Monitoring and Evaluation of Mitchell Act-Funded National Fish Hatcheries in the Columbia River Gorge Complex - 2021 Annual Report

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

Table of Contents

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Introduction

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

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

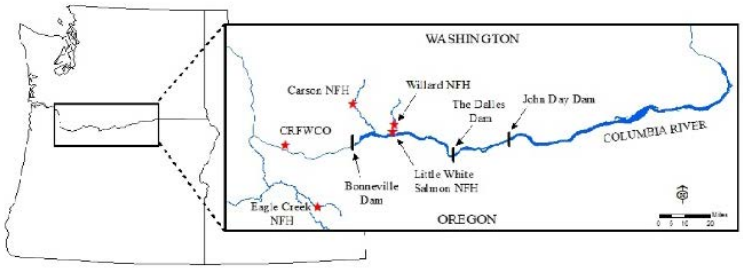

Figure 1. The Columbia River (blue) and the four Mitchell Act funded NFHs of the Columbia River Gorge Complex: Willard, Little White Salmon, Eagle Creek, and Carson.

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

Carson NFH: Spring Chinook Program

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

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

On-Station Juvenile Production

a) Egg-to-Smolt Survival

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

These survival objectives include:

1. 95% or higher survival from the egg to eye up stage
2. 90% survival from the egg to fry stage; and
3. 97% survival from fry to smolt stage

Mortality can occur during each of these life stages due to disease, injury, predation, starvation, deformities, and genetic anomalies. 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. In 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 for Brood Year 2021, production was increased by 100,000 spring Chinook to benefit Southern Resident Killer Whales (SRKW). Broodstock goals were adjusted to spawn an additional 100 females in order to supplement SRKW production. 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 1,171,352 juveniles being annually released since release year (RY) 2012 which is within 0.12% of the release goal.

Carson NFH has a mean juvenile size goal of 18 fish/lb for an April release of their yearling spring Chinook into the Wind River. Since RY 2012, the facility has achieved a mean juvenile size of 19.8 fish/lb at the time of release. Approximately 8% of the total number of juveniles released are adipose-clipped (AD) and coded-wire tagged (CWT). The remaining 92% of the juveniles released from the facility are AD only. The actual number of juveniles that are mass-marked annually are presented below (Table 1). CWT codes are stored in the USFWS Columbia River Information System (CRiS) database at the CRFWCO and reported annually to the Regional Mark Information System (RMIS).

Table 1. Annual release 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. Data retrieved from CRiS SR80S File: 8/23/2021.

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
Mean		**6.0**	**94,806**	**1,076,547**	**1,171,352**	**19.8**

* 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 records and the CRiS database, not the marking record.

c) Transfer Data

The facility also transfers approximately 250,000 yearling spring Chinook to the CTUIR for reintroduction of spring Chinook to the Walla Walla River each year (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 brood year (BY) 2021, Carson NFH shifted from transferring yearlings to providing approximately 250,000 gametes for the hatchery to incubate and rear. 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. In low return years to Carson NFH, unfertilized or newly fertilized eggs for the program have been provided by Little White Salmon NFH. 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 yearling spring Chinook transferred to the Walla Walla River from Carson NFH. Data retrieved from CRiS SR80S File: 8/23/2021.

Transfer Year	Transfer Dates	Transfer Location	AD + CWT	AD Only	Gametes	Total 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	
Mean			**49,336**	**197,957**	**~350,000**	**247,293**

Off-Station Juvenile Migration and Survival

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

a) PIT Tagging Program

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

The facility has tagged a mean 19,211 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. A mean of 2,061 PIT tagged juveniles have been detected at BONN for a mean detection rate of 10.9%. Mean juvenile travel time to BONN after release is approximately 12 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 22 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: 8/23/2021.

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2012	29,479	2,563	8.7	11	(0.5 - 74)	8	18	26
2013	29,580	3,574	12.1	16	(1.5 - 43)	15	20	24
2014	29,399	2,873	9.8	16	(1.5 - 57)	17	23	28
2015	14,734	2,263	15.4	15	(1 - 47)	17	20	21
2016	14,019	1,043	7.4	10	(1 - 44)	9	14	19
2017	14,967	1,137	7.6	11	(1 - 45)	9	17	24
2018	14,987	1,461	9.7	10	(1 - 49)	8	17	24
2019	14,973	1,570	10.5	10	(1 - 50)	8	14	19
2020	14,981	2,138	14.3	12	(1.5 - 36)	10	18	20
2021	14,995	1,986	13.2	10	(1.5 - 38)	9	13	19
Mean	**19,211**	**2,061**	**10.9**	**12**		**11**	**17**	**22**

b) Juvenile Survival

PIT tag detection histories are also used to estimate the apparent juvenile survival from hatchery release downstream to Bonneville Dam. A PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated in order to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged fish to estimate the detection probability at Bonneville Dam and estimate the apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 4, Figure 3). The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years. This is due to the fact that adult returns are added 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. 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 2012, median spring Chinook survival from release at Carson NFH to Bonneville Dam averaged 0.81 (95% CI = 0.66 - 0.93).

Table 4. Carson NFH juvenile spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals. Data retrieved from PTAGIS: 10/15/2021.

Release Year	Median Survival	95% Lower	95% Upper
2012	0.88	0.76	1.00
2013	0.85	0.75	0.98
2014	0.79	0.70	0.90
2015	0.71	0.65	0.77
2016	0.86	0.61	1.00
2017	0.90	0.67	1.00
2018	0.85	0.67	1.00
2019	0.53	0.44	0.64
2020	0.86	0.69	1.00
2021	0.86	0.61	1.00
Mean	**0.81**	**0.66**	**0.93**

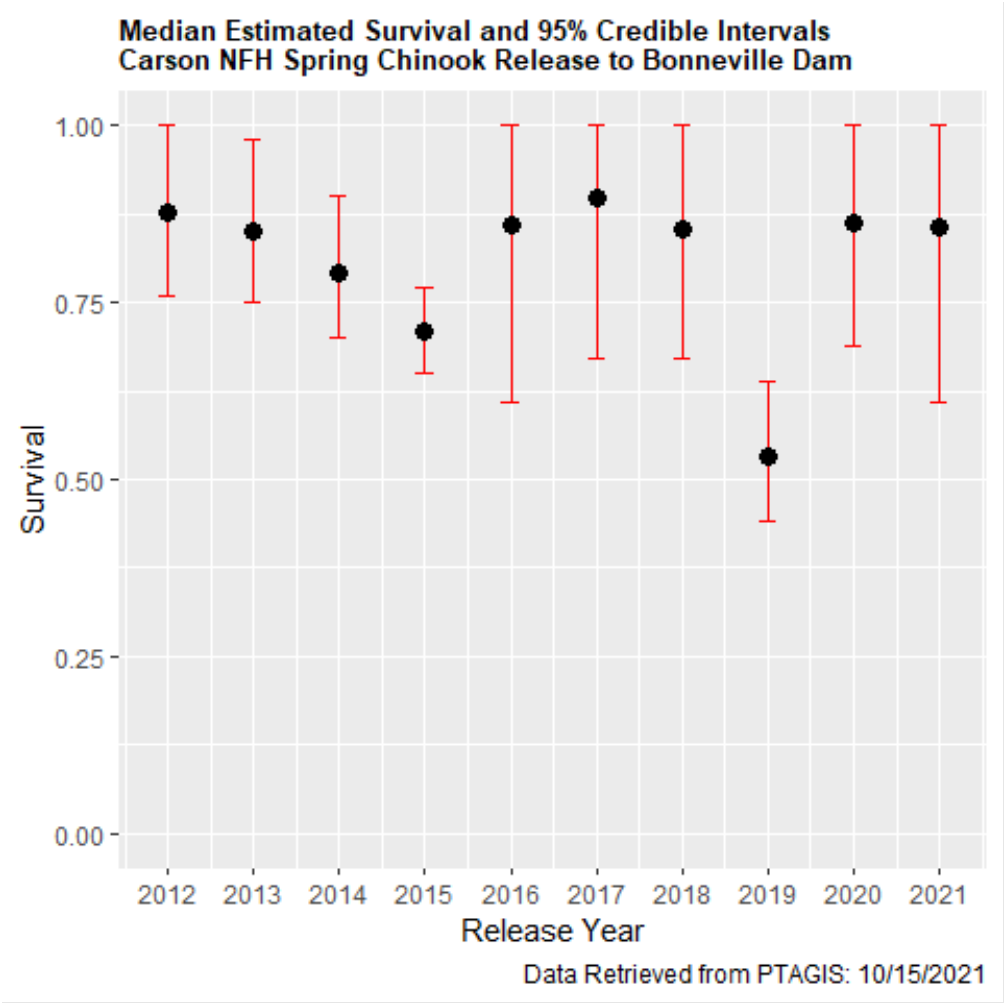

Figure 3. Carson NFH juvenile spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals

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

Adult returns to Carson NFH are estimated by hatchery personnel and the marking and biosampling crew from the CRFWCO. CWT recoveries maintained in the RMIS database are used to estimate the number of harvested adults and spawning ground recoveries (Table 5). At Carson NFH, the number of hatchery returns and harvested adults has fluctuated since brood year (BY) 2005. Collectively, the facility has produced a mean of 6,306 adults annually since BY 2005 resulting in a mean smolt-to-adult survival rate of 0.52% which exceeds the 10-year average goal of 0.5% set in the facility's Hatchery and Genetic Management Plan (HGMP; USFWS 2004a).

Table 5. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded wire tag recovery expansion data from RMIS for spring Chinook released from Carson NFH. Adult returns are used to estimate smolt-to-adult survival rates. Data retrieved from CRiS Stock Assessment Report: 9/30/2021.

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
Mean	**2,872**	**3,416**	**8**	**10**	**6,306**	**0.52**

An average 210 CWTs have been recovered each year at Carson NFH since 2011 (Table 6). The Carson NFH spring Chinook program accounts for 99.1 percent of all recoveries; spring Chinook from other programs include Little White Salmon NFH (<0.1%), Willard NFH (<0.6%), and the Nez Perce Tribal Hatchery (<0.3%).

Table 6. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Carson NFH 2011 - 2021. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from RMIS: 9/7/2021 and CRiS CWT Recover Report 10/22/2021.

Return Year	CWT Recoveries	Hatchery Origin	% of Total CWT Return
2011	316	Carson NFH	98.1
	4	L White Salmon NFH	1.2
	2	Nez Perce Tribal Hatchery	0.6
2012	148	Carson NFH	98.7
	2	Willard NFH	1.3
2013	426	Carson NFH	100.0
2014	560	Carson NFH	98.9
	2	L White Salmon NFH	0.4
	4	Willard NFH	0.7
2015	270	Carson NFH	99.3
	2	L White Salmon NFH	0.7
2016	144	Carson NFH	99.3
	1	L White Salmon NFH	0.7
2017	107	Carson NFH	99.1
	1	L White Salmon NFH	0.9
2018	50	Carson NFH	98.0
	1	L White Salmon NFH	2.0
2019	49	Carson NFH	98.0
	1	L White Salmon NFH	2.0
2020	52	Carson NFH	100.0
2021	163	Carson NFH	99.3
	1	L White Salmon NFH	0.7
Mean	**210**		

Since Return Year 2012, spring Chinook jacks (Age 3) and adults (Ages 4 and 5) PIT tagged and released from Carson NFH returned to Bonneville Dam as early as Mar-23 and as late as Jul-30 with the average median passage date May-04 (Table 7). Returns to the Carson NFH Hatchery ladder were detected as early as Apr-30 and as late as Aug-13 with the average median May-28. Actual returns to the hatchery average 33% 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). Data retrieved from PTAGIS: 9/7/2021.

Return Year	Bonneville Detections					Hatchery Detections					Actual Return	Actual Return/ Bonn Exp.
	Median	First	Last	Total	Bonn Exp.	Median	First	Last	Total	Ladder Exp.		
2012	May-09	Apr-13	May-20	130	10,802	Jun-10	May-24	Aug-06	21	1,739	1,612	15%
2013	May-01	Apr-03	Jun-07	96	3,672	May-19	May-05	Aug-04	27	1,022	1,913	52%
2014	Apr-30	Mar-26	Jul-21	178	6,789	May-30	May-07	Jul-24	43	1,640	2,416	36%
2015	Apr-23	Mar-23	May-28	306	11,634	May-22	Apr-30	Jun-18	50	1,901	2,841	24%
2016	May-01	Apr-02	Jul-01	181	7,055	Jun-01	May-08	Aug-13	33	1,264	1,318	19%
2017	May-16	May-01	Jul-04	58	4,490	May-31	May-24	Jun-06	9	708	1,596	36%
2018	May-09	Apr-24	Jun-12	32	2,682	May-25	May-20	Jun-07	8	668	1,042	39%
2019	May-07	Apr-17	Jul-30	29	2,444	May-31	May-21	Aug-01	11	929	742	30%
2020	May-02	Mar-28	May-26	35	2,800	Jun-05	May-02	Jun-12	7	557	742	27%
2021	May-04	Apr-19	Jul-18	62	5,081	May-17	May-10	Jun-05	24	1,969	2,744	54%
Mean	**May-04**	**Apr-09**	**Jun-22**	**111**	**5,745**	**May-28**	**May-12**	**Jul-07**	**23**	**1,240**	**1,697**	**33%**

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 a mean of 1,697 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: 10/19/2021.

Return Year	Age 3	Age-3 Prop. (%)	Age 4	Age-4 Prop. (%)	Age 5	Age-5 Prop. (%)	Age 6	Age-6 Prop. (%)	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
Mean	**103**	**6**	**1,526**	**90**	**68**	**4**	**0**	**0**	**1,697**

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 2016 - 2018 are not yet complete. Data retrieved from CRiS AGECOMP: 10/19/2021.

Brood Year	Age-3	Age-3 Proporiton (%)	Age-4	Age-4 Proporiton (%)	Age-5	Age-5 Proporiton (%)	Age-6	Age-6 Proporiton (%)	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	1	0	0	722
2016	74	-	716	-	29	-	-	-	-
2017	15	-	2,535	-	-	-	-	-	-
2018	180	-	-	-	-	-	-	-	-
Mean	**140**	**7**	**1,842**	**89**	**79**	**4**	**0**	**0**	**2,123**

Special Studies

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

Additionally, hatchery staff continue to be included in the CRFWCO 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). In the summer of 2021, CRFWCO staff removed 2,398 Brook Trout from Tyee Springs. In October 2021, Tyee Springs was stocked with 924 adipose clipped YY-male Brook Trout as well as 999 adipose clipped and PIT tagged YY-male Brook Trout (Brian Davis, pers. comm. October 2021).

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 an agreement with the Oregon Department of Fish and Wildlife (ODFW). However, the Memorandum of Agreement (MOA) for ODFW fish production at Eagle Creek NFH expired in May 2021. Due to the need to complete critical deferred maintenance infrastructure projects at the hatchery, the USFWS was unable to extend the MOA. 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 so their release the following spring would theoretically increase their brood return.

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

b) Juvenile Marking, Tagging, and Release Data

There is a cost share between Bonneville Power Administration and Mitchell Act for the Eagle Creek NFH Coho program. Bonneville Power Administration funds the Confederated Tribes and Bands of the Yakama Nation Coho program at Eagle Creek including all PIT tagging and marking. Mitchell Act funds support juvenile production costs including the PIT tagging and transfer of juveniles to other facilities and programs. Prior to RY 2009, the facility was rearing and releasing 500,000 juvenile Coho into Eagle Creek annually. However, production goals were changed to 350,000 juvenile Coho on-station releases beginning with RY 2009 (BY 2007) in order to reduce ecological risks (USFWS 2007). The actual number of juvenile Coho released into Eagle Creek has varied by release year (Table 10) with an annual mean of 355,739 juveniles released since RY 2012 which is within 1.6% of the release goal.

Eagle Creek NFH has a mean juvenile size goal of 12 fish/lb according to the most recent HGMP for a mid-April release of their yearling Coho salmon (USFWS 2004b). In recent years, a maximum size of 15 fish/lb and a preferred size of 18 fish/lb has been targeted to reduce excessive jack rates with high body fat percentages. Since RY 2012, the facility has achieved a mean juvenile size of 18.7 fish/lb at the time of release. Approximately 6.5% of the total number of juveniles that are released from the facility are AD and CWT. Another 6.5% is CWT only (Double Index Tagged, DIT fish) which is used to assess the impact of fishing pressures on wild populations. The remaining 86% of the juvenile Coho releases are AD only. The actual number of juveniles that are marked and tagged varies each year (Table 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. Data retrieved from CRiS SR80S File: 10/22/2021.

Release Year	Release Date	River Water Temp. 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
Mean		**5.5**	**23,139**	**23,336**	**308,704**	**560**	**355,739**	**18.7**

c) Transfer Data

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

Off-Station Juvenile Migration and Survival

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

a) PIT Tagging Program

At Eagle Creek NFH, no PIT tagging of the on-station juvenile releases is conducted given that juveniles migrate to the Pacific Ocean through the Clackamas, Willamette, and Columbia Rivers without passing over any major PIT tag detection locations. However, Mitchell Act funds are used to PIT tag Coho at Eagle Creek NFH for the Nez Perce Tribe and purchase an additional 5,000 PIT tags for the Nez Perce Tribe to tag Coho at Kooskia NFH. Approximately 10,000 juvenile Coho have been PIT tagged annually just prior to transfer to the Nez Perce Tribe program since RY 2013 (Table 11).

Table 11. 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: 9/8/2021.

Release Year	Tag Dates	# PIT Tagged
2013	18, 19, 20-Jan 2013	9,959
2014	14, 15, 16-Jan 2014	9,979
2015	21, 22, 23-Jan 2015	9,986
2016	12, 13, 14-Jan 2016	9,922
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
Mean		**9,421**

** 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 have fluctuated since BY 2005 (Table 12). Approximately 18% of adults are harvested in the Pacific Ocean as opposed to the 11% harvested in the Columbia River Basin. The facility has produced a mean of 6,842 adults annually since BY 2005 with a smolt-to-adult survival rate of 1.7% which is near the 10-year average goal of 2% set for the Coho program in the HGMP (USFWS 2004b).

Table 12. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded-wire tag recovery expansion data from RMIS for Coho released from Eagle Creek NFH. Adult returns are used to estimate smolt-to-adult survival rates. Data retrieved from CRiS Stock Assessment: 10/22/2021.

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2005	3,399	339	444	2	4,184	0.8
2006	11,425	1,530	5,243	55	18,253	3.6
2007	1,005	87	204	24	1,320	0.4
2008	1,418	123	146	26	1,713	0.5
2009	873	168	132	0	1,173	0.4
2010	3,372	81	442	0	3,895	1.1
2011	14,899	2,667	3,908	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
Mean	**4,824**	**738**	**1,260**	**20**	**6,842**	**1.7**

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 13). Zero returns Age-4 or greater have been documented. The facility has an annual mean of 4,959 adult returns to the facility since Return Year 2012.

Table 13. 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. Aging for 2021 has not yet been completed. Data retrieved from CRiS AGECOMP: 9/30/2021.

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	-	-	-	-	-	-	-
Mean	**320**	**9**	**4,639**	**91**	**0**	**0**	**4,959**

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 *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 2017 - 2019 are not yet complete. Data retrieved from CRiS AGECOMP: 9/30/2021.

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		5,014		-		-
2018	895		-		-		-
2019	-		-		-		-
Mean	**320**	**7**	**5,078**	**93**	**0**	**0**	**5,351**

Special Studies

In 2021, a study to examine the morphological variation of hatchery-reared Coho with different levels of predator burden (outer raceways versus inner raceways) began. Previous studies concluded hatchery-reared Coho possess a higher fineness ratio than their wild-run counterparts which is likely due to the relatively stable flow regime, easy access to food, and low predator abundance in the hatchery setting. A higher fineness ratio is more suitable for sustained/endurance swimming while, conversely, a lower fineness ratio is ideal for burst swimming. Burst swimming allows for more efficient escape responses and ram feeding and, therefore, increases the organism's chance of survival. If the raceways with higher predator influence (outer ponds) produce a fineness ratio similar to the North Fork Eagle Creek wild-run Coho population, then the potential probability of survival may increase. This information can be used to inform ponding plans with exposure to predators.

From 2005 through 2015, the USFWS conducted multiple year evaluations investigating the ecological and genetic interactions of hatchery and wild steelhead in Eagle Creek (Kavanagh et al. 2009, 2017). Brignon (2017) is an example of a recent publication from these evaluations.

Little White Salmon NFH: Spring Chinook Program

Little White Salmon NFH (Fig. 5) is located on the Little White Salmon River just upstream of Drano Lake, a small body of water that converges with the Columbia River at rkm 261. The facility is the oldest NFH in the Pacific Region (Fig. 1) becoming operational in 1898 to support the commercial fishing industry. In the late 1930s, the facility began receiving Mitchell Act funds to mitigate for habitat loss due to the completion of BONN. Mitchell Act funds are currently used for the annual production and PIT tagging of spring Chinook salmon into the Little White Salmon River as well as the transfer of URB fall Chinook eggs to Willard NFH and the Confederated Tribes and Bands of the Yakama Nation's Klickitat Hatchery. Additionally, the facility has an URB fall Chinook program with funding from the U.S. Army Corps of Engineers as part of the John Day/The Dalles Dam Mitigation (JDTD) Program. Broodstock need for the spring Chinook program at Little White Salmon NFH is a minimum of 1,000 adults. Currently, the broodstock need is met through adult returns to the facility.

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

On-Station Juvenile Production

a) Egg-to-Smolt Survival

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

1. 95% or higher survival from the egg to eye up stage
2. 90% survival from the egg to fry stage; and
3. 97% survival from fry to smolt stage

Mortality can occur during each of these life stages due to disease, injury, predation, starvation, deformities, and genetic anomalies. 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. The program has an annual juvenile release goal of 1,000,000 yearling spring Chinook into the Little White Salmon River. In Brood Year 2021, production was increased by 650,000 spring Chinook to benefit SRKW. To accommodate the increase in production, 575 females were spawned, an increase of 215 females from 360. Since RY 2012, the program has produced an annual mean of 1,078,712 yearling spring Chinook that were released into the Little White Salmon River in mid-April which is within 7.9% of the release goal (Table 15). From 2010 to 2014, a proportion of the programs juvenile production was reared and released at Willard NFH into the Little White Salmon River.

Approximately 10% of juveniles are AD and CWT. The remaining 90% of fish are AD only just prior to release (Table 15). 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 17.2 fish/lb which is near the program's goal of 15 fish/lb at release listed in the HGMP (USFWS 2004c).

Table 15. 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. Data retrieved from CRiS SR80S File: 10/22/2021.

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
	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
	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
	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
Annual Means	**LWS/WI**	**Mid-Apr**	**5.9**	**87, 316**	**991,396**	**1,078,712**	**17.2**

c) Transfer Data

Little White Salmon NFH does not transfer any spring Chinook yearlings as part of the Mitchell Act funded program; however, the facility does use Mitchell Act funds to transfer surplus eggs to other spring Chinook programs like Carson NFH. On October 21, 2021, approximately 147,000 spring Chinook gametes were provided to the new CTUIR Walla Walla hatchery to incubate and rear. 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.

Since 2018, 250,000 spring Chinook gametes are 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. Little White Salmon NFH has also provided unfertilized or newly fertilized eggs to programs that cannot filled by Carson NFH due to low returns.

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 14,960 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 16). 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 13 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 22 days after release versus 31 days after release from Willard NFH.

Table 16. 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: 9/8/2021.

Release Year	Release Site	# PIT Tagged	# Detected at BONN	% Detected	Mean	Range	50th	75th	90th
2012	LWS	11,959	1,003	8.4	11	(1 - 40)	7	18	24
	WI	2,960	273	9.2	25	(4 - 63)	26	29	33
2013	LWS	10,480	1,273	12.1	13	(1 - 41)	13	17	20
	WI	4,492	475	10.6	22	(4.5 - 66)	22	25	28
2014	LWS	11,991	1,325	11	13	(0.5 - 39)	12	20	24
	WI	2,989	302	10.1	23	(3.5 - 44)	24	28	31
2015	LWS	14,945	2,840	19	14	(0.5 - 44)	15	18	20
2016	LWS	14,974	2,097	14	11	(0.5 - 51)	11	15	19
2017	LWS	14,964	2,413	16.1	14	(0.5 - 40)	15	18	23
2018	LWS	14,935	1,418	9.5	12	(0.5 - 37)	10	19	24
2019	LWS	14,968	1,961	13.1	14	(1 - 46)	13	19	25
2020	LWS	14,964	2,413	16.1	14	(0.5 -40)	15	18	23
2021	LWS	14,983	2,449	16.3	11	(1.5 -37)	10	18	21
Mean	**LWS**	**14,960**	**1,919**	**13.6**	**13**		**12**	**18**	**22**
Mean	**WI**	**14,960**	**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 PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and

some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated in order to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged fish to estimate the detection probability at Bonneville Dam and estimate the apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 17, Figure 6). The variance of the estimates for each year (represented by the credible intervals) increases in the more recent years. This is due to the fact that adult returns are added 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 2012, median spring Chinook survival from release at Little White Salmon NFH (or Willard NFH) to Bonneville Dam averaged 0.89 (95% CI = 0.75 - 0.98).

Table 17. Little White Salmon NFH juvenile spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals. Data retrieved from PTAGIS: 10/15/2021.

Release Year	Median Survival	95% Lower	95% Upper
2012	0.95	0.83	1.00
2013	0.96	0.89	1.00
2014	0.90	0.77	1.00
2015	0.85	0.77	0.91
2016	0.96	0.89	1.00
2017	0.93	0.79	1.00
2018	0.88	0.65	1.00
2019	0.75	0.60	0.90
2020	0.84	0.63	1.00
2021	0.87	0.70	1.00
Mean	**0.89**	**0.75**	**0.98**

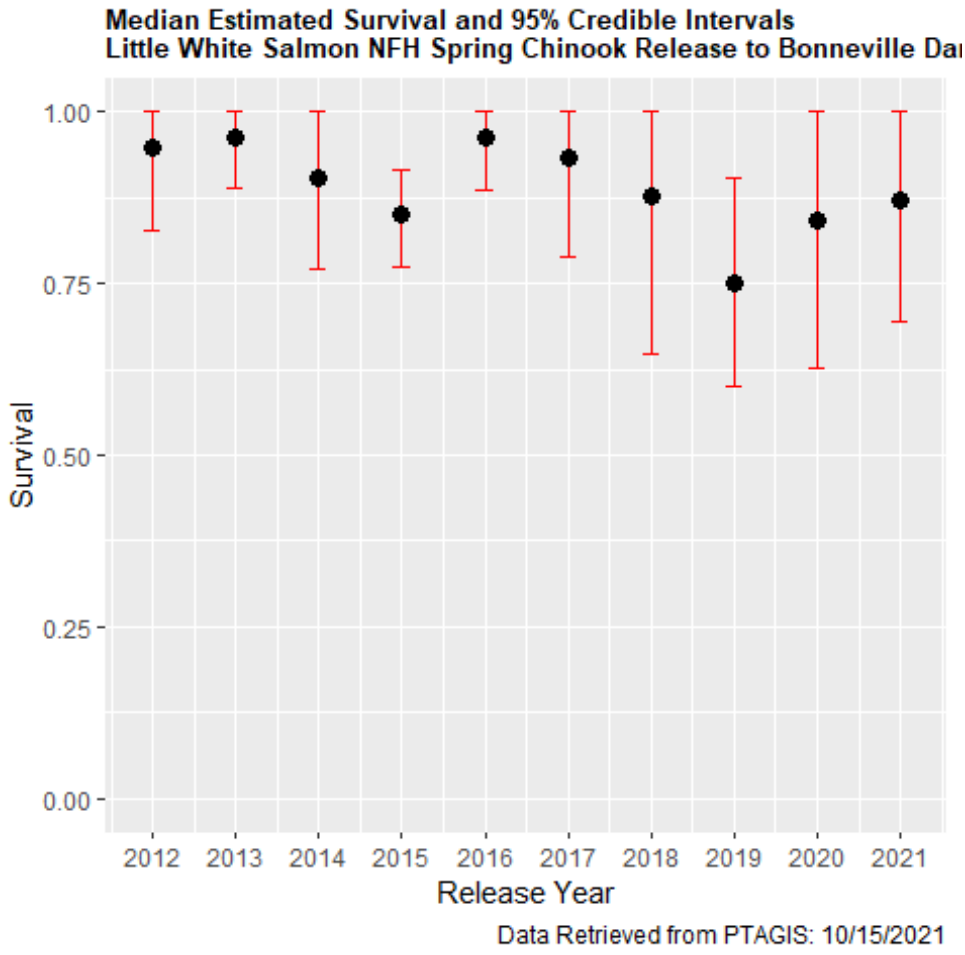

Figure 6. Little White Salmon NFH juvenile spring Chinook survival from release to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals

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 5,379 adults (Table 18). 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 7,493 adult spring Chinook since BY 2005 with a smolt-to-adult survival rate of 0.87% which is greater than the 0.2% rate set in the HGMP (USFWS 2004c).

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

Table 18. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds based on coded-wire tag recovery expansion data from RMIS for spring Chinook released from Little White Salmon (LWS) and Willard (WI) NFHs. Adult returns are used to estimate smolt-to-adult survival. Data retrieved from CRiS Stock Assessment: 9/30/2021.

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	3,880*	0.66
	WI	510	1,116	0	534	2,160	0.51
2008	LWS	1,784	1,480	0	8	3,272	0.56
	WI	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	0.59
	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
Mean	**LWS**	**3,406**	**3,717**	**4**	**366**	**7,493**	**0.87**
Mean	**WI**	**707**	**668**	**0**	**100**	**1,475**	**0.44**

*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.

An average 280 CWTs have been recovered each year at Little White Salmon NFH since 2012 (Table 19). The Little White Salmon NFH spring Chinook program accounts for 83.5 percent of all recoveries; spring Chinook from other programs include Carson NFH (11.2%), Willard NFH (5.2%), other state and federal fish hatcheries account for less than 0.1%.

Table 19. 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 RMIS: 10/22/2021.

Return Year	CWT Recoveries	Hatchery Origin	% of Total CWT Return
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
2014	63	Willard NFH	33.0
	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
2021	166	L. White Salmon NFH	84.3
	31	Carson NFH	15.7
Mean	**280**		

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 Apr-08 and as late as Jul-26 with the average median passage date May-04 (Table 20). 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 80% of the Bonneville Expansion.

Table 20. Median Bonneville Dam 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. Data retrieved from PTAGIS 9/30/2021.

Return Year	Bonneville Detections					Hatchery Detections					Actual Return	Actual Return/ Bonn Exp.
	Median	First	Last	Total	Bonn Exp.	Median	First	Last	Total	Ladder Exp.		
2012	May-08	Apr-20	May-17	36	2,827	May-15	May-15	May-29	13	1,021	2,891	102%
2013	May-03	Apr-08	May-26	40	3,086	May-16	Apr-28	Sep-28	22	1,692	3,678	119%
2014	May-01	Apr-12	Jul-25	110	7,095	May-14	May-04	Jun-29	33	2,128	2,967	42%
2015	Apr-25	Apr-10	Jun-01	158	10,939	May-27	Apr-27	Jun-08	54	3,739	7,786	71%
2016	May-03	Apr-16	May-20	87	6,297	May-09	May-08	May-29	30	2,172	4,404	70%
2017	May-20	Apr-21	Jul-26	79	5,528	May-20	May-09	Sep-12	35	2,454	5,423	98%
2018	May-07	Apr-21	Jun-05	99	8,568	May-12	May-06	Jun-24	20	1,725	3,748	44%
2019	May-02	Apr-20	May-22	82	5,975	May-13	May-03	Aug-22	37	2,674	2,806	47%
2020	Apr-30	Apr-12	May-27	26	1,874	May-10	May-04	Jun-21	14	1,008	2,592	138%
2021	May-02	Apr-20	May-25	51	3,556	May-07	May-02	May-23	19	1,324	2,353	66%
Mean	**May-04**	**Apr-16**	**Jun-06**	**77**	**5,575**	**May-14**	**May-04**	**Jul-07**	**28**	**1,994**	**3,865**	**80%**

d) Age Structure

Similar to Carson and Eagle Creek NFHs, aging of adult returns to Little White Salmon NFH are determined using CWT recoveries and scale sampling. On average, the majority (~89%) of spring Chinook return to Little White Salmon NFH as Age-4 adults (Table 21). Approximately 3% return as jacks at Age-3 and 8% of adults return to the facility at Age-5. For Return Years 2012-21, no Age-6 adults have been documented. The facility has a mean of 4,011 adult returns each year.

Table 21. 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 10/22/2021.

Return Year	Age-3	Age-3 Prop. (%)	Age-4	Age-4 Prop. (%)	Age-5	Age- 5 Prop. (%)	Age-6	Age-6 Prop. (%)	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
Mean	**126**	**3**	**3,575**	**89**	**310**	**8**	**0**	**0**	**4,011**

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 *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 2016 - 2018 are not yet complete. Data retrieved from CRiS 9/8/2021.

Brood Year	Age-3	Age-3 Prop. (%)	Age-4	Age-4 Prop. (%)	Age-5	Age-5 Prop. (%)	Age-6	Age-6 Prop. (%)	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	-	2,464	-	50	-	-	-	-
2017	49	-	2,241	-	-	-	-	-	-
2018	62	-	-	-	-	-	-	-	-
Mean	**130**	**4**	**3,543**	**88**	**295**	**9**	**0**	**0**	**4,252**

Special Studies

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

From 2018 to 2020, two release groups targeted different average release sizes for monitoring and comparison (Table 23). The majority of spring Chinook were reared at 20 fish/lb and one raceway targeted fish at 15 fish/lb. In 2018, chronic, low mortality BKD was diagnosed in the raceway with the 15 fish/lb target, medicated feed was administered, and fish only reached 17 fish/lb before release. Approximately 14% of the 15 fish/lb target and 12.7% of the 20 fish/lb target were detected at BONN. On average, the 15 fish/lb target took approximately 14 days and the 20 fish/lb target took 13 days after release for detection at BONN. The majority (90th percentile) of both 15 and 20 fish/lb targets passed over BONN within 24 days after release. No substantial difference in juvenile travel time was observed.

Table 23. Release date, total number, and travel times to Bonneville Dam following release into the Little White Salmon River of juvenile spring Chinook released at 15 fish/lb and 20 fish/lb targets. Data retrieved from PTAGIS 9/14/2020.

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

Willard NFH: Upriver Bright Fall Chinook Program

Willard NFH (Fig. 7) is located on the Little White Salmon River approximately 6.5 rkm upstream of Little White Salmon NFH (Fig. 1). Mitchell Act funds are cost shared with Bonneville Power Administration to fund Willard NFH's Coho program and the Confederated Tribes and Bands of the Yakama Nation Coho program. In 2013, Willard also began rearing URB fall Chinook with funding from the Mitchell Act. The purpose of the URB fall Chinook program at Willard NFH is to provide adults for harvest as mitigation for hydropower development on the mainstem of the Columbia River. A natural waterfall above Little White Salmon NFH prevents all adults from passing upstream to Willard NFH so broodstock need is provided by hatchery returns to Little White Salmon NFH. The current broodstock needed to meet Willard NFH's juvenile release goal is a minimum of 500 females or approximately 2.2 million eggs and is set by the USFWS. Little White Salmon NFH successfully fulfilled this broodstock need from BY 2013 to BY 2020 except in BY 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 2020 and 2021, production was increased by 200,000 URB fall Chinook to benefit SRKW. Since RY 2015, Willard NFH has produced a mean of 1,774,801 sub-yearling, URB fall Chinook and released into the Little White Salmon River in mid to late July which is within 11.3% of the release goal (Table 24). Approximately 6% of these juveniles were AD and CWT, and another 6% were CWT only (DIT fish). The remaining 83% of juveniles were AD only prior to release. In March and April 2020, marking was temporarily suspended due to COVID-19. Because of health and safety precautions and time constraints, it was necessary to

reduce the number of fish marked with AD only to 50% prior to release. In 2021, an extreme heat wave affected much of the Pacific Northwest. With high temperatures greater than 110°F in the forecast, the facility released juveniles earlier (June 29 -July 1) to avoid thermal stress from excessive heat and increased water temperatures.

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 87.2 fish/lb., near the program's goal of 70-90 fish/lb at release listed in the HGMP (USFWS 2004d).

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 9/8/2021.

Rel. Year	Rel. Dates	Rel. Loc.	Rel. River Temp (C)	AD + CWT	CWT (DIT)	AD Only	No Mark, No CWT	Total Rel.	Mean Size Fish/lb
2015	1-Jul	WI	7.6	100,029	100,038	1,603,197	0	1,803,264	81.8
2016	11-Jul	WI	6.4	99,698	99,462	1,361,075	577	1,560,812	101.5
2017	12-Jul	WI	7.1	97,906	99,687	1,685,042	381	1,883,016	96.5
2018	10-Jul	WI	6	49,691	49,749	857,967	303	957,710	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	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	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	85
	30-Jun, 1-Jul	LWS	7.2	49,610	48,577	780,239	1,444	879,870	81
Mean	**Mid-Jul**	**WI & LWS**	**7.1**	**99,475**	**99,542**	**1,464,441**	**111,343**	**1,774,801**	**87.2**

* Due to low adult returns at Little White 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

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 14,939 juveniles (Table 25). Approximately 7.4% of PIT tagged juveniles released at Willard NFH have been detected at BONN and 14.2% of fish released at Little White Salmon NFH/Drano Lake were detected; an average 8.6% 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 15 days to reach BONN with the majority of juveniles (90th percentile) passing over BONN within 21 days after release. Some individuals have spent up to 89 days between Willard NFH and BONN before migrating downstream.

Predation and passage within the Little White Salmon River between Willard and Little White Salmon NFHs may be contribute to low detection rates. Beginning in 2018, a strategy to address this concern was carried out by trucking half of the juveniles down to Little White Salmon NFH/Drano Lake for release. In 2018, the first truckload was released at Little White Salmon NFH, due to low water concerns, the remaining truckloads were released 1 km downstream at Drano Lake (future releases will take place at Little White Salmon NFH or Drano Lake depending on water conditions). The detection rate for Juvenile URB fall Chinook migrating over BONN was 150% greater for fish trucked down and released at Little White Salmon NFH/Drano Lake (mean = 14.2%) 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. Data retrieved from PTAGIS 9/8/2021.

Release Year	Release Site	# PIT Tagged	# Detected at BONN	% Detected	Range	50th	75th	90th
2015	WI	14,934	434	2.9	(5.5 - 287)	18	24	31
2016	WI	14,958	579	3.9	(2.5 -114)	13	15	17
2017	WI	14,895	680	4.6	(1.5 - 103)	9	14	17
2018	WI	7,489	750	10	(3.5 - 116)	11	13	18
	LWS	7,483	1,246	16.7	(1 - 42)	11	12	14
2019	WI	7,478	516	6.9	(3 – 303)	17	23	30
	LWS	7,479	849	11.4	(3 - 68)	13	17	22
2020	WI	7,422	989	13.3	(2.5 - 56)	16	18	23
	LWS	7,466	1,016	13.6	(5 - 56)	15	18	21
2021	WI	7,484	757	10.1	(3.5 - 41)	14	16	18
	LWS	7,487	1,135	15.2	(1.5 - 42)	11	14	16
Mean	**WI**	**14,939**	**672**	**7.4**	**-**	**14**	**18**	**22**
	LWS		**1,062**	**14.2**	**-**	**12**	**15**	**18**

b) Juvenile Survival

PIT tag detections can be used to estimate apparent juvenile survival after release downstream to Bonneville Dam. A PIT tagged downstream migrating juvenile fish can pass Bonneville Dam using a variety of routes, some of which have PIT tag detection arrays and some of which do not. For example, tagged fish passing through the turbines or through spillways would not be detected, while a fish passing through the juvenile bypass or corner collector could be detected. Since there is not 100% detection capability at Bonneville Dam, detection probability must be estimated in order to separate out a tagged fish that died before reaching Bonneville Dam from a tagged fish that was alive but was not detected as it passed Bonneville Dam. For this analysis, apparent survival from release to Bonneville Dam was estimated using the live recapture Cormack-Jolly-Seber model in Program MARK. The model uses encounter histories of tagged fish after passing downstream of Bonneville Dam to estimate Bonneville Dam's detection probability. This probability of detection at Bonneville Dam is then used to estimate apparent survival of fish from release to Bonneville Dam. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 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. This is due to the fact that 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 a 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 and

we were unable to generate encounter histories. We will, however, be able to back-calculate juvenile survival from the 2020 release based on adult returns in future years.

Since release year 2015, median survival of Willard NFH URB fall Chinook released at Little White Salmon NFH or Willard NFH to Bonneville Dam averaged 0.38 (95% CI = 0.24 - 0.52). 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. Data retrieved from PTAGIS: 10/15/2021.

Release Year	Median Survival	95% Lower	95% Upper
2015	0.27	0.16	0.41
2016	0.22	0.14	0.32
2017	0.21	0.12	0.31
2018	0.45	0.38	0.51
2019	0.37	0.26	0.46
2020	0.50	0.38	0.62
2021	0.66	0.25	1.00
Mean	**0.38**	**0.24**	**0.52**

Note: survival estimates vary greatly for the current year due to the limited time after release and number of fish detections downstream

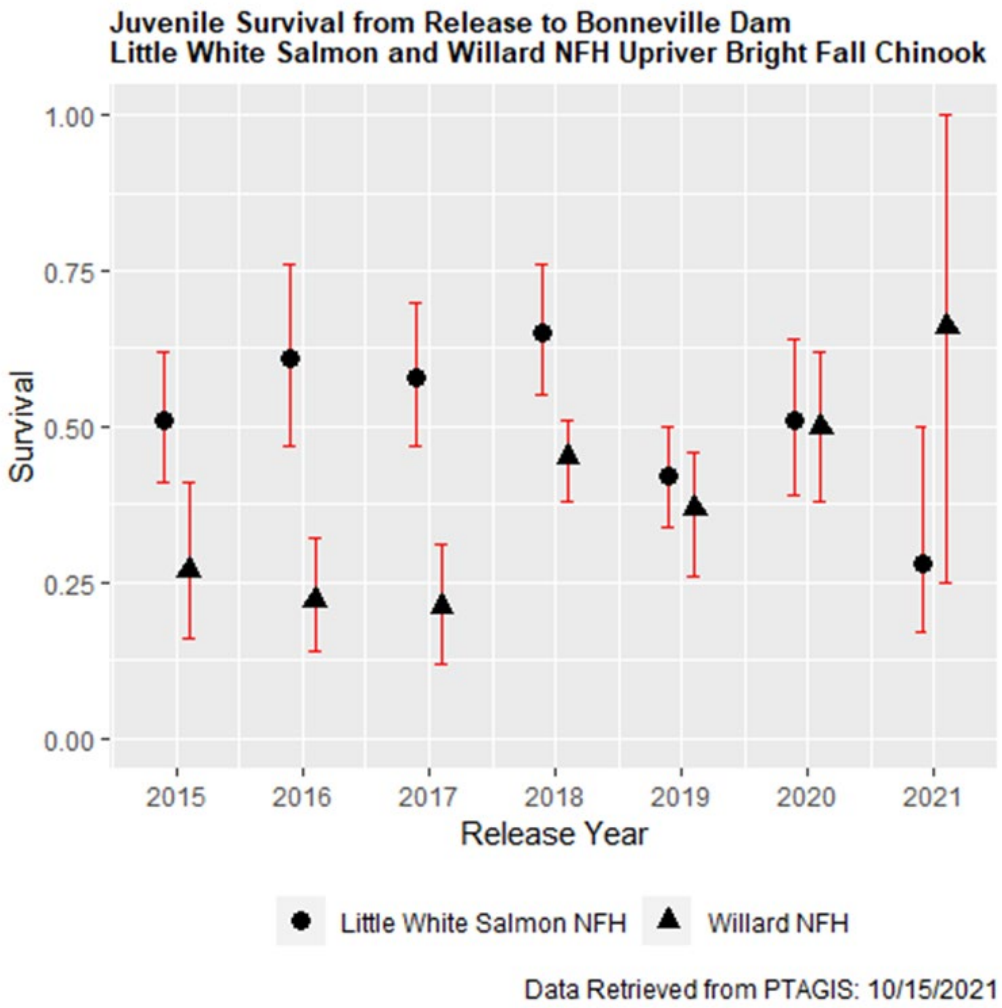

Figure 8. Estimated apparent survival of Willard and Little White Salmon NFH upriver bright fall Chinook (+/- 95% credible intervals). Survival estimates vary greatly for the current year due to the limited time after release and number of fish detections downstream.

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.

For Brood Year 2014, 248 adults returned to LWSNFH(Table 27). Approximately 48% of adult returns were harvested in the Columbia River, zero were harvested in the ocean and 2% were observed on spawning grounds. The facility produced 497 adult spring Chinook with a smolt-to-adult survival rate of 0.03% which is less than the 0.32% 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. Data retrieved from CRiS Stock Assessment: 9/30/2021.

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

d) Age Structure

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

Special Studies

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

Starting with the brood year 2017 release in 2018, Willard NFH investigated trucking a portion of their release downstream to Little White Salmon NFH and Drano Lake. The objective of the study was to assess whether the low apparent juvenile survival of the Willard program was due to factors in the Little White Salmon River, between the hatchery release site and Little White Salmon NFH. For brood years 2017-2020 (release years 2018-2021) a portion of the hatchery production was trucked downstream to the Little White Salmon River at Little White NFH. Differential PIT tagging and coded-wire tagging was conducted, and juvenile survival and subsequent adult returns will be monitored. For 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 44% for hatchery release vs 61% 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. Release year 2021 will be monitored to see if the trend holds. Additionally, adult returns will be monitored to see if juvenile survival translates into adult survival, as well as if differences in stray rates of adult returns are found.

Table 28. Willard NFH juvenile upriver bright fall Chinook survival to Bonneville Dam from release at Willard NFH or trucked to Little White NFH. Release year is one year after brood year. Estimates are median survival and lower and upper credible intervals. Data retrieved from PTAGIS: 10/15/2021.

	Release Year	Stock	Release Site	Median Survival	95% Lower	95% Upper
	2018	Willard	Willard NFH	0.33	0.24	0.42
		Willard	Little White NFH	0.60	0.49	0.72
		Little White	Little White NFH	0.65	0.55	0.76
	2019	Willard	Willard NFH	0.26	0.15	0.41
		Willard	Little White NFH	0.53	0.35	0.77
		Little White	Little White NFH	0.42	0.34	0.50
	2020	Willard	Willard NFH	0.44	0.29	0.67
		Willard	Little White NFH	0.55	0.38	0.75
		Little White	Little White NFH	0.51	0.39	0.64
	2021	Willard	Willard NFH	0.72	0.24	1.00
		Willard	Little White NFH	0.77	0.46	1.00
		Little White	Little White NFH	0.28	0.17	0.50
Mean		**Willard**	**Willard NFH**	**0.44**	**0.23**	**0.62**
		Willard	**Little White NFH**	**0.61**	**0.42**	**0.81**
		Little White	**Little White NFH**	**0.47**	**0.36**	**0.60**

Note: survival estimates vary greatly for the current year due to the limited time after release and number of fish detections downstream

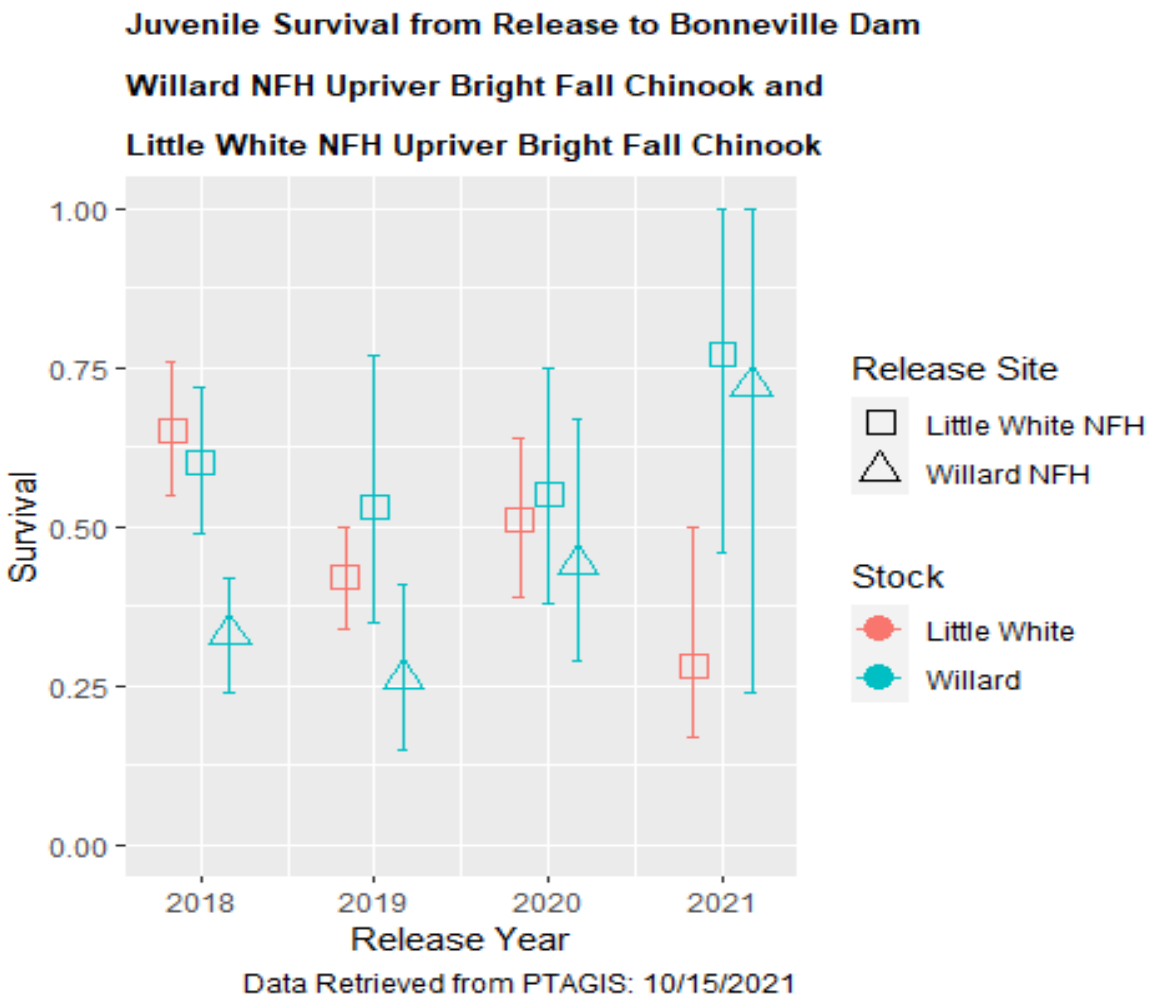

Figure 9. Willard NFH juvenile upriver bright (URB) fall Chinook survival to Bonneville Dam from release at Willard NFH or trucked to Little White NFH compared to Little White Salmon URB Fall Chinook survival to Bonneville Dam from release at Little White NFH. Release year is one year after brood year. Estimates are median survival and lower and upper credible intervals; Survival estimates vary greatly for the current year due to the limited time after release and number of fish detections downstream.

Precocial Juvenile Monitoring

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

- "The incidental take through ecological interactions relating specifically to residualization shall have been exceeded if the percent of yearling releases that are

determined to be precocially mature exceeds 5% in any one year, or if the 5-year average exceeds 3% at any time. Section 2.8.1 Amount and Extent of Take (p. 415)"

- "Terms and Conditions # 5 b) NMFS shall require funding grantees to report to NMFS the estimated proportion of precocial male smolts released annually from each program."

Our sampling for precocial fish included sixty fish from each program's on station release, sampled within 2-8 weeks of their scheduled release date (Table 29). Fish were netted from the front, middle, and end of representative raceways (i.e. about 10 fish/raceway; not all raceways were sampled). During the fish health exams (lethal), the size of the gonads (i.e. testes present/ not present) were also observed. Our sampling rate was based on statistics. If zero fish are precocial out of a 60 fish sample, then the precocial rate probability is less than 5% with a 95% C.I. If one fish is precocial out of a sample of 100, the probability is still <5% precocial rate with a 95% C.I. (Table 30). No precocial fish were observed during the fish health exams at any facility in 2021.

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 - 2021	Carson NFH	60	0
2018 - 2021	Eagle Creek NFH	60	0
2018 - 2021	Little White Salmon NFH	60	0
2018 - 2021	Willard NFH	60	0

Table 30. Analysis of the probability that the precocial rate is less than 5% with a 95% C.I.

SampleSize	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 10-year-averages, Carson, Eagle Creek, and Little White Salmon have reached their production goals set under *U.S. v. Oregon* agreements. All but the Willard NFH

URB fall Chinook program have remained within 8% of their target release number and successfully collected enough eggs or produced enough juveniles to either meet or be close to meeting their transfer goals to other programs or facilities in most years. Additionally, the programs at Carson, Eagle Creek, and Little White Salmon NFHs have been close to or exceeded their 10-year-average, smolt-to-adult survival rate goals as outlined in their respective HGMPs. In most of the past 10 years, all programs have produced enough adult returns to sufficiently meet their on-station broodstock needs except the Carson spring Chinook program in 2016 and 2018 - 2020, the Eagle Creek Coho program in 2012, and the Willard URB fall Chinook program in 2018. Based on the age structure of adult returns, jack rates at the facilities are relatively low (i.e., 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 will be used to estimate the number of mini-jack/precocial fish either a) migrating back upstream over BONN during the year of release, or b) returning to the hatchery during the year of release.

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.

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.

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. Haeseker. 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). 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.

Poirier, J., B. Davis, and J. Harris. 2020. Feasibility Assessment of Stocking YY Males to Eradicate Nonnative Brook Trout from Tyee Springs. https://www.fws.gov/CRFWCO/publications/Poirier_2020_YYMale_Progress_Report.pdf.

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.

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.

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). 2013. PIT-Tag Effects Study: Carson National Fish Hatchery Spring Chinook Salmon. https://www.fws.gov/columbiariver/publications/PTES_fact_sheet.pdf.

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.