little White Salmon NFH. Release year is one year after brood year. Estimates are median survival and lower and upper credible intervals, due to the limited time and number of fish detections downstream, survival is not reported for the current year. Data retrieved from PTAGIS: 12/13/2023

Release Year	Stock	Release Site	Median Survival	95% Lower	95% Upper
2018	Willard	Willard NFH	0.33	0.26	0.45
	Willard	Little White NFH	0.6	0.49	0.74
	Little White	Little White NFH	0.65	0.57	0.80
2019	Willard	Willard NFH	0.25	0.16	0.36
	Willard	Little White NFH	0.41	0.29	0.54
	Little White	Little White NFH	0.44	0.38	0.53
2020	Willard	Willard NFH	0.5	0.36	0.74
	Willard	Little White NFH	0.58	0.42	0.79
	Little White	Little White NFH	0.59	0.48	0.71
2021	Willard	Willard NFH	0.42	0.29	1.00
	Willard	Little White NFH	0.85	0.62	1.00
	Little White	Little White NFH	0.6	0.46	0.81
2022	Willard	Willard NFH	0.37	0.24	0.64
	Willard	Little White NFH	0.52	0.38	0.73
	Little White	Little White NFH	0.88	0.72	1.00
Average	Willard	Willard NFH	0.37		
	Willard	Little White NFH	0.59		
	Little White	Little White NFH	0.63		

**Juvenile Survival from Release to Bonneville Dam
Willard NFH Upriver Bright Fall Chinook and
Little White Salmon NFH Upriver Bright Fall Chinook**

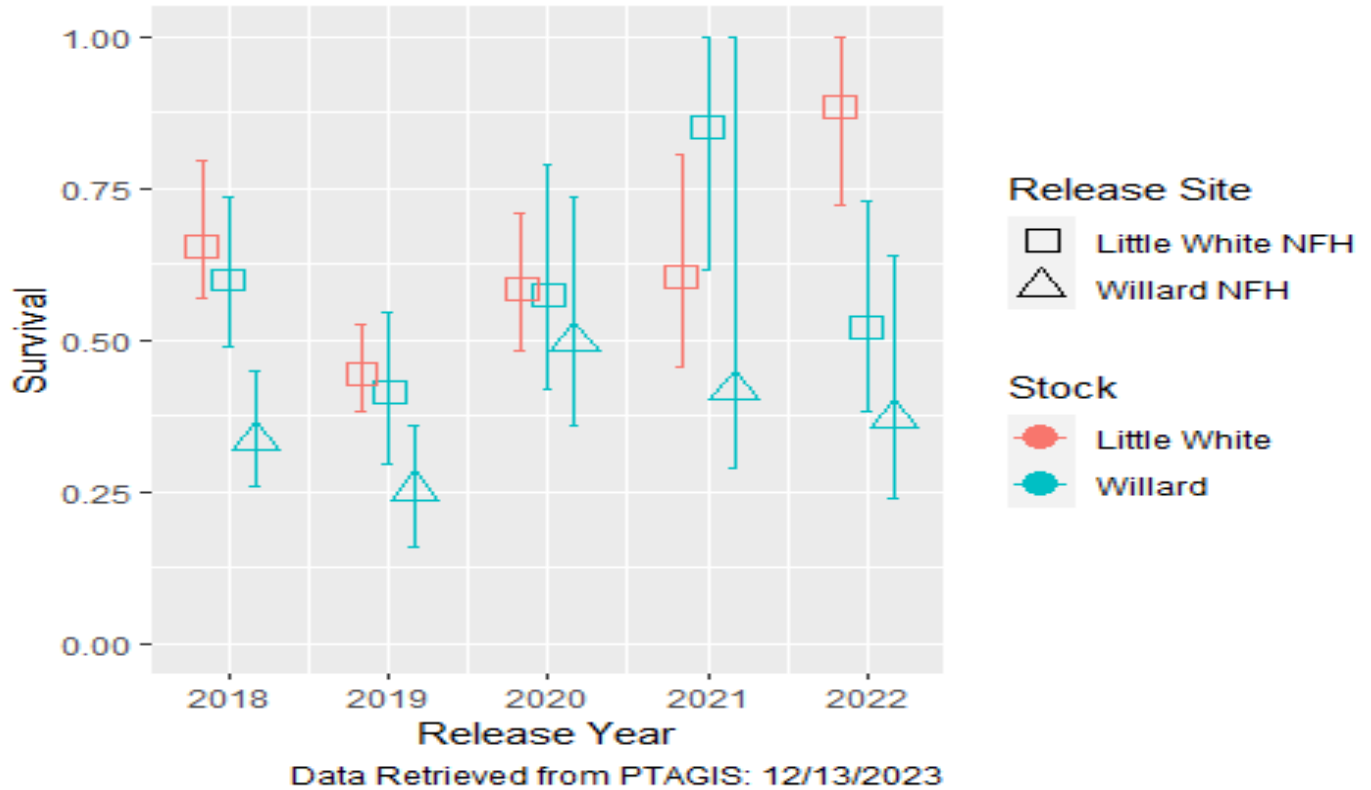


Figure 9. Willard NFH juvenile upriver bright (URB) fall Chinook survival to Bonneville Dam from release at Willard NFH or trucked to Little White Salmon NFH compared to Little White Salmon URB Fall Chinook survival to Bonneville Dam from release at Little White Salmon NFH. Release year is one year after 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 includes sixty fish from each program’s on station release, sampled within 2-8 weeks of their scheduled release date (Table 29). Fish are netted from the front, middle, and end of representative raceways (i.e. about 10 fish/raceway; not all raceways were sampled). Pre-release sampling will be conducted by CRFWCO staff. Our sampling rate is 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 30). No precocial fish were observed at any facility in 2023.

Table 29. 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 - 2023	Carson NFH	60	0
2019 - 2023	Eagle Creek NFH	60	0
2020 - 2023	Little White Salmon NFH	60	0
2021 - 2023	Willard NFH	60	0

Table 30. 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	NA	NA	NA	NA	NA
40	0	0	0	NA	NA	NA
50	0	0	0	0	NA	NA
60	1	1	0	0	0	NA
70	1	1	1	0	0	NA
80	2	1	1	1	0	NA
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 12-year-averages, Carson, Eagle Creek, and Little White Salmon have reached their production goals set under *U.S. v. Oregon* agreements. All programs have remained within 11% 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. After release, juveniles have moved downstream past Bonneville Dam within a median of less than 14 days for all programs. Additionally, the programs at Carson, Eagle Creek, and Little White Salmon NFHs have been close to or exceeded their 12-year-average, smolt-to-adult survival rate goals as outlined in their respective HGMPs. The Willard NFH URB fall Chinook program smolt-to-adult survival rate has been increasing in recent years towards their goal. In most of the past 12 years, all programs have produced enough adult returns to sufficiently meet their on-station broodstock needs except the Carson spring Chinook program in 2018, and the Willard URB fall Chinook program in 2018. Based on the age structure of adult returns, jack rates at the facilities are low (ranging from 3 - 9%) 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

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 were 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 can 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.

Acknowledgements

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.

Appendix A: Other Species Handled

Table 31. Annual allowed take (handling and release) of ESA-listed salmon and steelhead for each of the proposed spring Chinook hatchery programs during broodstock collection.

Hatchery Program	ESA-listed Species	Handled-Maximum Number Allowed	Number Handled	Mortality-Maximum Number Allowed	Number Mortalities
Carson NFH	LCR Coho	5	0	1	0
	LCR Steelhead	5	0	1	0
Eagle Creek NFH	LCR Chinook	100	1	5	0
	LCR Coho	5	0	1	0
LWS NFH	LCR Coho	5	0	1	0
	LCR Steelhead	5	0	1	0

Appendix B: Annual Hatchery Notes

Carson NFH: Spring Chinook

RY23 reflects the BY21 increased release goal from 1.17M to 1.42M. Eggs were treated with iodine in lieu of formalin.

Eagle Creek NFH: Coho

Jeremiah Civil is the new hatchery manager.

Little White Salmon NFH: Spring Chinook

Willard NFH: Upriver Brights

Ken Lujan is the new hatchery manager.

References

- Brignon, W. R. 2017. Spatial and temporal segregation of wild and hatchery winter steelhead populations in Eagle Creek, Oregon. *North American Journal of Fisheries Management* 37(3):667–675.
- Brignon, W., S. Haeseke. 2011. PIT-Tag Effects Study: Carson National Fish Hatchery Spring Chinook Salmon. https://www.fws.gov/sites/default/files/documents/PTES_AR_2011.pdf.
- Kavanagh, M., W. R. Brignon, D. E. Olson, S. K. Gutenberger, A. P. Matala, and W. R. Ardren. 2009. Ecological and genetic interactions between hatchery and wild steelhead in Eagle Creek, Oregon. Page 121. U.S. Fish; Wildlife Service, Columbia River Fish; Wildlife Conservation Office, Vancouver, WA.
- Kavanagh, M., D. E. Olson, B. Davis, J. Poirier, and S. Haeseke. 2017. Eagle Creek Hatchery-Wild steelhead ecological interactions: comparative abundance, growth, migration behavior, and survival of winter steelhead in upper Eagle and North Fork Eagle Creeks. Page 51. U.S. Fish; Wildlife Service, Columbia River Fish; Wildlife Conservation Office, Vancouver, WA.
- National Marine Fisheries Service (NMFS). 2007. Section 7 Biological Opinion USFWS Artificial Propagation Programs in the Lower Columbia River and Middle Columbia River. NMFS Consultation Number: 2004/02625. Page 255.
- National Marine Fisheries Service (NMFS). 2016. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. NMFS Consultation Number: WCR-2015397.
- National Marine Fisheries Service (NMFS). 2017. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on NOAAs National Marine Fisheries Service’s Implementation of the Mitchell Act Final Environment Impact Statement preferred alternative and administration of Mitchell Act hatchery funding. NMFS Consultation Number: NWR-2014-697.
- Northwest Power and Conservation Council (NPCC). 2008. Mitchell Act. <https://www.nwcouncil.org/history/MitchellAct>.
- Schill, D. J., J. A. Heindel, M. R. Campbell, K. A. Meyer, and E. R. J. M. Mamer. 2016. Production of a YY male Brook Trout broodstock for potential eradication of undesired Brook Trout populations. *North American Journal of Aquaculture* 78:72–83.
- Silver B.P., T. Gilmore, S. Lazzini, K. Beard, J. Baker, D. Hand, J. Rivera, J. Voeltz. 2021. Monitoring and Evaluation of Mitchell Act-Funded National Fish Hatcheries in the Columbia River Gorge Complex, 2021 Annual Report. https://www.fws.gov/sites/default/files/documents/MitchellAct_2021_Final.pdf.
- U.S. Fish and Wildlife Service (USFWS). 2004a. Carson National Fish Hatchery Spring Chinook Salmon Hatchery and Genetic Management Plan. Page 59.
- U.S. Fish and Wildlife Service (USFWS). 2004b. Eagle Creek National Fish Hatchery Coho Salmon Hatchery and Genetic Management Plan. Page 85.
- U.S. Fish and Wildlife Service (USFWS). 2004d. Little White Salmon/Willard Complex Upriver Bright Fall Chinook Salmon Hatchery and Genetic Management Plan. Page 49.

U.S. Fish and Wildlife Service (USFWS). 2004c. Little White Salmon National Fish Hatchery Spring Chinook Salmon Hatchery and Genetic Management Plan. Page 55.

U.S. Fish and Wildlife Service (USFWS). 2006. Mitchell Act Coalition Fact Sheet.
[https://www.fws.gov/gorgefish/carson/reports/MA Fact Sheet 3_3_06.pdf](https://www.fws.gov/gorgefish/carson/reports/MA_Fact_Sheet_3_3_06.pdf).

U.S. Fish and Wildlife Service (USFWS). 2007. Eagle Creek NFH Assessments and Recommendations Final Report. <http://www.fws.gov/pacific/fisheries/Hatcheryreview/team.html>.

U.S. Fish and Wildlife Service (USFWS). 2015. Endangered Species Act Section 7 Consultation on the Continued Operation of Five National Fish Hatchery Programs and one Fish Technology Center Program related to Potential Impact to Bull Trout and Bull Trout Critical Habitat.