Warm Springs National Fish Hatchery - Spring Chinook Salmon Program FY 2020 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.

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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 Tribe. 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 Tribe's 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 Spateholts 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 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 kilometers 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 (USFWS 1995, 2004; Integrated Hatchery Operations Team (IHOT) 1995) 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.

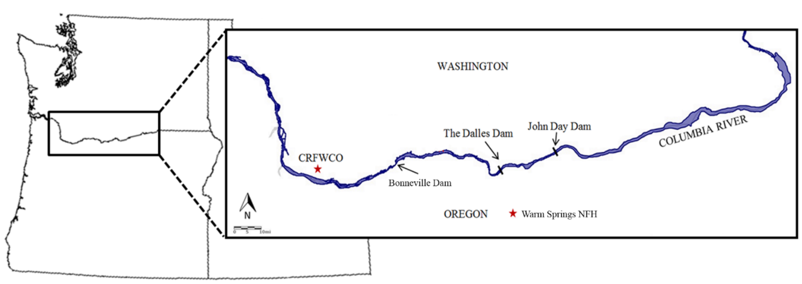

Figure 1. The Warm Springs NFH is located within the Warm Springs Reservation of Oregon and uses funds from the USFWS to support its rearing program.

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 in excess of $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, the majority 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. 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. In recent years, eggs and juveniles from Parkdale Hatchery, located within the Hood River basin, have also been used to augment the WSNFH production. 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 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 U.S. 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 CTWS
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

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.

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 566,352 juveniles released since release year (RY) 2011.

Since RY 2011, the facility has achieved a mean juvenile size of 32.8 fish/lb. at the time of release. While all juveniles are given an AD clip and coded wire tag, 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. 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 12/14/2020.

Release Year	Brood Year	Rel. Dates	Rel. Type	AD + CWT	AD Only	CWT Retention	Total Released	Mean Size (Fish/lb)
2011	2009	4/13 – 4/27	V	311,296	8,591	97.3	319,887	29
2011	2009 (A)	4/4 – 4/11	V	216,162	1,231	99.3	217,393[a]	34
2012	2010	4/2 – 4/26	V	471,834	9,110	96.4	480,944	29
2013	2011	3/27 – 4/10	V	770,451	13,095	99.3	783,546	24
2013	2012	6-May	A	19,908	242	98	20,150	160
2014	2012	3/31 – 4/4	F	713,563	13,379	98	726,942	24
2015	2013	3/30 – 3/31	F	344,834	26,621	93.1	371,455	28
2016	2014	30-Mar	F	129,349	3,682	93.5	133,031	22
2017	2015	30-Mar	F	396,864	17,451	95.8	414,315	24
2017	2015 (B)	30-Mar	F	112,460	6,939	94.2	119,399[b]	30
2018	2016	29-Mar	F	533,560	7,881	98.9	541,441	22
2019	2017	4/3, 4/5	F	736,730	27,510	96.4	764,240	26
2019	2017 (A)	3-Apr	F	120,045	3,496	97.2	123,541a	30
2020	2018	8-Apr	F	277,211	3,922	98.6	281,133	24.8
2020	2018 (A)	8-Apr	F	228,470	1,840	99.2	230,310[a]	24.3
2020	2018 (B)	8-Apr	F	135,798	0	100	135,798[b]	23.3
Mean by Stock	**Warm Springs**			**427,782**	**11,953**	**96.8**	**439,735**	**38**
	Round Butte (A)			**188,226**	**2,189**	**98.6**	**190,415**	**29**
	Parkdale (B)			**124,129**	**3,470**	**97.1**	**127,598**	**27**
Total Annual Mean				**551,854**	**14,499**	**96.8**	**566,352**	**32.8**

[a] Left ventral clip to distinguish as Round Butte Stock

[b] 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) 2011-2020, approximately 15,000 juvenile spring

Chinook were annually tagged with passive integrated transponder (PIT) tags in later 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 2011, an average 15,269 juveniles have been PIT tagged at and released from WSNFH each year. The mean annual number of detections at BONN is 1,105, a detection rate of 7.1%. Average mean juvenile travel time to BONN after release is approximately 26 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 14 days or less after release (10^{th} percentile mean). However, the majority of fish (90^{th} percentile) pass over BONN within 37 days after release.

Table 2. The number of juvenile spring Chinook PIT tagged in a given release year and travel times to Bonneville Dam (BONN) following release from Warm Springs NFH. Migration times to BONN may be underestimated in release years 2011 -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 12/14/2020.

Release Year	# PIT Tagged	# Det. at BONN	% Det.	Travel Time (Days)					
				Mean	Range	Percentile			
						10th	50th	75th	90th
2011	14,924	661	4.4	32	5 – 114	21	32	38	41
2012	14,862	906	6.1	35	5 – 106	21	37	41	45
2013	14,965	1,244	8.3	28	3 – 102	15	29	31	35
2014	14,898	1,107	7.4	30	4 – 121	19	31	35	41
2015	14,915	1,425	9.6	21	3 – 96	7	23	28	33
2016	14,975	1,345	9	19	3 – 118	8	17	23	30
2017	9,896	289	2.9	25	3 – 84	7	27	34	37
2017 (B)	4,972	95	1.9	34	4 – 56	15	36	41	51
2018	14,903	955	6.4	24	4 – 56	9	26	33	36
2019	12,887	1,141	8.9	24	3 – 94	11	23	30	35
2019 (A)	2,097	160	7.6	30	8 - 48	22	30	35	38
2020	7,944	775	9.8	18	4.5 - 121	10	17	21	27
2020 (A)	6,566	598	9.1	18	4.5 - 111	10	18	21	25
2020 (B)	3,884	353	9.1	18	4.5 - 106	10	17	21	27
Warm Springs	**13,517**	**985**	**7.3**	**26**		**13**	**13**	**31**	**36**
Round Butte (A)	**4,332**	**379**	**8.4**	**24**		**16**	**16**	**28**	**32**
Parkdale (B)	**4,428**	**224**	**5.5**	**26**		**12**	**12**	**31**	**39**
Total Annual Mean	**15,269**	**1,105**	**7.1**	**26**		**14**	**27**	**32**	**37**

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). 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 2009-2018 (release years 2011-2020) ranged from 0.41 to 0.83 (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:1/14/21.

Release Year	Brood Year	Median Survival	95% Lower	95% Upper
2011	2009	0.41	0.30	0.60
2012	2010	0.54	0.41	0.67
2013	2011	0.70	0.57	0.86
2014	2012	0.62	0.50	0.79
2015	2013	0.50	0.44	0.58
2016	2014	0.55	0.44	0.73
2017	2015	0.43	0.17	0.99
2018	2016	0.54	0.35	0.88
2019	2017	0.46	0.34	0.64
2020	2018	0.83	0.60	0.99
Mean		**0.56**	**0.41**	**0.77**

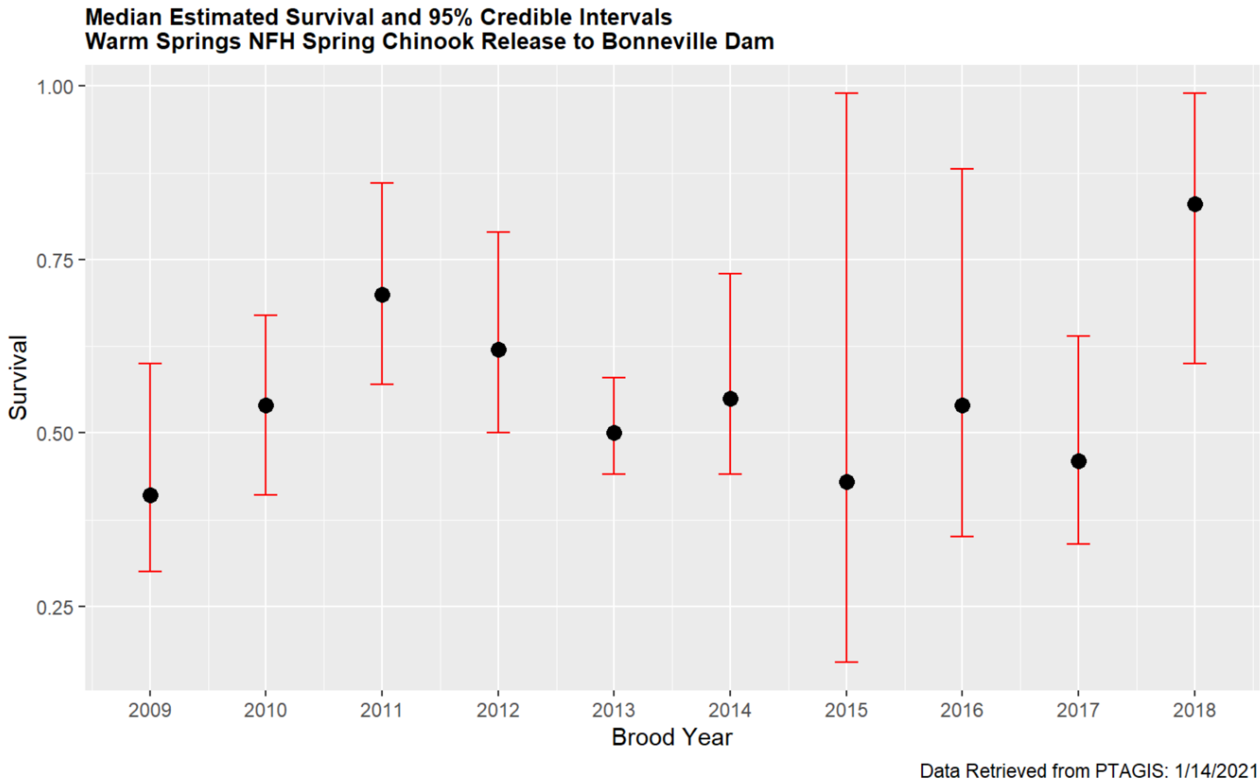

Figure 2. Juvenile Spring Chinook survival from release at Warm Springs NFH to Bonneville Dam. Estimates are median survival with 95% lower and upper credible intervals (2009 - 2018).

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) 2004. Collectively, the facility has produced a mean of 2,772 adults annually since BY 2004 resulting in a mean smolt-to-adult survival rate (SAR) of 0.47%. 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 3/25/2021.

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2004	2,175	866	3	0	3,044	0.45
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
Mean	**2,325**	**633**	**8**	**0**	**2,772**	**0.47**

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

An average 754 CWTs have been recovered each year at Warm Springs NFH since 2011 (Table 5). The Warm Springs NFH spring Chinook program accounts for 98.5 percent of all recoveries; spring Chinook from other programs include Round Butte (0.6%) and Irrigon (0.5%), both state hatcheries in Oregon; returning spring Chinook from other programs account for < 0.1% of all recoveries.

Table 5. Coded Wire Tag (CWT) recoveries for all hatchery programs collected at Warm Springs NFH 2011 – 2020. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates.

Return Year	CWT Recoveries	Hatchery Origin	% of Total Annual Return
2011	2	Clearwater Hatchery	0.1
	1	Coleman NFH	0.1
	1	Cottonwood Cr Pond	0.1
	22	Irrigon Hatchery	1.5
	2	Little White Salmon NFH	0.1
	1	NPT Hatchery	0.1
	10	Round Butte Hatchery	0.7
	7	Wallowa Hatchery	0.5
	1,465	Warm Springs NFH	97.0
2012	3	Lookingglass Hatchery	0.4
	3	Round Butte Hatchery	0.4
	699	Warm Springs NFH	99.1
2013	4	Lookingglass Hatchery	0.5
	1	NPT Hatchery	0.1
	1	Parkdale	0.1
	7	Round Butte Hatchery	0.9
	1	Sawtooth Hatchery	0.1
	798	Warm Springs NFH	98.3
2014	1	Rapid River Hatchery	0.1
	3	Round Butte Hatchery	0.3
	982	Warm Springs NFH	99.6
2015	5	Irrigon Hatchery	0.2
	1	Little White Salmon NFH	< 0.1
	2	Magic Valley Hatchery	0.1
	3	Round Butte Hatchery	0.1
	2,192	Warm Springs NFH	99.5
2016	1	Cle Elum Hatchery	0.3
	1	Cottonwood Cr Pond	0.3
	4	Irrigon Hatchery	1.4
	4	Round Butte Hatchery	1.4
	279	Warm Springs NFH	96.5
2017	1	Irrigon Hatchery	4.3
	22	Warm Springs NFH	95.7
2018	7	Round Butte Hatchery	3.1
	222	Warm Springs NFH	96.9
2019	1	Imnaha Pond	0.3
	1	Klickitat Hatchery (YKFP)	0.3
	3	Round Butte Hatchery	0.9
	326	Warm Springs NFH	98.5
2020	6	Round Butte Hatchery	1.3
	2	Sawtooth Hatchery	0.4
	443	Warm Springs NFH	98.2
Mean	**754**		

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-09 (Table 6).

Table 6. Median Bonneville Dam passage date of adult spring Chinook PIT tagged and released from Warm Springs NFH (≥ Age 3).

Return Year	Median Passage Date	First Det. Date	Last Det. Date	# of Fish Det.	Bonneville Expansion (95% CI) *	Hatchery Count	Hatchery Count/Bonn Exp. *100
2011	May-20	May-01	Jun-23	22	1,041 (691 - 1,655)	3,826	368%
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%
Mean	**May-09**	**Apr-18**	**Jun-24**	**74**	**2,956**	**1,983**	**104%**

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

Since Return Year 2011, spring Chinook adults (≥ 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-27 (Table 7).

Table 7. Median passage date at Warm Springs NFH Ladder of adult spring Chinook PIT tagged and released from Warm Springs NFH (≥ Age 3).

Return Year	Median Passage Date	First Det. Date	Last Det. Date	# of Fish Det.	Hatchery Expansion (95% CI) *	Hatchery Count	Hatchery Count/Bonn Exp. *100
2011	Jun-04	May-14	Sep-02	10	473 (260 - 982)	3,826	809%
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%
Mean	**May-27**	**May-06**	**Aug-15**	**43**	**1,740**	**1,983**	**200%**

* Confidence limits do not include detections of five fish or less 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 2011, approximately 89% of adults have returned to the facility at Age-4 (Table 8). Additionally, approximately 10% 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 2,125 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 adult spring Chinook returns to Warm Springs NFH by *brood year*. Non-Warm Springs stock are excluded from this table. Data from CRiS Age Composition Report 3/25/2021

Brood Year	Age-3	Age-4	Age-5	Age-6	Total # Adults
2005	246	2,649	38	0	2,933
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	449
2015*	15	354	8	NA	NA
2016*	30	373	NA	NA	NA
2017*	161	NA	NA	NA	NA
Mean	**283**	**1,866**	**31**	**0**	**2,547**

Table 9. Total number of adult spring Chinook returns to Warm Springs NFH and estimated age structure by *return year*. Non-Warm Springs stock are excluded from this table. Data from CRiS Age Composition Report 3/25/2021

Return Year	Age-3	Age-4	Age-5	Age-6	Total # Adults
2011	708	3,047	71	0	3,826
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	30	354	7	0	391
2020	161	373	8	0	542
Mean	**229**	**1,724**	**31**	**0**	**1,983**

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 10).

Table 10. Deschutes harvest estimates of wild and WSNFH spring Chinook salmon 2011 - 2020. Estimates based on ODFW and CTWSRO creel surveys. 2011 Warm Springs NFH harvest is composed of both WS stock and RB (Age 3 and 4) hatchery stock that were reared and released at WSNFH. Dashed line indicates limited Tribal harvest; however, no creel survey took place in 2020 due to COVID-19 safety precautions.

Return Year	Wild Harvest				Warm Springs NFH Harvest				Total Harvest
	Adult Sport	Jack Sport	Adult Tribal	Jack Tribal	Adult Sport	Jack Sport	Adult Tribal	Jack Tribal	
2011	0	0	10	0	643	265	407	29	1,354
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[a]	0	0	0	0	0	0	22	0	22
2020[a]	0	0	-	-	0	0	-	-	-
Mean	**0**	**0**	**7**	**0**	**225**	**49**	**213**	**26**	**550**

[a] No Sport Harvest in 2019 or 2020

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 surplussed and given to tribal representatives for distribution. Disposition of fish depends on number of returns, their condition, and origin (Table 11).

Table 11. Disposition of hatchery (all stocks) and wild spring Chinook salmon at Warm Springs NFH, 2011 - 2020. Numbers include spring Chinook salmon adults (age 4-5) and jacks (age 3) that were surplussed 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.

	Hatchery Fish							Wild Fish			
Year	Upstream	Surplus Donated	Surplus Dump	Brood	Transfer	Mort	Total	Upstream	Brood	Mort	Total
2011	39	2,145	5	665	0	155	3,009	809	0	8	817
2012	34	310	0	560	0	65	969	380	0	5	385
2013	63	689	0	482	0	184	1,418	397	0	3	400
2014	0	996	0	194	35 [c]	486	1,711	761	0	6	767
2015	78	4,901	145	615 [a]	0	188	6,635	1,369	0	12	1,381
2016	0	1,550	3	758 [b]	323 [d]	150	2,784	335	0	13	348
2017	-	-	-	747	-	80	1,555[c]	-	-	-	193 [e]
2018	0	5	0	206	0	47	260	247	0	0	247
2019	0	0	39	259	0	94	394	204	0	0	204
2020	3	0	70	360	0	79	566	10	35	5	50
Mean	**24**	**1,177**	**26**	**498**	**40**	**161**	**1,924**	**501**	**4**	**6**	**479**

[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
Data retrieved from Fish Removal file 3/26/2021

2020 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 2020, an estimated 50 wild and 508 hatchery Warm Springs River spring Chinook (Tables 12 and 13) and 259 Round Butte hatchery spring Chinook (Table 14) 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, CTWSR).

Table 12. Run reconstruction of *wild* spring Chinook salmon from the Warm Springs River, 2020. Run reconstruction performed 12/18/2020, aging for age 3 fish based on hatchery records of jacks (fish < 60cm), ages 4 and 5 were estimated based on historical data (85% of fish > 60cm Age 4).

Location	Wild Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To WSNFH	Upstream of WSNFH	0	9	1	10	10
	WSNFH Broodstock	2	28	5	33	35
	DIPS/Jumpouts/killed	0	5	0	5	5
	Total	**2**	**42**	**6**	**48**	**50**
Harvest	Sport	0	0	0	0	0
	Tribal	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**
Below WSNFH	Spawned	0	0	0	0	0
Total Estimated Return		**2**	**42**	**6**	**48**	**50**

Table 13. Run reconstruction of *hatchery* spring Chinook salmon from the Warm Springs River, 2020. Run reconstruction performed 12/18/2020.

Location	Hatchery Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To WSNFH	Upstream of WSNFH	0	0	0	0	0
	Surplus	0	0	0	0	0
	WSNFH Broodstock	147	352	9	361	508
	Strays	0	0	0	0	0
	Total	**147**	**352**	**9**	**361**	**508**
Harvest	Sport*	0	0	0	0	0
	Tribal†	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**
Total Estimated Return		**147**	**352**	**9**	**361**	**508**

*No sport harvest in 2020

†Limited Tribal harvest in 2020

Table 14. Run reconstruction of *hatchery* spring Chinook salmon from the Round Butte Hatchery, 2020. Run reconstruction performed 12/18/2020.

Location	Hatchery Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To Pelton Trap*	Hatchery	33	203	6	209	242
Harvest	Sport†	0	0	0	0	0
	Tribal‡	1	16	0	16	17
	Total	**1**	**16**	**0**	**16**	**17**
Total Estimated Return (RB Stock)		**34**	**219**	**6**	**225**	**259**

*Based on size (AD only fish)

†No sport harvest in 2021

‡Limited tribal harvest in 2021

2020 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 11). 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). With the 2020 preseason forecasts for wild adult (ages 4 and 5) Spring Chinook Salmon returns to the Deschutes Basin ranging from 50 to 300 total returns, the CTWSRO developed a plan to transport some 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 some of the wild fish for on-hatchery spawning and rearing at Warm Springs NFH. The preliminary 2020 wild fish plan was to transport 1/3 of the wild adults, collect 1/3 of the wild adults for on-hatchery spawning and rearing, and pass 1/3 of the adults upstream of the hatchery. Due to the Covid-19 outbreak in March of 2020, and subsequent working restrictions, no fish were transported upstream and only 10 wild fish were passed upstream (Table 12). The decision was made in mid-May to collect *all* wild fish for holding and spawning at the hatchery. A total of 40 fish were collected at the hatchery, with five of these fish dying prior to broodstock collection (Table 15, Figure 3).

Monitoring adult returns at the hatchery provided information on sex ratios, length information, and age structure based on scale samples. Approximately 80% of adults collected at the facility were Age-4, 10% were jacks at Age-3, and 10% were Age-5; zero Age-6 fish were documented. (Table 15).

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 31st and September 11th and occurred in three 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 a hatchery female in standard 1x1 spawning (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).

Table 15. Total number of *wild* adult spring Chinook returns to WSNFH, estimated age structure, and disposition. Data from CRiS Age Composition Report 3/25/2021.

	Total Adult Return	Passed Upstream	Held at WSNFH			Hatchery Disposition	
			Age 3	Age 4	Age 5	Mortality	Spawned
Male	20	1	5	14	0	2	17
Female	28	7	0	16	5	3	18
Unknown	2	2	0	0	0	0	0
Total	**50**	**10**	**5**	**30**	**5**	**5**	**35**

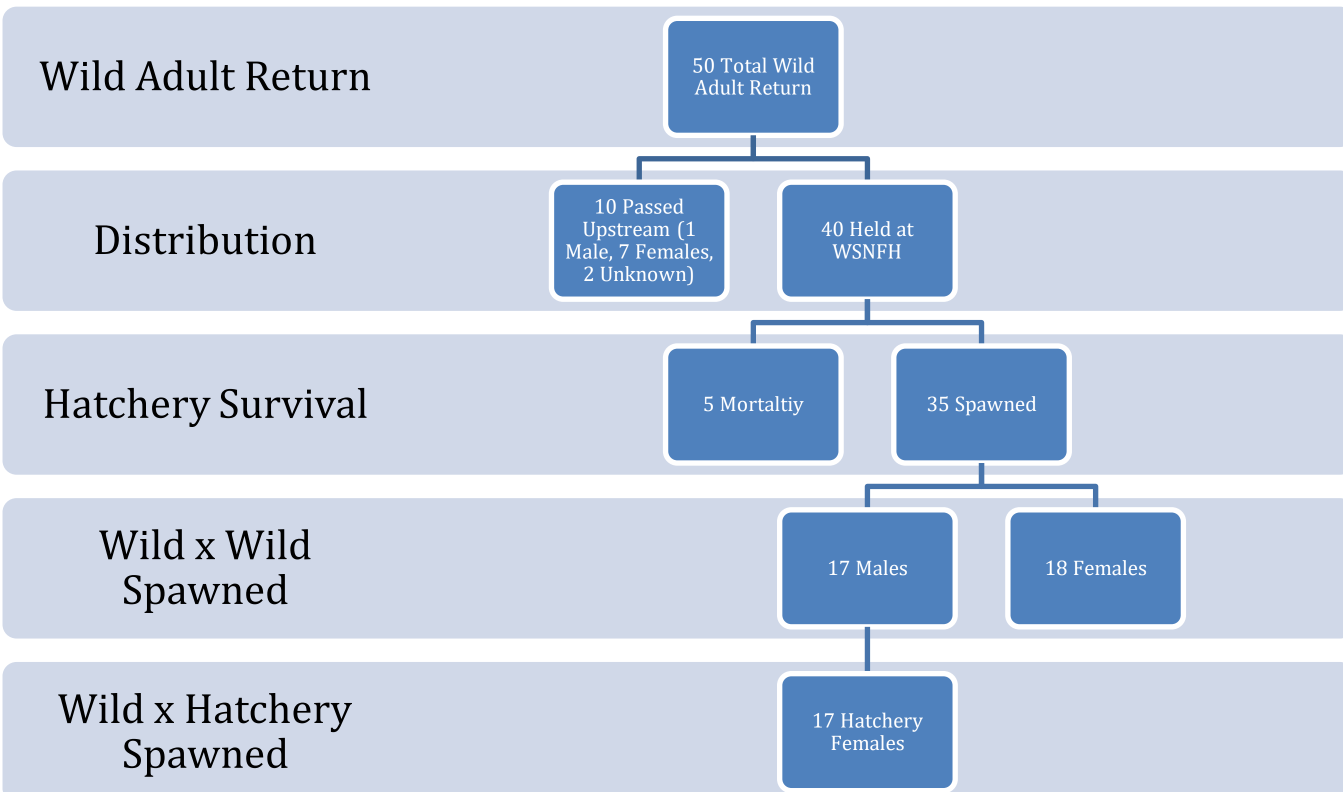

Figure 3. Wild adult spring Chinook returns to WSNFH and their distribution. Ten fish were passed upstream, and thirty-five fish were spawned at the hatchery. An additional seventeen hatchery females were spawned with wild males to integrate wild fish genetics into the hatchery population.

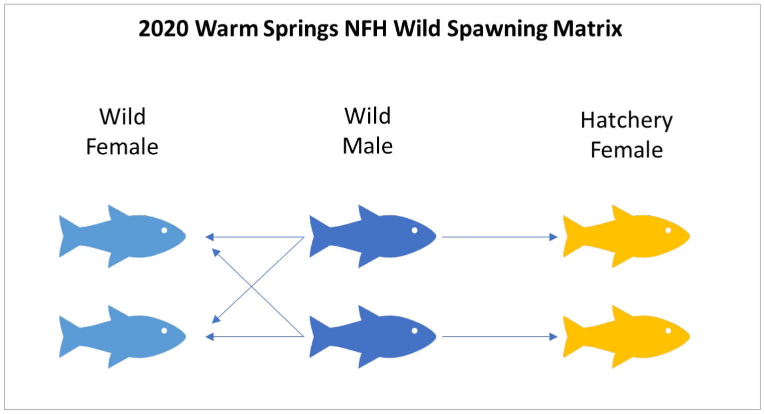

Figure 4. A 2x2 spawning matrix was used to increase wild adult spring Chinook family groups and genetic diversity. Each wild female's eggs were spawned with 2 wild males. Excess milt from each wild male was spawned with one hatchery female in standard 1x1 spawning.

2021 Run Forecast

There is high confidence that wild adult returns (age 4 and age 5) will be less than 500 fish. Recent year trends (10-year dataset) indicate >61% probability that the return will be less than 500 fish (Table 16). There is high confidence that hatchery adult returns will be greater than 1,000 fish (Table 16).

Table 16. Forecast Model Predictions of Spring Chinook Salmon Returns to the Deschutes River in 2021 based on Hand and Haeseker (2011)

	Std Reg (All data)	Std Reg (10 yr Data)	Return Ratio (10 yr Data)	% Age Model (10 yr Data)
Wild Fish Age 4	240	186	28	18
Wild Fish Age 5	8	NA	6	6
Wild Fish Total	**248**	**186**	**34**	**24**
Prob. <500 adults return	NA	NA	61%	63%
	Std Reg	**LN Reg**	**Return Ratio (All Data)**	**% Age Model (All Data)**
WSNFH Age 4	1,381	1,249	1,629	1,055
WSNFH Age 5	30	17	21	20
WSNFH Total	**1,411**	**1,266**	**1,650**	**1,075**
Prob. <1,000 adults return	NA	38%	33%	41%
	Std Reg	**LN Reg**	**Return Ratio (All Data)**	**% Age Model (All Data)**
RBH Age 4	742	290	94	72
RBH Age 5	7	3	6	6
RBH Total	**749**	**293**	**100**	**78**

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 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 17).

Table 17. 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	Life stage	Transfer From	Transfer To	Total # Transferred
2015	Spring	NA	WS	Adults	WS	LW	680
2015	Spring	NA	WS	Adults	WS	RB	708
2015	November	2015	WS	Eggs	LW	WS	926,679
2015	November	2015	WS	Eggs	RB	WS	401,954
2016	Spring	2015	P	Juveniles	P	WS	130,000
2016	Spring	2015	RB	Juveniles	RB	WS	45,000
2016	Summer	2015	WS, RB, P	Juveniles	WS	LW	450,000
2016	July	NA	WS	Adults	WS	LW	NA
2016	November	2016	WS	Eggs	LW	WS	NA
2017	June	NA	WS	Adults	WS	LW	NA
2017	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

- **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 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** - Warm Springs stock adults were transferred to Round Butte hatchery to meet Round Butte program shortfalls.
    - ~450,000 Warm Springs stock fertilized eggs were transferred back to WSNFH from Round Butte State Hatchery in November of 2015. 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.
    - In July 2015, the remaining Warm Springs stock adults were transferred from WSNFH to Little White NFH where they were spawned and the eggs moved for incubation to the Spring Creek National Fish Hatchery (SCNFH) until eye-up, and then back to the WSNFH for hatching.
    - 926,679 green eggs were collected from spawning at Little White NFH and transferred to WSNFH. There was an unexplained egg loss with an estimated mortality of 47% (~491,143 eggs survived).
- **2016** - In the spring of 2016, ~ 130,000 Parkdale stock juveniles and ~45,000 Round Butte stock juveniles were transferred to WSNFH to supplement the 2015 egg loss (all non-WS stock fish given Left Ventral clip). In summer 2016, concerns about electrical power interruption during construction prompted the transfer of 450,000 juveniles to Little White Salmon NFH; ~90,000 juveniles remained at WSNFH. Mortality (marking to release) of fish transferred to Little White NFH was higher than the fish that remained at WSNFH.

- **2017** - Due to the fear of another year of high egg loss, the hatchery requested surplus brood year 2017 Spring Chinook salmon eggs from Round Butte state hatchery to help them cushion expected high egg mortality.

- **2018** - Low Warm Springs stock adult returns in 2018 led to WSNFH requesting and receiving eggs from both Parkdale hatchery and Round Butte hatchery to augment hatchery production. These fish were segregated according to their source 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.

- **2019** - Upon examination of records and better than usual survival, Round Butte State Fish Hatchery had an excess of approximately 15,000 +/- of brood year 2018 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 station release goal of 750,000 for brood year 2018 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 approximately 234,000 Round Butte source fingerlings 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 (Frejie 2019).

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). Since 2011, stray hatchery fish have decreased to a mean of 10.8% (range of 3% to 16%) of the total number of steelhead counted at the ladder (Table 18).

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. Zero fall and summer Chinook have been counted passing upstream since 2015. Similarly, the count of Rainbow and Bull Trout has been below the 10-year mean since 2013. Northern Pikeminnow have always been rare at the ladder. Since a Lamprey Passage Structure (LPS) was installed in 2018, 40 Pacific Lamprey were counted when a total of seven were counted in the previous seven years combined.

Table 1. 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 2009 - 2019. Except for Steelhead, counts are intermittent and may not necessarily reflect total number of fish each year (-- indicates no data recorded).

Year	Wild Steelhead	Hatchery Steelhead	Fall/Summer Chinook	Coho	Rainbow Trout	Bull Trout	Whitefish	Northern Pikeminnow	Sucker	Pacific Lamprey
2011	830	131	0	1	100	18	392	0	266	0
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[a]
2019	24	4	0	443	7	0	0	0	0	24[a]
2020	52	7	6	747	14	1	0	0	0	3[a]
Mean	**289**	**37**	**3**	**251**	**31**	**5**	**240**	**0**	**341**	**5**

[a] Counted in LPS

Data retrieved from Fish Removal files 2/25/2021

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 24.5% 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 4 on average). All the juveniles have been successfully marked with an adipose fin clip, non-WSNFH stocks have been differentially marked with a left ventral clip, and a subsample 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. 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, all fish were spawned between August 31 and September 14.

The facility has produced a mean hatchery smolt-to-adult survival rate that exceeds the previous 10-year average for WSNFH fish returning to the mouth of the Deschutes River but is variable year to year (mean = 0.47 [0.24 SD]). However, 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. 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 2021 forecast for WSNFH stock adult returns (model estimates of 1,075 to 1,411 Age 4 and 5 fish) indicate that is likely that the hatchery's broodstock needs will be met. Round Butte hatchery, however, may not meet its broodstock needs. The wild fish forecast (24 - 248 Age 4 and 5 fish) is again 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 or loss of eggs in 2018, WSNFH has 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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Disclaimer:

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

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