

Warm Springs National Fish Hatchery - Spring Chinook Salmon Program FY 2021 Annual Report

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In 1966, congress authorized the Warm Springs National Fish Hatchery to stock salmon and trout within the Confederated Tribes of the Warm Springs Reservation of Oregon reservation to increase tribal harvest opportunities. The current focus of the Warm Springs National Fish Hatchery is to produce spring Chinook Salmon for tribal harvest in the Deschutes and Columbia River and for on-reservation distribution to tribal members. The facility is managed as an integrated hatchery program to minimize genetic divergence between Warm Springs River hatchery and wild stocks. The Columbia River Fish and Wildlife Conservation Office conducts monitoring and evaluation of this hatchery program. This report summarizes broodstock need, juvenile production levels, and marking and tagging information for the past ten years. After juvenile release, the detection rates at Bonneville Dam, juvenile survival, adult returns, smolt-to-adult survival rates inferred from coded-wire tag recoveries, and adult age structures are reported. Special studies and recommendations for future studies supported by U.S. Fish and Wildlife Service funds are also discussed.

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On the Cover: Aerial photograph of Warm Springs NFH located along the Warm Springs River, within the Warm Springs Reservation of OR. U.S. Fish and Wildlife Service stock photograph.

Disclaimer:

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Introduction

Salmon are an integral part of the spiritual and cultural identity of the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) and are an essential component of their traditional and contemporary diet. Each year, returning salmon allow the transfer of traditional values from generation to generation. It is a tribal priority to meet current and future needs of the resource as well as those of the Tribes. Because the CTWSRO tribal population is growing, the need for salmon is more important than ever.

The tribes, states, and federal government share the responsibility to protect fish habitat and enhance fish runs in all waters. The Treaty of 1855 recognizes tribal sovereignty as the right of the CTWSRO to govern their members and manage their territories and resources. Furthermore, the federal government and its implementing agencies owe an affirmative duty to use their expertise and authority in meaningful consultation with CTWSRO and safeguard natural resources of crucial importance to self-government and prosperity. In 1959, the CTWSRO requested the U.S. Fish and Wildlife Service (USFWS) investigate the possibilities of salmon and Steelhead enhancement on the Reservation. It was determined that operation of a national fish hatchery on the Reservation was pivotal for the enhancement of the anadromous fish runs. On May 31, 1966, Warm Springs National Fish Hatchery (WSNFH) was authorized by Federal Statute 184 to stock salmon and trout within the CTWSRO reservation to increase tribal harvest opportunities. Since 1978, WSNFH has supplemented fish for harvest in the waters of the Warm Springs Reservation. Production from the hatchery is considered essential for the enhancement of spring Chinook Salmon (*Oncorhynchus tshawytscha*) populations and meeting tribal trust responsibilities.

The CTWSRO has the principal management responsibility for fishery resources on the Warm Springs Reservation. Since 1977 the USFWS and CTWSRO have worked together to draft hatchery operations and management plans to assure the operation of the hatchery is compatible with and compliments the Tribes' fishery management goals. This cooperative management of the hatchery provides tribal and sport harvest opportunities, enhances anadromous fish runs in Reservation waters, and meets the future needs of the resource and those of the Tribes while protecting wild fish populations.

The current focus of the WSNFH is to produce spring Chinook Salmon for tribal harvest in the Deschutes and Columbia River and for on-reservation distribution to tribal members. The facility is managed as an integrated hatchery program. The Service and Tribes have taken this integrated approach to managing the hatchery to not only produce fish, but also minimize genetic divergence between Warm Springs River hatchery and wild stocks, as well as determine what effects hatchery fish have on the ecosystem into which they are released (Olson et al. 2004). The Warm Springs River is one of two rivers in the Deschutes River subbasin that supports natural production of spring Chinook Salmon. Although spring Chinook Salmon are not listed under the Endangered Species Act (ESA), the WSNFH program does cause interactions with listed Mid-Columbia River summer Steelhead (Olson and Spatcholts 2001). The safe passage of all wild fish populations, both downstream and upstream of WSNFH, is also an important goal. The hatchery is operated in compliance with the ESA (National Marine Fisheries Service (NMFS) 2007) and consistent with the 2018 - 2027 *United States v. Oregon* Management Agreement

(NMFS 2018). The purpose of this report is to summarize programs conducted at the facility over the past ten years and describe special studies conducted and supported by USFWS funds.

Program Description

Warm Springs NFH is located at river kilometer (rkm) 16 of the Warm Springs River, within the Warm Springs Reservation of Oregon, approximately 23 kilometers (km) north of the town of Warm Springs (Fig. 1). The Warm Springs River enters the Deschutes River at rkm 135, which enters the Columbia River 329 km from the Pacific Ocean. It is upstream of two main-stem dams on the Columbia River, Bonneville (rkm 235) and The Dalles (rkm 308), and downstream of the Pelton/Round Butte (rkm 161) dams on the Deschutes River. The facility is part of the Columbia River Gorge Complex and operated by the USFWS on land and water leased from the CTWSRO. The water intake structure and pumps are located at the hatchery site just upstream of a barrier dam across the Warm Springs River, adjacent to the hatchery facility. Prior water intake, water passes through a trash rack and traveling screen. The primary prevention of fish entrainment is the drum screens located in the intake structure behind the trash racks. In addition, a redundant fish bypass located in front of the traveling screens may deposit small fish below the barrier dam.

The hatchery currently has a staff of five full-time USFWS employees; the hatchery manager, three animal caretakers, and a maintenance mechanic. The Pacific Region Fish Health Program (PRFHP) manages fish health and disease prevention in accordance with USFWS Fish Health Policy and Implementation Guidelines and IHOT policies ([Integrated Hatchery Operations Team \(IHOT\) 1995](#); USFWS 1995, 2004) and with protocols of Oregon Department of Fish and Wildlife (ODFW). Fish health personnel promptly manage any health problems to limit mortality and reduce disease transmission.

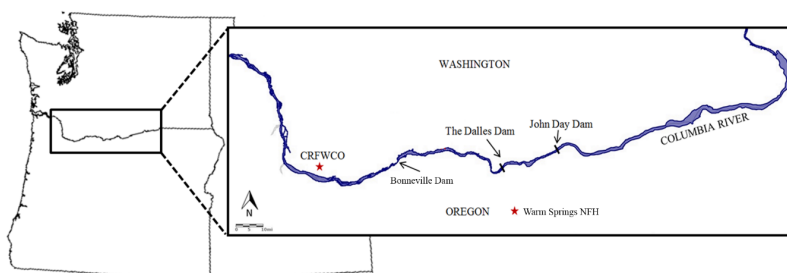


Figure 2. The Warm Springs NFH is located within the Warm Springs Reservation of Oregon and uses funds from the USFWS to support its rearing program.

Past Objectives

Fish production began in 1978 with eggs from wild spring Chinook Salmon and steelhead (*O. mykiss*) captured from the existing natural runs passing the hatchery site. The steelhead program was terminated in 1981 because of disease, growth problems and physical limitations of the facility. To protect wild steelhead, only wild steelhead are passed above WSNFH and all known hatchery origin steelhead are sacrificed and distributed to the CTWSRO.

In 1984, the CTWSRO asserted that separating the hatchery and natural producing fish would best serve the fish and the needs of the tribal people. The CTWSRO proposed a two-stock concept, whereby only wild (unmarked) fish are passed above the hatchery. To this end, 100 percent of fish released from the hatchery are marked with a coded-wire tag (CWT) and an adipose fin-clip (AD) to distinguish them from wild fish. The differential marking of hatchery and wild fish provides consistent long-term data on the life-history patterns and possible changes that may occur within stocks. It also allows for maintenance of the genetic integrity of the naturally producing stock. The hatchery tries to maintain the genetic and life-history characteristics of the wild population in the hatchery environment by incorporating wild fish into its broodstock, but only when wild returns are greater than 1,000 adults. The minimum escapement goal for naturally produced spring Chinook salmon above the hatchery is 1,000 adults, with a long-term goal of a run of 2,800, similar to runs before the hatchery was constructed (CTWSRO and USFWS 2007).

In 1996, WSNFH installed an automated fish passage system to minimize handling of natural fish and reduce pre-spawn mortality by separating out returning hatchery spring Chinook salmon with CWTs. During the spring Chinook migration period, generally from April 15th to September 30th, the barrier dam directed fish into the adult ladder. Fish swam through a tube in the adult ladder, which triggered a pneumatic gate if a CWT was detected. The goal was to have all CWT hatchery fish shunted to a holding pond and pass non-tagged fish to another catch pond where an underwater video camera monitored them as they swam out through the ladder and upstream of the hatchery. The minimum operating standard for the system was the removal of 95 percent of the fish with CWTs and 95 percent accuracy in counting upstream bound fish. However, the passage system failed to meet the efficiency standards and cost for upgrade was more than \$75,000 (Archibald 2013). In 2014, the system was decommissioned, and hatchery personnel manually sort all fish trapped in the holding ponds.

The release goal for juvenile spring Chinook released from the hatchery has ranged from 400,000 to 1.2 million during 1978 through 1991. From 1992 to the present, the juvenile release goal has been consistently set at 750,000. From brood years (BY) 1979 to 2007, there have been two release strategies, spring and fall. For brood years 1979 to 1992, a graded fall release strategy was employed. During this time, raceways were graded, with the larger fish being released into the Warm Springs River during the fall. Between brood years 1993 and 2007, a fall volitional release strategy was used at WSNFH. The fall volitional release strategy was a partial volitional release, where raceways were opened for approximately 4 weeks, between October and November, and fish could volitionally exit the hatchery and enter the Warm Springs River. Based on PIT tag monitoring of the fall release, anywhere from 10% to 60% of the fish in a raceway would exit during the fall period. Once the fall volitional release period ended, the raceways were closed and the remaining fish would be released the following spring, generally

during a spring volitional release period of late-March through April. Fish remaining at the end of April were forced out to make room for the next year's brood. Studies from the 1980s indicated that most smolts released in the spring reached the estuary within three to four weeks, the behavior of fish released in the fall was not clear (Cates 1992). Scale analysis of adult returns indicated that most fall-released fish that ultimately survived to adulthood over-wintered in fresh water before migrating to the ocean the following spring. Follow-up studies from 2000 to 2003 indicated that some fish released in the fall (5% to 36% of the total release each year) quickly migrated downstream and exited the Deschutes River within days of release; however, most of the fish released in the fall overwintered in the Deschutes River (Reagan et al. 2005). The size at release of fish at the hatchery was reduced during the early 2000s, from a size at spring release of 10-15 fish per pound to 20-30 fish per pound. It was thought that the smaller size of fish reared at WSNFH may have contributed to the overwintering behavior of the fall released fish (Reagan et al. 2005). Subsequent studies (brood years 2005-2007) using PIT tag detections of fish leaving the hatchery found that very few fish that left the hatchery during the fall survived to migrate downstream to Bonneville Dam or survived to adult return. The fall volitional release strategy ended with brood year 2007. A spring only release has been used at the hatchery since brood year 2008.

Present Objectives

Operations at the hatchery presently consist of adult collection, egg incubation and rearing of spring Chinook salmon. The current hatchery broodstock objective is to spawn 650 - 693 Chinook Salmon adults with a 60:40 female:male spawning ratio with jacks (< 60 cm in length) making up 5% of the broodstock (USFWS 2019). To account for 10% mortality between collection and spawning, 726-770 adults will be collected for broodstock proportionately through the run based on wild stock timing and may be adjusted if temperatures exceed 16 °C. To maintain the stock integrity and genetic diversity of hatchery and wild spring Chinook salmon, approximately 10 percent natural origin fish have been incorporated into broodstock collection based on pre-season forecasts and in-season run size updates. However, if the wild run is less than 1,000 fish, no wild fish will be collected for broodstock. In a USFWS review of the WSNFH spring Chinook salmon program, the Hatchery Review Team (USFWS 2006) recommended that the program maintain the current goal of a minimum of 10 percent natural-origin spring Chinook Salmon in the broodstock and continue to limit hatchery-origin spring Chinook salmon on the spawning grounds to less than 10 percent. Small numbers of wild adult returns over the past decade has resulted in no wild fish being incorporated into the hatchery broodstock in most years. Remaining surplus hatchery origin spring Chinook salmon are dispatched and provided to the CTWSRO for tribal needs. After spawning, spring Chinook salmon are either placed in a landfill or are used for nutrient enhancement after they have been screened for disease and treated (eviscerated and heat-baked) to prevent disease transmission.

During years of low returns to the hatchery or unexpected losses to production, consideration has been given to augmenting the hatchery production with eggs or juveniles from other hatchery programs. The primary source of eggs during years of shortfall is from ODFW's Round Butte Hatchery (RB), located within the Deschutes River basin. Eggs and juveniles from Parkdale Hatchery, located within the Hood River basin, have also been used to augment the WSNFH production in recent years. To maintain the WSNFH genetic stock, any releases from non-WSNFH stocks are differentially marked (e.g., left or right ventral clip) and coded-wire tagged

to distinguish them from WSNFH fish upon return. These stocks are excluded from the broodstock and distributed to the CTWSRO or to RB if needed. If returns to WSNFH are projected to be below broodstock needs, RB fish returning to WSNFH may be spawned and their progeny reared and marked separately from WSNFH stock. The performance of Parkdale and Round Butte stocks reared and released at Warm Springs NFH is currently being assessed.

The current production goal is on-station spring release of 750,000 (+/- 10%) externally marked smolts into the Warm Springs River (NMFS 2018). All juvenile fish released from the hatchery are marked (CWT and AD) to differentiate them from naturally produced fish upon return. Approximately 15,000 juveniles have been PIT tagged annually since BY 2005 (migration year 2007).

Hatchery Management Goals (USFWS 2019)

1. Produce Spring Chinook Salmon consistent with *United States v. Oregon* production goals for annual tribal harvest opportunity in Deschutes River and Columbia River fisheries
2. Provide for distribution to tribal members and the community freezer at CTWSRO
3. Provide safe passage for wild fish consistent with CTWSRO management of the Warm Springs River

CRFWCO Monitoring and Evaluation Objectives:

1. Monitor and evaluate on-station rearing strategies
 2. Monitor and evaluate juvenile releases, off-station juvenile survival, and migration
 3. Monitor release to adult return survival
 4. Develop run-reconstruction of adult returns, including contribution to harvest and returns to the hatchery
 5. Produce run forecasts for wild and hatchery returns
 6. Track passage of wild fish
 7. Conduct special studies as needed in consultation with the Warm Springs Hatchery Evaluation Team
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Hatchery Operations Summary

On-Station Juvenile Production

a) Egg-to-Smolt Survival

Survival metrics during the early life stages 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 <0.2 to minimize disease risk (USFWS 2019). Hatchery staff report these metrics to describe their production levels and determine whether alternative rearing and release practices are needed to improve on-station survival when warranted. This data is collected by hatchery staff and is not part of this report. A bulleted summary of infrastructure modifications or on-station rearing notes unique to 2021 can be found in Appendix A.

b) Juvenile Marking, Tagging, and Release Data

Funds distributed by the USFWS are used to meet annual juvenile release goals, process adult returns, for costs associated with PIT tagging, and for equipment maintenance. The facility has an annual release goal of 750,000 spring Chinook salmon into the Warm Springs River. Fish released contribute to sport, commercial, and tribal fisheries while also providing for adequate escapement for hatchery production. The actual number of juveniles produced at WSNFH has varied by release year (Table 1) with a total annual mean of 539,371 juveniles released since release year (RY) 2012.

Since RY 2012, the facility has achieved a mean juvenile size of 31.8 fish/lb. at the time of release. While all juveniles are given an adipose fin (AD) clip and coded wire tag (CWT), the actual number of fish with clips and tags at release is estimated based on clip quality and tag retention sampling. Approximately 97% of the total number of juveniles released are AD and CWTed, with the remaining 3% released as AD only due to coded-wire tag loss and a very small percentage with no mark and no CWT (due to missing marks during the marking process). 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).

In fall 2017, WSNFH requested surplus eggs from Round Butte state hatchery due to concerns about another year of high egg loss. Fortunately, the brood year 2017 production did not experience elevated losses, however this led them to have extra juveniles on station above their 750,000 +/- 10% target (~65,000 above the high end 825,000 allowable). A one-time release of the extra 65,000 spring Chinook juveniles on-station was determined not to have a substantial effect on ESA-listed species above and beyond what was considered in the USFWS BiOp covering the WSNFH program (Rich Turner, 3/18/2019).

Table 1. Annual juvenile spring Chinook release dates from Warm Springs NFH into the Warm Springs River. Releases include Warm Springs Stock, Round Butte Stock (A), and Parkdale Stock (B). Round Butte stock fish were identified by a left ventral mark and Parkdale stock fish were identified by a right ventral mark in addition to the AD to distinguish stocks. Data includes marking and tagging information, number of juveniles released, release type forced (F), volitional (V), or accidental (A), and mean juvenile size at release. Data retrieved from CRiS 11/8/2021.

Release Year	Brood Year	Release Dates	Release Temp (C)	Release Type	AD + CWT	AD Only	CWT Retention	Total Released	Mean Size (Fish/lb)
2012	2010	2 – 26-Apr	10	V	471,834	9,110	96.4	480,944	29
2013	2011	27-Mar – 10-Apr	-	V	770,451	13,095	99.3	783,546	24
2013	2012	6-May	-	A	19,908	242	98	20,150	160
2014	2012	31-Mar – 4-Apr	12.1	F	713,563	13,379	98	726,942	24
2015	2013	30, 31-Mar	8	F	344,834	26,621	93.1	371,455	28
2016	2014	30-Mar	10.6	F	129,349	3,682	93.5	133,031	22
2017	2015	30-Mar	6.7	F	396,864	17,451	95.8	414,315	24
2017	2015 (B)	30-Mar	5.6	F	112,460	6,939	94.2	119,399†	30
2018	2016	29-Mar	7	F	533,560	7,881	98.9	541,441	22
2019	2017	3, 5-Apr	7.8	F	736,730	27,510	96.4	764,240	26
2019	2017 (A)	3-Apr	8.8	F	120,045	3,496	97.2	123,541*	30
2020	2018	8-Apr	8.3	F	277,211	3,922	98.6	281,133	24.8
2020	2018 (A)	8-Apr	8.3	F	228,470	1,840	99.2	230,310*	24.3
2020	2018 (B)	8-Apr	8.3	F	135,798	0	100	135,798†	23.3
2021	2019	8-Apr	6.4	F	263,732	3,729	98.4	267,461	21.57
Mean by Stock	Warm Springs				423,458	11,511	96.9	434,969	37
Mean by Stock	Round Butte (A)				174,258	2,668	98.2	176,926	27
Mean by Stock	Parkdale (B)				124,129	3,470	97.1	127,598	27
Total Annual Mean			8.5		525,481	13,890	96.8	539,371	31.8

* Left ventral clip to distinguish as Round Butte Stock

† Right ventral clip to distinguish as Parkdale Stock

Off-Station Juvenile Production

a) PIT Tagging Program

PIT tagging provides real-time tracking data as fish migrate from the Warm Springs 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) and utilized by staff at CRFWCO to estimate juvenile post-release migration and survival, track adult returns, and estimate stray rates. In release years (RY) 2012-2021, approximately 15,000 juvenile spring Chinook were annually tagged with passive integrated transponder (PIT) tags in late January or early February during the year of release from WSNFH (Table 2).

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. Since RY 2012, an average 15,275 juveniles have been PIT tagged at and released from WSNFH each year. The mean annual number of detections at BONN is 1,198, a detection rate of 7.7%. Average mean juvenile travel time to BONN after release is approximately 25 days with some juveniles spending up to 121 days between the facility and BONN before migrating downstream. Juveniles travel downstream and pass over BONN as quickly as 13 days or less after release (10th percentile mean). However, the majority of fish (90th percentile) pass over BONN within 35 days after release.

Table 2. The number of juvenile spring Chinook PIT tagged in a given release year and travel times in days (D) to Bonneville Dam (BONN) following release from Warm Springs NFH. Migration times to BONN may be underestimated in release years 2012 -2013 due to PIT tagged fish having the option to exit ponds volitionally eight days before being forced into the Warm Springs River. Releases include Warm Springs Stock, Round Butte Stock (A), and Parkdale Stock (B). Data retrieved from PTAGIS 11/8/2021.

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Mean (D)	Median (D)	Range (D)	10 th Percentile (D)	75 th Percentile (D)	90 th Percentile (D)
2012	14,862	906	6.1	35	37	(5 – 106)	21	41	45
2013	14,965	1,244	8.3	28	29	(3 – 102)	15	31	35
2014	14,898	1,107	7.4	30	31	(4 – 121)	19	35	41
2015	14,915	1,425	9.6	21	23	(3 – 96)	7	28	33
2016	14,975	1,345	9	19	17	(3 – 118)	8	23	30
2017	9,896	289	2.9	25	27	(3 – 84)	7	34	37
2017 (B)	4,972	95	1.9	34	36	(4 – 56)	15	41	51
2018	14,903	955	6.4	24	26	(4 – 56)	9	33	36
2019	12,887	1,141	8.9	24	23	(3 – 94)	11	30	35
2019 (A)	2,097	160	7.6	30	30	(8 - 48)	22	35	38
2020	7,944	775	9.8	18	17	(4.5 - 121)	10	21	27
2020 (A)	6,566	598	9.1	18	18	(4.5 - 111)	10	21	25
2020 (B)	3,884	353	9.1	18	17	(4.5 - 106)	10	21	27
2021	14,986	1,585	10.6	18	19	(4.5 - 38)	12	21	24
Warm Springs	13,523	1,077	7.9	24	25		12	30	34
Round Butte (A)	4,332	379	8.4	24	24		16	28	32
Parkdale (B)	4,428	224	5.5	26	26		12	31	39
Total Annual Mean	15,275	1,198	7.7	25	26		13	30	35

b) Juvenile Survival

PIT tag detection histories are used to estimate the apparent juvenile survival from release at WSNFH downstream to BONN. A PIT tagged downstream migrating juvenile fish can pass BONN 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 BONN, detection probability must be estimated in order to separate out a tagged fish that died before reaching BONN from a tagged fish that was alive but was not detected as it passed BONN. For this analysis, apparent survival from release to BONN 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 BONN and estimate the apparent survival of fish from release to BONN. Survival estimates are reported on a scale from 0.0 to 1.0 (Table 3, Figure 2). To account for minijack returns, all juveniles detected at BONN before June 1 and in the juvenile bypass or corner collector after June 1 of their release year were considered juvenile detections. Minijacks detected in adult ladders after June 30 were considered downstream detections. As a note, the term “apparent survival” is used to indicate that a tagged fish that is alive, but never migrates past BONN, is considered a “mortality” in the model.

Estimated apparent juvenile survival of the Warm Springs NFH spring Chinook for brood years 2010-2019 (release years 2012-2021) ranged from 0.50 to 0.80 (Table 3; Figure 2).

Table 3. Juvenile Spring Chinook survival from release at Warm Springs NFH to Bonneville Dam. Release year is two years after brood year. Estimates are median survival and lower and upper credible intervals. The Markov chain Monte Carlo Bayesian parameter estimation method in MARK was used to estimate the variance of the estimated survival. Data retrieved from PTAGIS: 1/28/2022.

Release Year	Brood Year	Median Survival	95% Lower	95% Upper
2012	2010	0.54	0.41	0.67
2013	2011	0.70	0.57	0.86
2014	2012	0.71	0.53	0.90
2015	2013	0.50	0.41	0.59
2016	2014	0.64	0.45	0.83
2017	2015	0.56	0.20	0.92
2018	2016	0.70	0.41	0.99
2019	2017	0.57	0.39	0.79
2020	2018	0.80	0.46	0.99
2021	2019	0.51	0.32	0.78
Mean		0.62	0.42	0.83

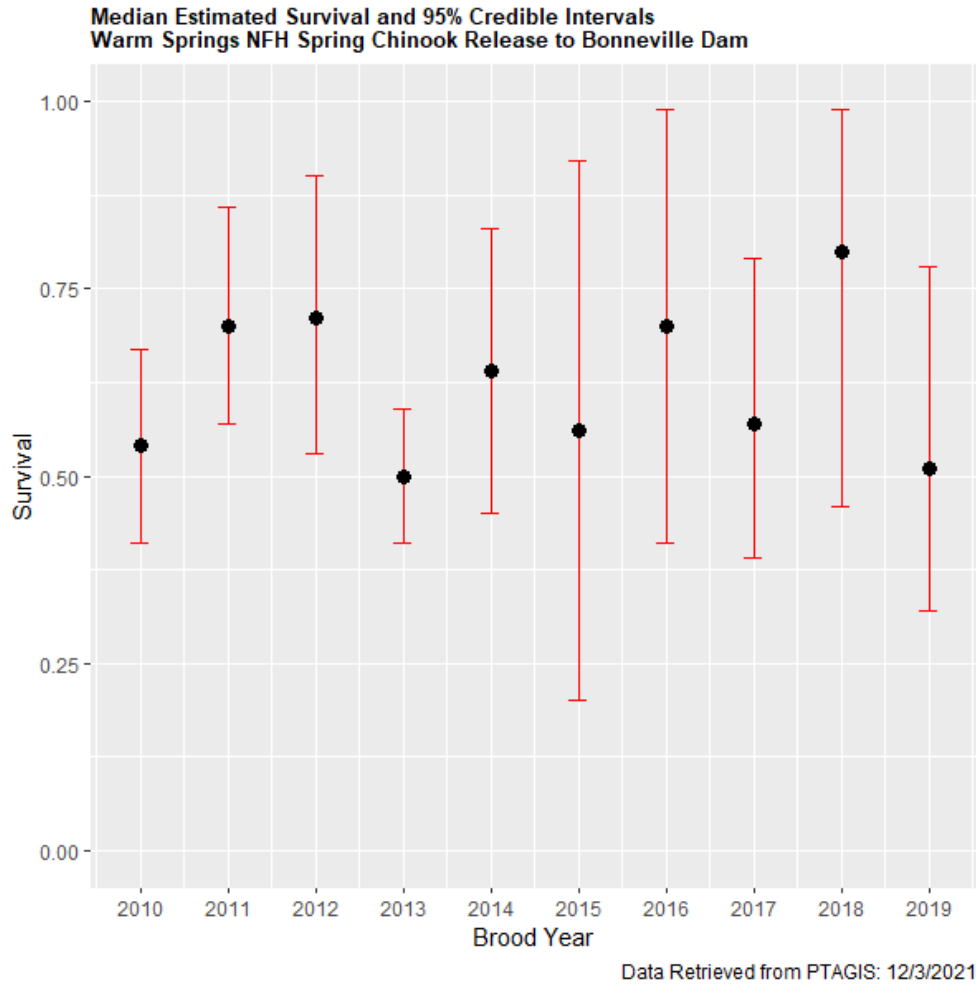


Figure 2. Juvenile Spring Chinook survival from release at Warm Springs NFH to Bonneville Dam (Brood Years 2010 - 2019). Estimates are median survival with 95% lower and upper credible intervals.

Adult Returns: Smolt-to-Adult Survival, Detections, Age Structure, and Harvest Data

a) Adult Returns

Adult returns to WSNFH are estimated by hatchery personnel and the marking and biosampling crew from CRFWCO. Coded Wire Tag recoveries maintained in the RMIS database are used to estimate the number of harvested adults and spawning ground recoveries (Table 4). At WSNFH, the number of hatchery returns and harvested adults has fluctuated since brood year (BY) 2005. Collectively, the facility has produced a mean of 2,508 adults annually since BY 2005 resulting in a mean smolt-to-adult survival rate (SAR) of 0.45%. This is above the target SAR of 0.39% set from brood years 1978 – 2001 (CTWSRO 2007).

Table 4. The estimated number of hatchery returns, harvested adults, and fish present on the spawning grounds for spring Chinook released from Warm Springs NFH. Adult returns are based on coded wire tag recovery expansion data from RMIS*. Hatchery return estimates include returns to Warm Springs NFH. Strays to non-federal hatcheries are included in the Total # of Adults. Data retrieved from CRiS Database 12/23/2021.

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2005	2,147	507	3	0	2,657	0.43
2006	1,561	387	3	0	1,951	0.56
2007	2,938	507	1	0	3,446	0.59
2008	1,387	373	11	0	1,771	0.25
2009	1,366	73	5	0	1,444	0.27
2010	1,552	787	8	0	2,347	0.49
2011	6,451	1,555	26	0	8,032	1.03
2012	384	1,076	13	0	1,473	0.20
2013	1,350	197	9	0	1,556	0.42
2014	322	83	1	0	406	0.31
Mean	1,946	554	8	0	2,508	0.45

*Due to delays in reporting to RMIS, CWT recoveries may be adjusted every year for accuracy.

An average 662 CWTs have been recovered each year at Warm Springs NFH since 2012 (Table 5). The Warm Springs NFH spring Chinook program accounts for 99 percent of all recoveries; spring Chinook from other programs include Round Butte (0.5%); returning spring Chinook from other programs account for < 0.5% of all recoveries.

Table 5. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Warm Springs NFH 2012 – 2021. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from RMIS: 1/27/2022.

Return Year	CWT Recoveries	Hatchery Origin	% of Total Annual CWT Return
2012	3	Lookingglass Hatchery	0.4
2012	3	Round Butte Hatchery	0.4
2012	699	Warm Springs NFH	99.1
2013	4	Lookingglass Hatchery	0.5
2013	1	Npt Hatchery	0.1
2013	1	Parkdale	0.1
2013	7	Round Butte Hatchery	0.9
2013	1	Sawtooth Hatchery	0.1
2013	798	Warm Springs NFH	98.3
2014	1	Rapid River Hatchery	0.1
2014	3	Round Butte Hatchery	0.3
2014	982	Warm Springs NFH	99.6
2015	5	Irrigon Hatchery	0.2
2015	1	Little White Salmon NFH	0.0
2015	2	Magic Valley Hatchery	0.1
2015	3	Round Butte Hatchery	0.1
2015	2,192	Warm Springs NFH	99.5
2016	1	Cle Elum Hatchery	0.3
2016	1	Cottonwood Cr Pond	0.3
2016	4	Irrigon Hatchery	1.4
2016	4	Round Butte Hatchery	1.4
2016	279	Warm Springs NFH	96.5
2017	1	Irrigon Hatchery	4.3
2017	22	Warm Springs NFH	95.7
2018	7	Round Butte Hatchery	3.1
2018	222	Warm Springs NFH	96.9
2019	1	Imnaha Pond	0.3
2019	1	Klickitat Hatchery (YKFP)	0.3
2019	3	Round Butte Hatchery	0.9
2019	326	Warm Springs NFH	98.5
2020	6	Round Butte Hatchery	1.3
2020	2	Sawtooth Hatchery	0.4
2020	443	Warm Springs NFH	98.0
2021	592	Warm Springs NFH	100.0
Mean	662		

b) Bonneville Dam and Ladder Detections

Spring Chinook adults return and pass Bonneville Dam as early as Mar-20 and as late as Jul-20. The average median Bonneville Dam passage date of PIT tagged Spring Chinook adults (Ages 3, 4, and 5) released from WSNFH is May-08 (Table 6).

Table 6. Median Bonneville Dam passage date of adult spring Chinook PIT tagged and released from Warm Springs NFH (\geq Age 3). Data retrieved from PTAGIS: 12/23/2021.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion	95% CI*	Hat. Return	Hat. Return/Bonn. Expansion (%)
2012	May-10	Apr-23	Jun-16	32	1,462	(999 - 2,097)	1,354	93
2013	May-10	Apr-26	Jul-01	58	1,597	(1,087 - 2,304)	1,818	114
2014	May-05	Apr-05	Jun-21	136	5,180	(4,058 - 6,711)	2,478	48
2015	Apr-27	Mar-20	Jul-04	195	10,348	(8,691 - 12,483)	6,635	64
2016	May-07	Apr-06	Jul-01	142	6,724	(5,517 - 8,119)	782	12
2017	May-23	May-04	Jul-20	76	1,620	(1,156 - 2,067)	1,748	108
2018	May-07	Apr-23	Jun-11	46	456	(289 - 520)	260	57
2019	May-09	Apr-30	May-13	9	371	(172 - 772)	391	105
2020	May-07	Apr-22	Jul-13	19	759	(361 - 1,012)	542	71
2021	May-11	Apr-24	Jun-28	56	3,079	(2,047 - 4,897)	1,746	57
Mean	May-08	Apr-18	Jun-24	77	3,160		1,775	73

* Confidence limits do not include detections of five fish or fewer per age group to reduce the variability and increase the accuracy of the estimate

Since Return Year 2012, spring Chinook adults (\geq Age 3) PIT tagged and released from Warm Springs NFH returned to the Warm Springs NFH Ladder as early as Apr-14 and as late as Sep-07 with the average median May-25 (Table 7).

Table 7. Median passage date at Warm Springs NFH Ladder of adult spring Chinook PIT tagged and released from Warm Springs NFH (\geq Age 3). Data retrieved from PTAGIS: 12/23/2021.

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Ladder Expansion	95% CI*	Hat. Return	Hat. Return /Ladder Expansion (%)
2012	May-31	May-15	Aug-13	16	705	(398 - 1,207)	1,354	192
2013	May-29	May-11	Sep-04	47	1,300	(806 - 1,902)	1,818	140
2014	May-22	Apr-24	Jul-27	79	3,015	(2,186 - 4,270)	2,478	82
2015	May-15	Apr-18	Sep-07	138	7,310	(5,933 - 9,123)	6,635	91
2016	May-25	May-03	Sep-06	59	2,788	(2,026 - 3,499)	782	28
2017	Jun-11	May-20	Aug-28	43	926	(571 - 1,274)	1,748	189
2018	May-23	May-12	Aug-26	24	213	(147 - 327)	260	122
2019	May-23	May-19	May-27	4	162	(NA - NA)	391	241
2020	May-26	Apr-14	Aug-16	12	505	(174 - 711)	542	107
2021	May-17	May-01	Jun-09	31	1,791	(1,202 - 2,562)	1,746	97
Mean	May-25	May-04	Aug-07	47	1,872		1,775	129

* Confidence limits do not include detections of five fish or fewer per age group to reduce the variability and increase the accuracy of the estimate

c) Age Structure

Monitoring adult returns to the hatchery provides information on sex ratios, length information, and age structure Table 8: brood year; Table 9: return year. USFWS staff uses CWT recoveries and scale sampling to age fish. Since return year 2012, approximately 89% of adults have returned to the facility at Age-4 (Table 8). Additionally, approximately 9% have returned as jacks at Age-3, and 1% have returned at Age-5. No Age-6 returns have been documented. The facility has a mean of 1,794 adult returns each year. There is a goal to have between 2% and 5% of jacks in the broodstock based on the percentage of jacks in the wild population and their estimated contribution during spawning (CTWSRO 2007).

Table 8. Estimated age structure of hatchery adult spring Chinook returns to Warm Springs NFH by brood year. CRiS Age Composition Report run on 1/14/2022.

Brood Year	Age-3	Age-4	Age-5	Age-6	Total # Adults
2006	591	2,501	71	0	3,163
2007	553	3,047	59	0	3,659
2008	708	1,249	45	0	2,002
2009	46	1,425	7	0	1,478
2010	348	2,082	39	0	2,469
2011	389	6,207	29	0	6,625
2012	389	748	40	0	1,177
2013	5	1,509	2	0	1,516
2014	199	243	7	0	450
2015	15	355	8	0	565
2016*	29	373	3	NA	NA
2017*	161	1,677	NA	NA	NA
2018*	67	NA	NA	NA	NA
Mean	269	1,785	28	0	2,292

* Denotes incomplete brood years given that adults have not yet returned to the hatchery.

Table 9. Total number of hatchery adult spring Chinook returns to Warm Springs NFH and estimated age structure by *return year*. CRiS Age Composition Report run on 1/14/2022.

Return Year	Age-3	Age-4	Age-5	Age-6	Total # Adults
2012	46	1,249	59	0	1,354
2013	348	1,425	45	0	1,818
2014	389	2,082	7	0	2,478
2015	389	6,207	39	0	6,635
2016	5	748	29	0	782
2017	199	1,509	40	0	1,748
2018	15	243	2	0	260
2019	32	542	8	0	582
2020	161	373	8	0	542
2021	67	1,677	3	0	1,747
Mean	165	1,606	24	0	1,794

Collecting CWTs from adult returns to the hatchery provides additional information for multiple stocks released on station (Table 10). Each stock has a unique CWT which can be used to calculate the age at return for each fish. Most adults from all stocks return to the facility at Age-4 and no Age-6 returns have been documented (Table 10). Brood years 2017 and 2018 have not yet returned to the hatchery and will require additional years for a complete return analysis.

Table 10: Proportion of age at adult (\geq Age-3) returns for the Warm Springs, Parkdale, and Round Butte stock releases based on CWT recoveries of fish returning to WSNFH by stock and brood year. Data retrieved from CRFWCO marking files and RMIS 2/8/2022.

Stock	Brood Year	Total CWT Released	Total CWT Return	Age-3 at Return (n)	Age-4 at Return (n)	Age-5 at Return (n)
Round Butte	2009	217,393	136	2.2% (3)	97.8% (133)	0
Warm Springs	2009	319,887	542	4.1% (22)	95.2% (516)	0.7% (4)
Parkdale	2015	119,399	19	0	89.5% (17)	10.5% (2)
Warm Springs	2015	414,315	292	4.5% (13)	93.8% (274)	1.7% (5)
Round Butte	2017	123,541	0	0	0	NA
Warm Springs	2017	764,240	246	47.6% (117)	52.4% (129)	NA
Parkdale	2018	135,798	3	100% (3)	NA	NA
Round Butte	2018	230,310	3	100% (3)	NA	NA
Warm Springs	2018	281,133	0	0	NA	NA

d) Adult Harvest

The WSNFH provides salmon to supplement tribal and sport harvest opportunities in the Deschutes and Columbia Rivers. Estimates of wild and hatchery spring Chinook are based on ODFW and CTWSRO creel surveys (Table 11).

Table 11. Deschutes harvest estimates of wild and WSNFH spring Chinook salmon 2012 - 2021. Estimates based on ODFW and CTWSRO creel surveys, and estimated proportion of total harvest of Warm Springs NFH and Round Butte Hatchery returns. Dashed line indicates limited Tribal harvest; however, no creel survey took place in 2020 or 2021 due to COVID-19 safety precautions. Creel data retrieved from ODFW 12/16/2021, and hatchery return data from Round Butte Hatchery on 11/23/21.

Return Year	Wild Adult Sport	Wild Jack Sport	Wild Adult Tribal	Wild Jack Tribal	WSNFH Adult Sport	WSNFH Jack Sport	WSNFH Adult Tribal	WSNFH Jack Tribal	Total Harvest
2012	0	0	10	0	156	8	138	3	315
2013	0	0	2	0	0	0	40	134	176
2014	0	0	21	0	436	189	124	22	792
2015	0	0	17	0	0	0	365	23	405
2016	0	0	0	0	955	21	643	19	1,638
2017	0	0	0	0	0	0	172	11	183
2018	0	0	0	0	57	3	9	0	69
2019*	0	0	0	0	0	0	22	0	22
2020*	0	0	-	-	0	0	-	-	-
2021*	0	0	-	-	0	0	-	-	-
Mean	0	0	5	0	160	22	151	21	360

* No Sport Harvest 2019 - 2021

During the spring Chinook salmon migration period (April 15 - August 30) all fish ascending the fish ladder are diverted into catch and holding ponds. Fish are sorted, and either passed up stream if wild appearing (i.e., adipose fin marked), vaccinated and held for broodstock, or surplused and given to tribal representatives for distribution. Disposition of fish depends on number of returns, their condition, and origin (Tables 12 and 13).

Table 12. Disposition of hatchery (all stocks) and wild spring Chinook salmon at Warm Springs NFH, 2012 - 2021. Numbers include spring Chinook salmon adults (age 4-5) and jacks (age 3) that were surplus to hatchery broodstock needs before being distributed to the CTWSRO. Number distributed based on hatchery fish-removal-file records of distribution of adult fish that returned to Warm Springs NFH prior to August 1 of each year. Total may include uses not listed. Data retrieved from Fish Removal files 1/6/2021. Unresolved data discrepancies in 2019, 2020, and 2021 Fish Removal files.

Return Year	WSNFH Upstream	WSNFH Surplus Donated	WSNFH Surplus Dump	WSNFH Brood	WSNFH Transfer	WSNFH Mortality	WSNFH Total	Wild Upstream	Wild Brood	Mortality	Wild Green	Wild Surplus	Wild Total
2012	34	310	0	560	0	65	969	380	0	5	0	0	385
2013	63	689	0	482	0	184	1,418	397	0	3	0	0	400
2014	0	996	0	194	35 ^c	486	1,711	761	0	6	0	0	767
2015	78	4,901	145	615 ^a	0	188	6,635	1,369	0	12			
2016	0	1,550	3	758 ^b	323 ^d	150	2,784						
2017	-	-	-	747	-	80	1,555 ^e	-	0	-	0	0	193 ^e
2018	0	5	0	206	0	47	260	247	0	0	0	0	247
2019	0	0	39	259	0	94	394	204	0	0	0	0	204
2020	3	0	70	360	0	79	566	10	35	5	0	0	50
2021	352 ^f	159	73	166	414	570	1,746	67	78	35	3	1	184
Mean	59	957	37	435	87	194	1,804	418	13	9	0	0	415

^a All fish spawned at Little White NFH in 2015

^b 645 fish spawned at Little White NFH in 2016

^c Transferred to ODFW for research

^d Transferred to Round Butte

^e No data recorded for other uses of fish in 2017

^f Fish were transferred to CTWSRO (352) or Round Butte Hatchery (12) and outplanted upstream

Table 13: Adult Spring Chinook passed at WSNFH or trucked upstream each year to spawn naturally (– indicates no passage data recorded). Data from Fish Removal Files 2/8/2022.

Return Year	Origin	Upstream Passage Method	Females	Males	Jacks	Unknown	Total	Annual Total
2012	Wild	Passed	2	5	24	349	380	414
	Hatchery	Passed	0	3	7	24	34	
2013	Wild	Passed	1	1	88	307	397	460
	Hatchery	Passed	0	0	3	60	63	
2014	Wild	Passed	2	6	100	653	761	761
2015	Wild	Passed	0	0	58	1,311	1,369	1,447
	Hatchery	Passed	0	0	28	50	78	
2016	Wild	Passed	0	0	4	331	335	335
2017	Wild	Passed	0	3	14	169	186	186
	Hatchery	Passed	-	-	-	-	-	
		Trucked	-	-	-	-	-	
2018	Wild	Passed	6	15	5	221	247	248
	Hatchery	Passed	0	1	0	0	1	
2019	Wild	Passed	3	5	3	193	204	204
2020	Wild	Passed	7	1	0	2	10	13
	Hatchery	Trucked	0	0	3	0	3	
2021	Wild	Trucked	30	37	0	0	67	419
	Hatchery	Trucked	204	123	1	24	352	

2021 Run Reconstruction

Run reconstruction estimates the number of age 3, age 4, and age 5 fish that returned to the mouth of the Deschutes River for a given brood year. Run reconstruction methods and data can be found in the annual run forecast reports (Lovtang et al. 2011). In 2021, an estimated 174 wild and 1,746 hatchery Warm Springs River spring Chinook (Tables 14 and 15) and 598 Round Butte hatchery spring Chinook (Table 16) are estimated to have returned to the Deschutes River.

There was limited tribal harvest and no sport harvest in 2020. During the 2020 Deschutes-Sherars Falls Spring Chinook Harvest, it is likely 50 fish may have been harvested. However, there were no spring or fall creel surveys due to COVID-19 safety precautions (Mark Manion, CTWSRO).

Table 14. Run reconstruction of *wild* spring Chinook salmon from the Warm Springs River, 2021. Run reconstruction performed 12/16/2021, ages based on scale samples from CRiS WSSCS21 file (61 readable scales), Age 3=4.9%; Age 4=93.4%; Age 5=1.6%.

Location	Wild Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To WSNFH	Upstream of WSNFH	0	67	0	67	67
To WSNFH	WSNFH Broodstock	7	69	2	71	78
To WSNFH	DIPS/Jumpouts/killed	0	39	0	39	39
To WSNFH	Total	7	165	2	167	184
Harvest	Sport	0	0	0	0	0
Harvest	Tribal	0	0	0	0	0
Harvest	Total	0	0	0	0	0
Below WSNFH	Spawned	0	0	0	0	0
Total Estimated Return		7	165	2	167	184

Table 15. Run reconstruction of *hatchery* spring Chinook salmon from the Warm Springs River, 2021. There was no sport harvest in 2021 and no creel survey due to COVID-19 health precautions. Run reconstruction performed 12/16/2021.

Location	Hatchery Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To WSNFH	Upstream of WSNFH	0	0	0	0	352
	Transferred to Round Butte (AdLV)	4	124	0	124	128
	Transferred to Round Butte (Ad only)	0	0	0	0	286
	Surplus	0	0	0	0	236
	Mortality	0	0	0	0	578
	Spawned					166
Harvest	Sport	0	0	0	0	0
	Tribal	0	0	0	0	0

Table 16. Run reconstruction of *hatchery* spring Chinook salmon from the Round Butte Hatchery, 2021. There was no sport harvest in 2021 and no creel survey due to COVID-19 health precautions. Run reconstruction performed 12/16/2021.

Location	Hatchery Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To Pelton Trap	Hatchery	453	141	4	145	598
Harvest	Sport	0	0	0	0	0
	Tribal	-	-	-	-	-

2021 Wild Return and Management

The wild Spring Chinook Salmon population in the Warm Springs River has been below the minimum escapement goal of 1,000 adults upstream of Warm Springs NFH in nine out of the last ten years (Table 12). Additionally, pre-spawn mortality of wild fish upstream of the hatchery (defined as the number of fish per redd) has been increasing in the past 10 years (ranging 10 -15 fish per redd). In 2020, the preseason forecast for wild adult (ages 4 and 5) spring Chinook salmon returns to the Deschutes Basin ranged from 50 to 300 total returns. In early 2020, the CTWSRO developed a plan to transport one-third of the wild adults from Warm Springs NFH to the spawning areas in the upper watershed. The hope was that transporting the fish would move them upstream of a possible thermal barrier that was hypothesized to block upstream migrating fish from reaching the spawning grounds. In addition to transporting wild adult fish, the CTWSRO began having discussions with the Service about collecting one-third of the wild fish for on-hatchery spawning and rearing at Warm Springs NFH. The remaining one-third of the fish would be passed upstream of the hatchery as in previous years. However, due to the COVID-19 outbreak in March of 2020, and subsequent working restrictions, only 10 wild fish were passed upstream of the hatchery and the decision was made to collect all 40 wild fish for holding and spawning at the hatchery.

In 2021, the preliminary wild fish plan was to collect all wild adults for on-hatchery spawning and rearing; if there were more than 60 females and 40 males before July 15th (as determined by ultrasound), excess wild adults would be trucked upstream of the hatchery to naturally spawn. After July 15th, broodstock held on station would be injected with antibiotics. To represent the entire run both at the hatchery and upstream, one out of every four females and every fifth or sixth male would not be injected with antibiotics and instead trucked upstream for release. Since the majority of wild fish were held at the hatchery, CTWSRO approved trucking of excess hatchery fish upstream to naturally spawn. All outplanted hatchery adults were PIT tagged and a genetic clip (either a caudal clip or caudal punch) was collected.

Between May 26 and July 6, 352 hatchery fish were trucked upstream and outplanted by the CTWSRO. An ultrasound was used to distinguish the sex of each hatchery fish before it was outplanted, it identified 204 females, 123 males, and 1 jack; 24 fish were undetermined. Between June 14 and July 14, after sufficient wild broodstock was collected at WSNFH, 67 wild adults (30 female and 37 male) were trucked upstream. A total of 184 wild fish were collected at the hatchery and 117 were held for broodstock, of which, 78 were spawned (Table 17, Figure 3).

The wild-origin broodstock were sexed by ultrasound, injected with Draxxin, and held separately from hatchery-origin broodstock in the broodpond closest to natural sunlight. Spawning took place between August 19th and September 9th and occurred in seven takes. A 2x2 spawning matrix was used to increase the number of family groups and genetic diversity for the supplementation production. With 2x2 spawning, each wild female's eggs were split into 2 buckets, and 2 wild males were spawned with each female (Figure 4). After time to allow for fertilization, the 2 buckets of eggs were recombined and placed into incubation trays.

With the supplementation program bringing wild fish into the hatchery program, it was possible to integrate wild fish into the hatchery population to minimize genetic divergence between Warm Springs River hatchery and wild stocks. Excess milt from each wild male was spawned with in a 2x2 spawning matrix as well (Figure 4). These wild x hatchery crosses are being tracked and

kept separate during incubation and ponding until a decision is made on their final disposition (e.g., leave all unmarked and release into the wild or use 50% for hatchery production and 50% for unmarked wild release).

Monitoring wild adult returns at the hatchery provided information on sex ratios, length information, and age structure based on scale samples. Approximately 93% of wild adults collected at the facility were Age-4 (n = 165), 5% were jacks at Age-3 (n = 7), and 2% were Age-5 (n = 2); zero Age-6 fish were documented (Table 18).

Table 17. Total number of wild adult spring Chinook returns to WSNFH in 2021, estimated age structure, and disposition.

	Total Adult Return	Passed Upstream	Surplussed	Green	Mortality	Spawned
Male	87	37	1	0	16	33
Female	97	30	0	3	19	45
Total	184	67	1	3	35	78

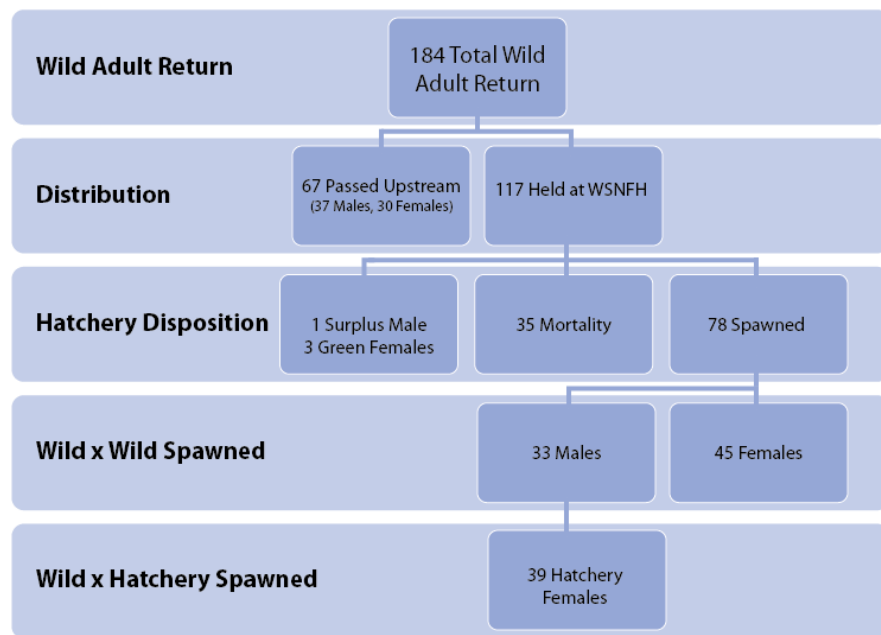


Figure 3. Wild adult spring Chinook returns to WSNFH and their distribution. Sixty-seven fish were passed upstream, and 78 fish were spawned at the hatchery. An additional 39 hatchery females were spawned with wild males to integrate wild fish genetics into the hatchery population.

2021 Warm Springs NFH Wild Spawning Matrix

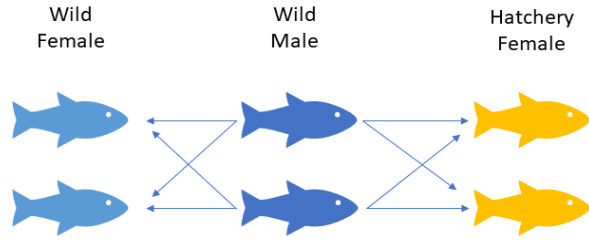


Figure 4. A 2x2 spawning matrix was used to increase wild adult spring Chinook family groups and genetic diversity. Each wild female's eggs were spawned with 2 wild males. Excess milt from each wild male was also spawned with two hatchery females in a 2x2 spawning matrix.

Table 18. Estimated age structure of wild adult spring Chinook returns to Warm Springs NFH based on scale samples of wild returns.

Return Year	Age-3	Age-4	Age-5	Total # Adults
2020	5	40	5	50
2021	9	172	3	184

2022 Run Forecast

There is moderate confidence that wild adult returns (age 4 and age 5) will be greater than 200 fish. Recent year trends (10-year dataset) indicate >50% probability that the return will be greater than 200 fish (Table 19). There is moderate confidence that hatchery adult returns will be greater than 1,000 fish (Table 19).

Table 19. Forecast Model Predictions of Spring Chinook Salmon Returns to the Deschutes River in 2022 based on Hand and Haeseker (2011). Run date as of 4/18/2022.

Return	Std Reg (All Data)	Std Reg (10 yr Data)	Return Ratio (10 yr Data)	% Age Model (10 yr Data)
Wild Age 4	317	181	182	88
Wild Age 5	29	39	22	22
Wild Total	346	220	204	110
Wild Prob. >200 adults return	59%	51%	51%	43%

Return	Std Reg	LN Reg	Return Ratio (All Data)	% Age Model (All Data)
WSNFH Age 4	1,000	788	876	572
WSNFH Age 5	67	56	88	84
WSNFH Total	1,067	844	964	656
WSNFH Prob. >1,000 adults return	52%	46%	49%	41%

Return	Std Reg	LN Reg	Return Ratio (All Data)	% Age Model (All Data)
RBH Age 4	1,350	1,380	1,332	969
RBH Age 5	4	2	4	4
RBH Total	1,354	1,382	1,336	973

Transfers

In recent years, the primary issues related to meeting release goals has been maintaining broodstock health after they have returned to the hatchery, achieving eye-up, and survival until marking. This facility has transferred spring Chinook between other state, tribal and federal hatcheries to make up for loss of eggs, provide relief from high water temperatures, and accommodate power outages due to hatchery construction. WSNFH stock has been transferred to Round Butte State Fish Hatchery and vice versa. Round Butte hatchery stock are the preferred stock for backfilling production shortfalls at WSNFH. Parkdale Hatchery stock have been reared and released from WSNFH; however, the Parkdale program has been trying to develop their own, Hood River, stock and the genetic and phenotypic differences between the Parkdale stock and the WSNFH stock are not fully known. Early results from release of Parkdale stock fish from WSNFH indicated lower adult returns than the WSNFH stock. An evaluation-of the brood year 2018 on-hatchery and off-hatchery performance of the WSNFH, Round Butte, and Parkdale stocks will provide additional information on the similarities and differences. All juvenile or egg transfers from Round Butte State Fish Hatchery to Warm Springs NFH are marked with AD+CWT+LV; all juvenile or egg transfers from Parkdale Fish Hatchery to Warm Springs NFH are marked with AD+CWT+RV. Lastly, both adults and juveniles have been transferred from WSNFH to the Little White Salmon NFH for spawning and temporary rearing before being transferred back to WSNFH again (Table 20).

Table 20. Transfer dates and total number of spring Chinook from three stocks, (WS) Warm Springs, (RB) Round Butte, and (P) Parkdale. Transfer locations were to or from (WS) Warm Springs NFH, (RB) Round Butte State Fish Hatchery, (P) Parkdale Hatchery, and (LW) Little White NFH.

Transfer Year	Transfer Dates	Brood Year	Stock	Lifestage	Transfer From	Transfer To	Total # Transferred
2015	Spring	–	WS	Adults	WS	LW	680
	Spring	–	WS	Adults	WS	RB	708
	November	2015	WS	Eggs	LW	WS	926,679
	November	2015	WS	Eggs	RB	WS	401,954
2016	Spring	2015	P	Juveniles	P	WS	130,000
	Spring	2015	RB	Juveniles	RB	WS	45,000
	Summer	2015	WS, RB, P	Juveniles	WS	LW	450,000
	July	–	WS	Adults	WS	LW	NA
	November	2016	WS	Eggs	LW	WS	NA
	2017	June	–	WS	Adults	WS	LW
Fall		2017	RB	Eggs	RB	WS	NA
2018	September	2018	P	Eggs	P	WS	153,538
2018	September	2018	RB	Eggs	RB	WS	249,186
2019	April	2018	RB	Fingerlings	RB	WS	15,000
2021	May - July	–	RB	Adults (AD/LV)	WS	RB	128
	May - July	–	WS	Adults (AD)	WS	RB	286
	May - July	–	WS	Adults (AD)	WS	Upstream Natural Spawning	352
	July	–	WS	Adults (Wild)	WS	Upstream Natural Spawning	57
	June	2020	WS	Juveniles	WS	LW	300,000
	Fall	2021	WS	Eggs	WS	WSU	200
	October	2020	WS	Juveniles	LW	WS	300,000

- **2010** – In early 2007, the water supply to egg trays at WSNFH was inadvertently shut-off and resulted in egg loss. Round Butte stock (BYs 2006 and 2007) were reared and released as juveniles at WSNFH to make up for the loss of eggs. In 2010, these fish returned as age 4 and were not included in Warm Springs Broodstock.
- **2011** - Round Butte stock adults returning as ages 4 and 5 were segregated and not included in Warm Springs Broodstock (see 2010 note). WSNFH collected eggs surplus to their production needs. The resulting surplus BY11 Warm Springs stock juveniles (approximately 107,000) were marked and released as sub-yearlings into Shitike Creek in spring of 2012. No monitoring was conducted to determine the fate of Shitike releases.
- **2012** - Round Butte stock adults returning as ages 5 and 6 were segregated and not included in Warm Springs Broodstock (see 2010 note).
- **2013** - In 2009, the hatchery spawned Warm Springs stock males (~63) with Round Butte stock females (no data on how many females). Adult returns in 2013 included these Round Butte-Warm Springs stock crosses but they were not used as broodstock.
- **2014** – High broodpond mortality (70%) was due to disease outbreaks.
- **2015** –Hatchery records are incomplete/inconsistent for 2015. Records of adults transferred are different between Warm Springs NFH and Little White NFH. Juvenile records also differ. Warm Springs BY15 release numbers are estimates. April to June, approximately 701 Warm Springs NFH stock adults (BY15) were transferred to Round Butte State Fish Hatchery to meet Round Butte program shortfalls.
 - In July 2015, the remaining Warm Springs NFH stock adults (~702) were transferred from WSNFH to Little White Salmon NFH where they were spawned (approximately 926,000 eggs taken). The fertilized BY15 eggs were moved to the Spring Creek National Fish Hatchery for incubation (SCNFH) until eye-up, and then back to the WSNFH for hatching. An unexplained egg loss (~47%) occurred, with the majority of loss at SCNFH during incubation. Approximately 490,000 eggs survived.
 - In November of 2015, ~450,000 fertilized eggs (BY15) of Warm Springs NFH genetic stock were transferred back to WSNFH from Round Butte State Hatchery. Almost all 92% (>400,000) eggs died approximately 7-10 days after their transfer. USFWS’s Fish Health program did an investigation and write-up ([Thompson and Goodwin 2016](#)); no cause for egg loss was identified. Approximately 50,000 eggs survived. Since these eggs were Warm Springs NFH genetic stock, the resulting juveniles were not ventrally clipped.

Figure 1: Transfers of Warm Springs NFH stock, April-November, 2015

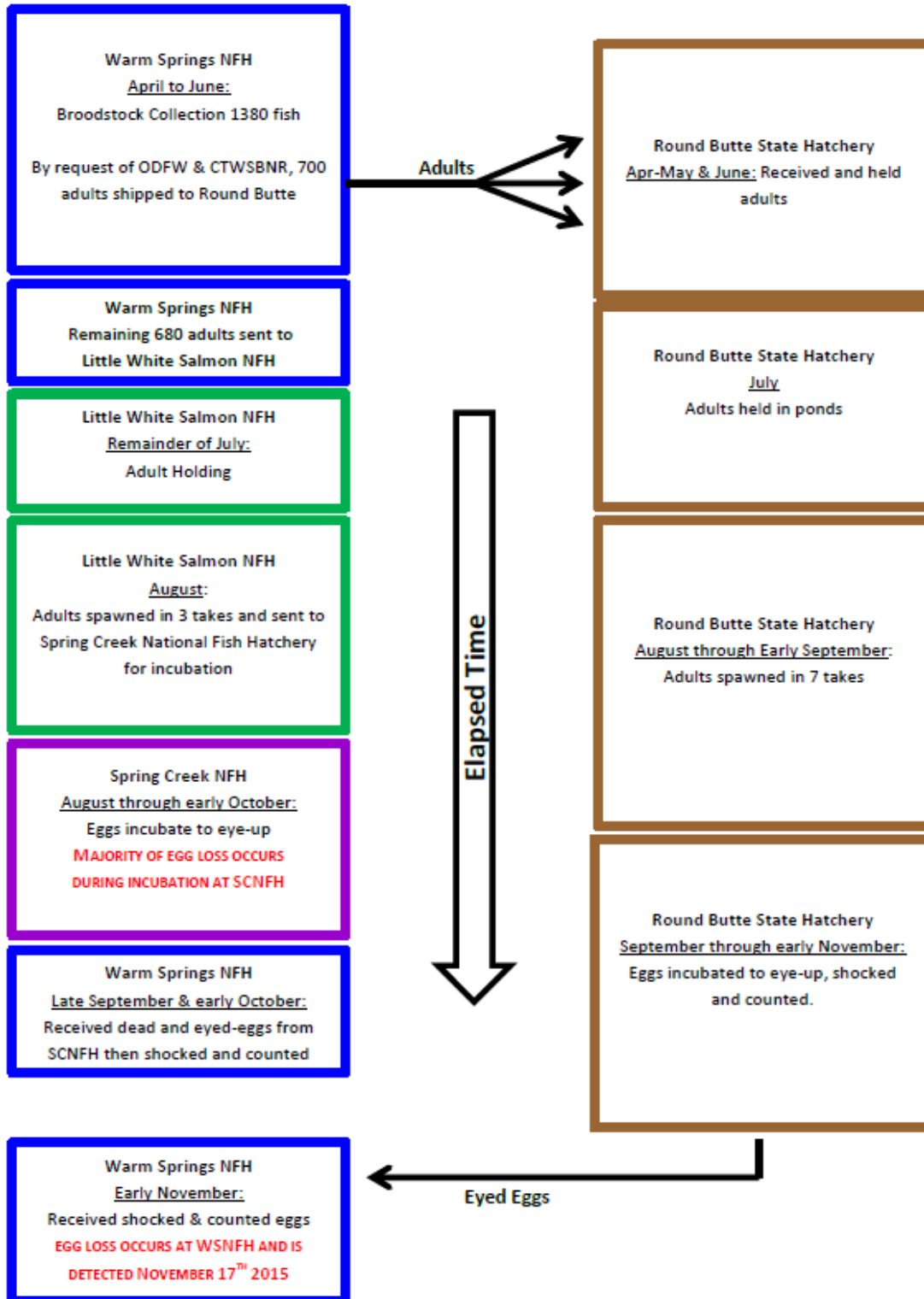


Figure 1 from Thompson and Goodwin 2016

- **2016** – Hatchery records are incomplete/inconsistent for Brood Year 2016 juveniles. Little White Salmon NFH juvenile data indicates fewer fish transferred back to Warm Springs NFH (444,313) than Warm Springs NFH says were released the following year (541,441). Warm Springs NFH release numbers are the same as the tagging numbers, no on-station mortality data was recorded for Warm Springs NFH. Total release numbers for BY16 are likely over-estimates. Release to adult survival estimates for BY16 are unreliable.
 - In the spring of 2016, ~130,000 BY15 Parkdale stock juveniles were transferred to WSNFH to supplement the 2015 egg loss. The Parkdale fish were differentially coded-wire tagged and given an adipose and left ventral clip. In summer 2016, concerns about electrical power interruption during construction prompted the transfer of 450,000 BY15 juveniles to Little White Salmon NFH; ~90,000 BY15 juveniles remained at WSNFH. Records do not indicate which fish were transferred to Little White Salmon NFH and which fish remained at Warm Springs NFH.
- **2017** - Due to concerns of another year of high egg loss, the hatchery requested surplus BY17 spring Chinook salmon eggs from Round Butte State Fish Hatchery to help them cushion expected high egg mortality. The BY17 Warm Springs NFH stock did not experience high egg mortality, and approximately 764,000 Warm Springs NFH stock juveniles were released in 2019. The additional BY17 Round Butte stock juveniles (~123,000 adipose and left ventral clipped) that were released at Warm springs NFH in 2019 resulted in the exceedance of the Warm Springs HGMP allowance. The one-time release of additional fish was determined not to have a substantial effect on ESA-listed species beyond what was considered in the USFWS BiOp covering the WSNFH program.
- **2018** - Low Warm Springs stock adult returns in 2018 led to WSNFH requesting and receiving BY18 eggs from both Parkdale Fish Hatchery and Round Butte State Hatchery to augment hatchery production. These fish were segregated according to their source, differentially coded-wire tagged, and received both an adipose clip and left ventral clip (Round Butte) or right ventral clip (Parkdale) to distinguish them from the Warm Springs stock upon their return. At release in 2020, 281,133 WSNFH stock, 135,798 Parkdale stock, and 230,310 Round Butte stock fish were released from brood year 2018 (sr80s.dbf file).
- **2019** - Upon examination of records and better than usual survival, Round Butte State Fish Hatchery had an excess of approximately 15,000 +/- of BY18 Spring Chinook salmon fingerlings. These fish were surplus to the needs and above the carrying capacity of the Round Butte facility and were made available to WSNFH. Warm Springs NFH was under its 2021 station release goal of 750,000 for BY18 due to low returns of brood fish and a higher-than-normal post eyed egg loss to a single take of eggs. Warm Springs NFH was already rearing Round Butte source fingerlings (from egg transfers) on station from the same brood year. These fish were segregated from the other populations on station and received both an adipose clip and left ventral clip to remain consistent with

the program for fish coming from the Round Butte source (Frejje, 2019). There are no Warm Springs NFH records indicating the transfer of the ~15,000 Round Butte juveniles, and it is unclear where these fish were placed and reared at Warm Springs NFH.

- **2021**

- 5/20/2021: Warm Springs began transferring all AD/LV Round Butte Stock (reared and released from Warm Springs NFH and returned to Warm Springs NFH) to Round Butte State Fish Hatchery to supplement their low returns. All adults transferred to Round Butte State Fish Hatchery received a dorsal fin punch to indicate Warm Springs NFH as their return location for RMIS reporting.
- 5/24/2021: Round Butte State Fish Hatchery submitted a formal request for Warm Springs stock adults; 100 (50 pair, 1:1 male:female) for Round Butte State Fish Hatchery and 120 (60 pair, 1:1 male:female) for Parkdale Fish Hatchery, a total request of 220 fish. All adults transferred adults received a dorsal fin punch to indicate Warm Springs NFH as their return location for RMIS reporting.
- 5/26/2021: The CTWSRO began trucking adult hatchery Warm Springs stock fish upstream to naturally spawn since the majority of wild fish were being held at the hatchery. All outplanted hatchery adults were PIT tagged and a genetic clip was collected (either a caudal clip or caudal punch). As temperatures warmed in July, the Tribes were willing to take the risk of mortality of the fish because they would add nutrients to the river.
- 6/14/2021: The Tribes were concerned about holding all wild on station until July 15th, however, the USFWS needed to hold some back to represent entire run in the spawning. Surplus fish above what was needed for spawning were removed from the holding pond and trucked upstream between 6/14 and 7/14).
- PGE inquired about passing excess hatchery brood upstream of Pelton Dam for reintroduction program. See Utilization of Excess Broodstock for Reintroduction _2021.docx
- 6/25/2021: One week before the record heat wave in June 2021, the Warm Springs HET recommended immediate transfer (within three days of decision) of BY20 juveniles from Warm Springs NFH to Little White Salmon NFH (LWSNFH). Fish held long-term in non-optimal conditions (i.e., chronic and acute stress) are less resistant to disease and treatment regimens are less effective. Morbidity and death will increase with longer exposure to higher water temperatures. Proactive steps considering transporting fish off-station during summer rearing conditions were previously developed and included in the BY20 AOP (see Appendix for criteria). With very hot temperatures forecasted for the next 10 days, uncertainty as to the July-August temperatures, and all the BY20 wild stock on-station at WSNFH, the Warm Springs HET met to consider transferring juveniles to another location.
 - Juvenile holding conditions were averaging 65° F for several days with the long-term climate and weather predictions showing a marked increase in

air and (assumed) water temperatures as well as (assumed) lower river flows.

- Fish were being managed for an acute bacterial infection (*C. shasta*) with topical chemicals and planned medicated feed.
 - There were 15 raceways with approximately 36K fish in each (13 raceways with hatchery or mixed hatchery/wild origin and 2 raceways with wild origin).
 - Secondary locations were discussed for wild stock (Parkdale Hatchery, an acclimation pond at the Moving Falls Facility on the Hood River, multiple facilities, LWSNFH). After evaluating further logistics (CDL personnel availability, environmental condition, etc.), Hauling priorities were wild fish to truck first and keep separate from the hatchery stock.
- 6/26/2021: Juvenile BY20 fish were trucked to LWSNFH for the summer where temperatures would be lower. The wild BY20 fish from 2 raceways were transferred Saturday afternoon. Sunday morning (6/27) the second load contained three raceways of fish and by 10 am Sunday, the last three raceways were transported to LWSNFH. Monday, 6/28, the Warm Springs River temperature was 77.7° F and raceways were 78.9 ° F. At LWSNFH Monday morning, there was some mortality, but they were looking better by Wednesday 6/30. Lessons learned: be proactive, communicate with the Regional Office and the Tribes, and work with other hatcheries for assistance (i.e., vehicles, space, CDL drivers). There is a need to put together a protocol with past knowledge to assist the hatchery manager and the decision-making process.
- 6/28/2021: CTWSRO Requested an additional 75 (25 females and 50 males) hatchery Warm Springs stock to be transferred to Round Butte State Fish Hatchery to fill Parkdale Fish Hatchery’s shortfall. This request was approved because it was from the CTWSRO and because fish sent to Round Butte State Fish Hatchery are more likely to contribute returns to the Deschutes River and ultimately contribute their genetic material to the larger population (compared to fish moved above the Dam).
- 6/29/2021: The adult fish requests and an additional request for eggs (WSU research proposal for 100-200 eggs total, green or eyed from a few different females) were approved by FWS.
- 7/14/2021: Forty-eight wild fish at Warm Springs NFH were transported upstream and released Wednesday, 7/14. As the hatchery ultrasounded and injected fish that were kept for broodstock, every 3rd female and every 4th or 5th male were not injected with antibiotics and instead moved to the truck to go upstream.
- 10/12/2021: BY20 juveniles were transferred back to Warm Springs.
- Warm Springs NFH adult records for 2021 are inconsistent. Excel spreadsheets do not match the fish removal file records. Additionally, Tribal records show approximately 50 more wild fish transferred into upper watershed than hatchery

records indicate. In the spring of 2022, the CRFWCO updated the fish removal file to account for the additional wild fish. Run forecasts were updated to reflect the ~30% increase in 2021 wild return counts. Total wild and hatchery adult returns in hatchery data should be considered estimates.

Other Fish counted and passed above Warm Springs NFH

The number of stray hatchery steelhead counted at the fish ladder at WSNFH increased beginning in 1987 but have decreased since 2003. From 1982 to 1986, stray hatchery steelhead composed a mean of 13.6% (range of 6.6% to 23.0%) of the total number of steelhead counted at the ladder. Between 1987 and 2003, a mean of 50.9% (range of 34.7% to 66.4%) of the steelhead counted were stray hatchery fish (Hand and Olson 2003). In more recent years, stray hatchery fish have decreased to a mean of 11.9% (range of 3% to 24%) of the total number of steelhead counted at the ladder (Table 21).

Except for Steelhead, counts of other species of fish are intermittent and may not necessarily reflect total number of fish each year (i.e., dashed lines in Table 18 indicate no data recorded). Numbers of fish passed upstream of the ladder have declined in recent years. Since 2015, Seven fall and summer Chinook and zero whitefish and suckers have been counted passing upstream. Northern Pikeminnow have always been rare at the ladder. Coho numbers have been above average for the last three years.

A Lamprey Passage Structure (LPS) was installed at the fish ladder in 2018. Since then, 62 Pacific lamprey have been observed when a total of 7 were counted in the previous seven years combined. The LPS is open and run from March to November each year with the majority of lamprey detected between mid-May and late August. In 2019, the LPS was fitted with a camera system triggered by lamprey passing an infrared break beam which is the primary method of lamprey detection. In 2018, adult lamprey were PIT tagged lower in the Warm Springs River and created an opportunity to verify camera detections with known PIT tag detections at the WSNFH fish ladder PIT antenna. That year, three PIT tagged lamprey were detected at the PIT array, all three detections had corresponding video detections on the camera system. More adult lamprey will be PIT tagged by the CTWSRO in 2022 to allow for additional truthing.

Table 21. Counts of wild Steelhead, hatchery Steelhead, Fall Chinook (wild and hatchery combined), Coho (wild and hatchery combined), Rainbow Trout, Bull Trout, Whitefish, Northern Pikeminnow, Sucker, and Pacific Lamprey counted at the Warm Springs NFH fish ladder 2012 - 2021. Except for Steelhead, counts are intermittent and may not necessarily reflect total number of fish in a given year (– indicates no data recorded). Data retrieved from CRiS Fish Removal file 2/9/2022.

Year	Wild Steelhead	Hatchery Steelhead	Fall/Summer Chinook	Coho	Rainbow Trout	Bull Trout	Whitefish	Northern Pikeminnow	Sucker	Pacific Lamprey
2012	219	16	12	206	52	10	190	0	536	6
2013	379	71	3	87	21	9	163	2	697	1
2014	196	30	2	269	16	0	150	0	521	0
2015	356	34	0	–	17	1	783	0	471	0
2016	280	30	0	–	17	1	–	0	236	0
2017	262	8	–	–	–	–	–	–	–	–
2018	–	–	–	3	–	–	–	–	–	13*
2019	24	4	0	443	7	0	0	0	0	25*
2020	52	7	6	747	14	1	1	0	388	4*
2021	85	27	1	556	17	5	0	0	0	20*
Mean	206	25	3	330	20	3	184	0	356	8

*Counted in LPS

Past M&E Studies

- **2007** – [Comparing Two Methods Used to Mark Juvenile Chinook Salmon: Automated and Manual Marking \(Hand et al. 2010\)](#). A study compared the automated fish-marking trailer to the manual-marking trailer. The automated fish-marking trailer had higher clip quality and tag retention with no increase in rates of injury or marking to release survival.
- **2008** – [Distribution and Survival of Adult Hatchery Spring Chinook Salmon Radio-Tagged and Released Upstream of Warm Springs NFH in 2008 \(Conder et al. 2010\)](#). During the spring and summer of 2008, 35 hatchery-origin spring Chinook salmon were radio-tagged and released upstream of the hatchery. We studied their movement patterns, identified potential holding areas, estimated survival, and approximated their contribution to spawning. Based on tag movements during the spawning period, 60% of the tagged fish survived to spawning and 31% of the radio-tagged hatchery fish contributed to natural spawning.
- **2008** – [Use of Parentage Analysis to Determine Reproductive Success of Hatchery-Origin Spring Chinook Salmon Outplanted into Shitike Creek, Oregon \(Baumsteiger et al. 2008\)](#). In 2002 and 2003, 83 and 265 adult hatchery salmon, respectively, were outplanted into Shitike Creek. The number of (juvenile) offspring attributed to an individual (adult) outplant was variable, ranging from 1 to more than 10. This study shows that under the right conditions, outplanted adult hatchery fish taken from localized hatchery stocks can contribute to the overall juvenile production in a natural stream. Outplanting adult salmon from Warm Springs NFH into Shitike Creek continued through 2005 ([Hand et al. 2005](#)).
- **2010** – [Feasibility of live spawning wild male spring Chinook salmon at Warm Springs NFH, 2010 Report \(Hand et al. 2014b\)](#). We evaluated the feasibility of using live-spawned wild males to provide a genetic contribution to both the hatchery broodstock and natural production by live-spawning five wild males and releasing the fish back into the Warm Springs River. It appeared that live-spawning of wild males may be a feasible method to include wild genetics into the hatchery broodstock while not compromising the overall wild production.
- **2012** – [Effectiveness of an integrated hatchery program: Can genetic-based performance differences between hatchery and wild Chinook salmon be avoided? \(Hayes et al. 2013\)](#). The authors evaluated the performance of fish from hatchery, wild, and crossed populations in hatchery and stream environments. Hatchery fish performed differently than wild fish possibly because they were accustomed to rearing at higher densities in a hatchery setting (domestication) leading to genetic divergence. Future studies are needed to evaluate which hatchery techniques are most useful for reducing performance differences and reducing risk to wild populations.

- **2013 – An Evaluation of Rearing Densities to Improve Growth and Survival of Hatchery Spring Chinook Salmon (Olson and Paiya 2013).** For three consecutive brood years (BY2000-02), density treatments consisted of low, medium, and high groups in 57.8-m³ raceways with approximately 16,000, 24,000, and 32,000 fish/raceway, respectively. Fish reared at high density exhibited the highest on-hatchery mortality rate during two brood years; however, differences in mortality rate among densities were not significant ($P = 0.20$). In one brood year, adult recovery rates appeared to support the hypothesis that lower initial densities improved post-release survival ($P < 0.01$). All rearing densities utilized in this evaluation were relatively low and may partially explain why more differences were not readily apparent among density groups.
- **2014 – Pacific lamprey and Bull Trout passage assessment at Warm Springs NFH (Gallion and Skalicky 2014).** An evaluation at the hatchery indicated significant passage deficiencies for Pacific lamprey which likely delay and limit passage through the fishway. Passage limitations for bull trout through the fishway were not as significant.
- **2014 – Genetic Composition of the Warm Springs River Chinook Salmon Population Maintained Following Eight Generations of Hatchery Production (Smith et al. 2014).** The genetic characteristics of the endemic population was examined before (1976–1977) and after (2001-2011) hatchery became operational. Natural-origin Chinook Salmon changed very little over the eight generations. However, differences between hatchery- and natural-origin fish are expected to increase if hatchery operations do not integrate natural-origin fish and incorporate Round Butte Hatchery fish into the broodstock.
- **2014 – Adult Recovery of Hatchery Spring Chinook Salmon Adipose Fin-Clipped and Coded-Wire-Tagged Using an Automated and Manual Marking Trailer (Hand et al. 2014a).** At WSNFH, the adult recovery rate for fish marked in the automated trailer was 0.16%, compared with a recovery rate of 0.14% for fish marked in the manual trailer. A fish was 1.17 times more likely to be recovered as an adult at the hatchery if marked in an automated trailer.
- **2015– Migratory Behavior of Chinook Salmon Microjacks Reared in Artificial and Natural Environments (Hayes et al. 2015).** Emigration was evaluated for hatchery age-1 mature males and immature parr. Mature age-1 fish were significantly longer, heavier, and had greater condition factor. These mature age-1 male fish have the potential to contribute to the spawning population but can also represent a loss of productivity.
- **2016 – Migration Timing and Survival of Warm Springs NFH Juvenile Spring Chinook Salmon in the Deschutes Basin (Davis et al. 2016).** In 2012, 2013 and 2014, radio-telemetry was used to evaluate where the majority of spring Chinook mortalities occur. Median travel time from WSNFH to Bonneville Dam was 27 days compared to a two-day travel time to the mouth of the Deschutes, suggesting the

rate of travel slows from an average 70 rkm/day to 3.5 rkm/day when fish enter the Columbia River.

- **2018** – Evaluation of adult Pacific Lamprey upstream passage at Warm Springs National Fish Hatchery, 2017 Annual Report (Barkstedt and Johnsen 2018). A previous evaluation of both physical structures and adult lamprey passage determined that the barrier dam and fish ladder impeded lamprey upstream migration (Gallion and Skalicky 2014). The Confederated Tribes of Warm Springs Reservation and the USFWS collaborated to design, install, and monitor a LPS. The LPS was installed in 2017, began operation in 2018, and successfully provided passage for 13 adult Pacific Lamprey in its first year
- **2018** – Evaluation of on-hatchery and off-hatchery performance of WSNFH stock, Round Butte stock, and Parkdale stock juveniles reared and released from Warm Springs NFH.

Summary and Future Studies

The WSNFH produces spring Chinook Salmon for tribal harvest in the Deschutes and Columbia Rivers, for on-reservation distribution to tribal members, and for sport fishery. The program's goal to produce within 10% of 750,000 juveniles for release is currently 28% below the target release. The primary issues related to meeting release goals has been maintaining broodstock health after they have returned to the hatchery, achieving eye-up, and survival until marking. The smolt-to-adult survival rate varies annually but has exceeded its goal seven times in the last ten years.

Warm Springs NFH juvenile releases have changed over time and are dependent on environmental and hatchery factors. Since 1991, the spring releases have ranged from March 27 to April 27 (April 3 on average). All the juveniles have been successfully marked with an adipose fin clip, non-WSNFH stocks have been differentially marked with a ventral clip, and a subsample are PIT Tagged or CWTed before release.

During the juvenile fish downstream migration season (March to late summer), the Columbia River hydropower system operations are modified to improve in-river conditions for migrating fish. One modification is to spill water and juvenile fish over dam spillways, instead of putting the water through the turbines. Spring spill dates for McNary, John Day, The Dalles, and Bonneville Dams start April 10. Based on PIT tag data since brood year 2005, the fastest hatchery releases reach Bonneville dam in approximately 4 days. These fish likely pass The Dalles Dam 1-2 days prior to reaching Bonneville Dam (see Davis (2016) for data on Deschutes River migration). If the fundamental objective of the hatchery release is to maximize the likelihood of hatchery releases passing through mainstem spillways instead of turbines, USFWS recommends hatchery releases should start no more than three days prior to spill (April 7). A less conservative approach, 90% of the fish passing the mainstem dams during spill, would be to start hatchery releases no more than 8 - 9 days prior to spill.

Wild and hatchery fish return to the Warm Springs River from late April through September and are spawned from late August through September dependent on environmental and hatchery

factors. Most wild and hatchery fish return to the Warm Springs River by late June. Hatchery spawning has begun as early as August 14 and as late as September 5, the average first date of spawning is August 23. In 2019, the first date of spawning was September 5th, five days after the previous latest start of spawning. Higher intensity daylight LED lights were installed over each pond and simulate the day length needed to cue future spawning. We did not see delayed spawning in 2020 or 2021, all fish were spawned between August 19 and September 14.

The facility has produced a mean hatchery smolt-to-adult survival rate that exceeds the target SAR of 0.39% but it is variable year to year (mean = 0.45 [0.23 SD]). Due to low wild fish returns (<1,000 fish) in recent years, wild fish have not regularly been incorporated into the hatchery broodstock. The threshold 1,000 returning wild fish has been met only once since 2004, so the program has effectively been operated under a segregated paradigm for several generations. Beginning in 2020, the wild fish supplementation program provided an opportunity to incorporate wild fish into the hatchery broodstock. Thus, improving the hatchery's ability to maintain wild fish genetic characteristics in the hatchery population and minimize genetic divergence between Warm Springs River hatchery and wild fish.

The 2022 forecast for WSNFH stock adult returns (model estimates of 656 to 1,067 Age 4 and 5 fish) indicate that it is likely that the hatchery's broodstock needs will be met. Round Butte Hatchery may also meet broodstock needs with model estimates of 973 to 1,382 Age 4 and 5 fish. While the wild fish forecast estimate is an improvement over 2020 and 2021 (85 - 313 Age 4 and 5 fish), it is however, still concerning and warrants close monitoring and discussions of potential emergency actions. All the forecasts have a high degree of uncertainty, which will necessitate in-season monitoring and readiness to adjust management plans.

To make up for insufficient eggs in 2018, WSNFH received spring Chinook eggs and juveniles from both the Round Butte State Fish Hatchery and CTWSRO's Parkdale Hatchery. These fish were released in 2020 and an evaluation of their on-hatchery and off-hatchery performance will provide additional information on the similarities and differences between these three stocks. Juvenile Parkdale Hatchery and Round Butte fish released from WSNFH are differentially marked (left ventral clip) to distinguish them from Warm Springs broodstock in subsequent years. Marked fish are excluded from spawning with Warm Springs stock, however, they can be inadvertently spawned with Warm Springs stock if the ventral fin grows back. Inadvertent inclusion in the hatchery broodstock may increase with the number and frequency of transfers from outside the Warm Springs population and could pose a genetic risk to the Warm Springs stock (Smith 2018). Future transfers are contingent upon availability and only after consultation and concurrence of CTWSRO and the USFWS.

Other species of fish collected at the WSNFH fish ladder include wild Steelhead, hatchery Steelhead, Fall Chinook (wild and hatchery), Coho (wild and hatchery), Rainbow Trout, Bull Trout, Whitefish, Northern Pikeminnow, Sucker, and Pacific Lamprey. These fish are counted and passed upstream, transferred to the Pacific Region Fish Health Program for disease analysis and disposal, or made available to the CTWSRO. Low wild fish counts at WSNFH of Spring Chinook and other species is of concern.

Future M&E Studies

- Annual run reconstruction of wild and hatchery spring Chinook salmon
- Collect data for population monitoring of ESA listed summer steelhead and bull trout

- Monitor other fish passing the hatchery site,
- Rearing and release studies at the hatchery to improve performance,
 - Diet
 - Growth
 - Reduced rearing densities
 - Fish health evaluations
- Explore funding available to continue developing collaborative projects with our partners, especially CTWSRO
- Evaluate performance and ecological interactions of hatchery and wild fish
- Evaluate & implement projects and/or facilities to reduce high water temperature during late spring to early fall juvenile rearing at the hatchery
- Evaluate on-hatchery and off-hatchery performance of BY18 Warm Springs, Round Butte, and Parkdale stocks reared at WSNFH

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Data used in this report was downloaded from CRiS maintained at the CRFWCO, RMIS, and PTAGIS. Hatchery personnel at WSNFH 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 this hatchery program was provided by the USFWS.

References

- Archibald, J. 2013. Warm Spring Fish Passage Evaluation Report 2013. U.S. Fish & Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.
- Barkstedt, J., and A. Johnsen. 2018. Evaluation of adult Pacific Lamprey upstream passage at Warm Springs National Fish Hatchery, 2017 Annual Report. U.S. Fish & Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.
- Baumsteiger, J., D. M. Hand, D. E. Olson, R. Spateholts, G. FitzGerald, and W. R. Ardren. 2008. Use of Parentage Analysis to Determine Reproductive Success of Hatchery-Origin Spring Chinook Salmon Outplanted into Shitike Creek, Oregon. *North American Journal of Fisheries Management*.
- Cates, B. 1992. Warm Springs National Fish Hatchery evaluation and anadromous fish study on the Warm Springs Indian Reservation of Oregon 1975-1989. United States Fish; Wildlife Service, Lower Columbia River Fishery Resource Office, Vancouver, WA.
- Conder, T., D. M. Hand, D. E. Olson, and J. Lovtang. 2010. Distribution and Survival of Adult Hatchery Spring Chinook Salmon Radio-Tagged and Released Upstream of Warm Springs National Fish Hatchery in 2008. U.S. Fish & Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.
- Confederated Tribes of the Warm Springs Reservation of Oregon, and U.S. Fish and Wildlife Service (USFWS). 2007. Warm Springs National Fish Hatchery: Operational Plan and Implementation Plan 2007-2011.
- Davis, B., J. Poirier, and D. M. Hand. 2016. Migration Timing and Survival of Warm Springs National Fish Hatchery Juvenile Spring Chinook Salmon in the Deschutes Basin, 2012-2014 final Report. U.S. Fish & Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.

- Frejcie, T. 2019. National Fish Hatchery Planned Release, Transfer Schedule or Research Request, 3/20/2019.
- Gallion, D., and J. Skalicky. 2014. Pacific Lamprey and Bull Trout Passage Assessment at Warm Springs National Fish Hatchery. Page 43. U.S. Fish & Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.
- Hand, D. M., W. R. Brignon, and D. E. Olson. 2014a. Adult Recovery of Hatchery Spring Chinook Salmon Adipose Fin-Clipped and Coded-Wire-Tagged Using an Automated and Manual Marking Trailer. *North American Journal of Aquaculture*.
- Hand, D. M., W. R. Brignon, D. E. Olson, and J. Rivera. 2010. Comparing Two Methods Used to Mark Juvenile Chinook Salmon: Automated and Manual Marking. *North American Journal of Aquaculture*.
- Hand, D. M., T. Conder, D. E. Olson, and J. Lovtang. 2014b. Feasibility of live spawning wild male spring Chinook salmon at Warm Springs National Fish Hatchery, 2010 Report. U.S. Fish & Wildlife Service, Columbia River Fisheries Program Office.
- Hand, D. M., and D. E. Olson. 2003. Steelhead Returns to Warm Springs National Fish Hatchery, 1978-2003.
- Hand, D. M., D. E. Olson, R. O. Engle, T. A. Hoffman, R. Spateholts, and G. FitzGerald. 2005. Distribution, Behavior, and Reproductive Success of Outplanted Hatchery Spring Chinook Salmon in Shitike Creek, OR. Progress Report for 2004 and Work Plan for 2005. Confederated Tribes of the Warm Springs Reservation of Oregon; U.S. Fish & Wildlife Service.
- Hand, David M. and Haeseker, Steven L. 2011. Retrospective Analysis of Preseason Run Forecast Models for Warm Springs stock Spring Chinook Salmon in the Deschutes River, Oregon. U.S. Fish & Wildlife Service. https://www.fws.gov/CRFWCO/publications/Analysis_of_Warm_Springs_Stock_Spring_Chinook_Salmon_Forecasting_Methods.pdf.
- Hayes, M. C., R. R. Reisenbichler, S. P. Rubin, D. C. Drake, K. D. Stenberg, and S. F. Young. 2013. Effectiveness of an integrated hatchery program: Can genetic-based performance differences between hatchery and wild Chinook salmon be avoided? *Canadian Journal of Fisheries and Aquatic Sciences*.
- Hayes, M. C., S. P. Rubin, R. R. Reisenbichler, and L. A. Wetzel. 2015. Migratory behavior of chinook salmon microjacks reared in artificial and natural environments. *Journal of Fish and Wildlife Management*.
- Integrated Hatchery Operations Team (IHOT). 1995. Policies and Procedures for Columbia Basin Anadromous Salmonid Hatcheries, Annual Report 1994, Report to Bonneville Power Administration, Contract No. 1992BI60629, Project No. 199204300. Pages 119 electronic pages (BPA Report DOE/BP-60629).
- Lovtang, J., M. W. Gauvin, and D. M. Hand. 2011. Spring Chinook Salmon in the Deschutes River, Oregon, Wild and Hatchery. 1975-2009 returns and 2010 Run Size Forecasts. Confederated Tribes of the Warm Springs Reservation of Oregon, Oregon Department of Fish & Wildlife, U.S. Fish & Wildlife Service, Warm Springs, OR.
- National Marine Fisheries Service (NMFS). 2007. Section 7 Biological Opinion USFWS Artificial Propagation Programs in the Lower Columbia River and Middle Columbia River.
- National Marine Fisheries Service (NMFS). 2018. Section 7 Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response.
- Olson, D. E., and M. Paiya. 2013. An evaluation of rearing densities to improve growth and survival of hatchery spring Chinook salmon.
- Olson, D. E., and R. Spateholts. 2001. Hatcheries, Harvest and Wild Fish: An Integrated Program at Warm Springs National Fish Hatchery, Oregon. Pages 23–42 52nd annual pacific northwest fish culture conference.

- Olson, D. E., R. Spateholts, M. Paiya, and D. E. Campton. 2004. Salmon hatcheries for the 21st century: A model at Warm Springs National Fish Hatchery. Pages 585–602 *in* M.J. Nickum, P. M. Mazik, J. G. Nickum, and D. D. MacKinlay, editors. Propagated fish in resource management Symposium. American Fisheries Society, Bethesda, Maryland.
- Reagan, R. E., N. S. Adams, D. W. Rondorf, G. FitzGerald, R. Spateholts, T. A. Hoffman, and D. E. Olson. 2005. Distribution, Migration Behavior, Habitat Use, and Species Interactions of Fall-Released Juvenile Hatchery Spring Chinook Salmon in the Deschutes River, Oregon, 2003 Annual Report for 2003 Columbia River Publications. Columbia River Publications web page.
- Smith, C. T. 2018. Memo to Mike Clark, Complex Manager, Columbia River Gorge NFH Complex. June 29, 2018.
- Smith, C. T., R. French, J. Lovtang, and D. M. Hand. 2014. Genetic Composition of the Warm Springs River Chinook Salmon Population Maintained Following Eight Generations of Hatchery Production. Transactions of the American Fisheries Society.
- Thompson, D., and A. Goodwin. 2016. An Investigation into the Cause of Egg Mortality at Warm Springs National Fish Hatchery during the fall of 2015. U.S. Fish & Wildlife Service.
- U.S. Fish and Wildlife Service (USFWS). 1995. Fish Health Policy and Implementation, 713 FW. U.S. Fish & Wildlife Service Manual (FWM).
- U.S. Fish and Wildlife Service (USFWS). 2004. Aquatic Animal Health Policy. <https://www.fws.gov/policy/713fw1.pdf>.
- U.S. Fish and Wildlife Service (USFWS). 2006. Columbia River Basin, Columbia Plateau Province, Deschutes River Watershed, Warm Springs National Fish Hatchery Assessments and Recommendations Final Report. U.S. Fish & Wildlife Service, Portland, Oregon. <http://www.fws.gov/pacific/fisheries/Hatcheryreview/team.html>.
- U.S. Fish and Wildlife Service (USFWS). 2019. Warm Spring National Fish Hatchery 2019 Draft Annual Operational Plan. U.S. Fish & Wildlife Service, Portland, Oregon.

Appendix A

A summary of on-station hatchery notes for 2021 (i.e., feeding changes, ponding, unique issues, etc.)

- Infrastructure/Tools
 - Generator replacement project was completed
 - Raceways 11-10 were given an epoxy coating. This will seal them to prevent further deterioration of the concrete.
 - All adult fish were sexed with the ultrasound unit
 - In late December, there was a freeze-up in the incubation room
- Fish Health
 - A new *Columinaris* vaccine was used with limited efficacy, post-exposure to the vaccine appeared hard on the fish.
 - There was severe ich in Brood Pond 1
 - Round Butte brood transferred from Warm Springs NFH to Round Butte Hatchery had a 60% broodstock mortality in the summer
 - One batch of BY21 eggs was culled due to BKD