Warm Springs National Fish Hatchery - Spring Chinook Salmon Program FY 2023 Annual Report

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Abstract

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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Figure 1. 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.

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 (Service) investigate the possibilities of salmon and steelhead enhancement on the Warm Springs Reservation. It was determined that operation of a national fish hatchery on the Warm Springs 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 Warm Springs 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 Service 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 Warm Springs Reservation waters, and meets the future needs of the resource and those of the CTWSRO 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 additional studies conducted and supported by Service 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 kms 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 Service on land and water leased from the CTWSRO until February 1, 2043 (BIA 1967). 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 are 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 Service 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 Service 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.

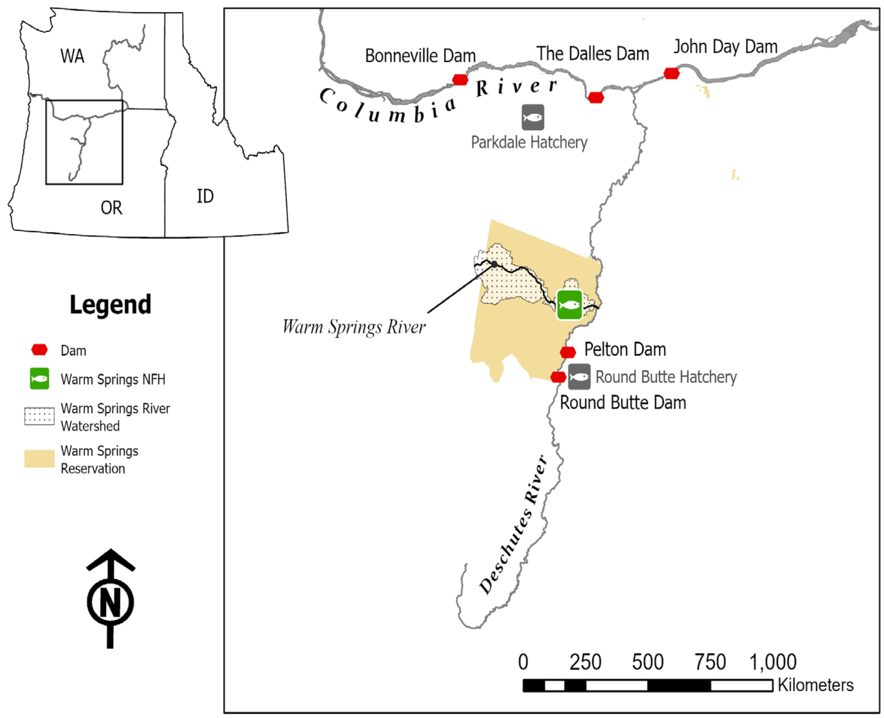

Figure 2. The Warm Springs NFH is located within the Warm Springs Reservation of Oregon and uses funds from the Service to support its rearing program.

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-mark (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. To maintain the genetic and life-history characteristics of the wild population in the hatchery environment, the hatchery incorporates wild fish into its broodstock 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. Fish were sorted into graded raceways by size and the larger fish were 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 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 Passive Integrated Transponder (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, however 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 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 are 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 have resulted in no wild fish being incorporated into the hatchery broodstock in most years. In recent years the CTWSRO developed a supplementation plan with the Service to hold and spawn a portion of the wild return at the hatchery. Excess milt from wild males has been spawned with hatchery females to integrate wild fish into the hatchery population. 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.

When considering whether to rear and release non-WSNFH stock fish, managers must consider the risks and benefits of such actions. The main benefit of importing non-Warm Springs stock fish during years of shortfalls is an increase in the likelihood of meeting the annual juvenile release goal, which in turn leads to increased adult returns, thereby increasing harvest opportunities. Risks include the possibility that mis-clipped/unclipped fish returning to WSNFH as adults could be spawned with Warm Springs hatchery and even wild fish. Fish that stray into the Warm Springs population have a lower ability for their progeny to be successful. If they are frequently brought into the population, it could reduce chances for the long-term survival of the population. 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. In 2022, the *United States v. Oregon* Policy Committee approved the change to the production table to incorporate the wild supplementation program (release goal of up to 125,000 smolts) into the existing hatchery program (release goal of at least 625,000 smolts), and to footnote the transfer of ~560,000 juveniles to Little White Salmon NFH during the summer due to high water temperature concerns at Warm Springs NFH. All juvenile hatchery stock released from the hatchery are marked (CWT and AD) to differentiate them from naturally produced fish upon return. Fish from the wild supplementation program are not marked. Approximately 15,000 juveniles have been PIT tagged annually since brood year 2005 (BY05) (release 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:

- 95% or higher survival from the egg to eye up stage
- 90% survival from the egg to fry stage; and
- 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 2023 can be found in Appendix A.

b) Juvenile Marking, Tagging, and Release Data

Funds distributed by the Service are used to meet annual juvenile release goals, process adult returns, for costs associated with PIT tagging, and equipment maintenance. The facility has an annual release goal of 750,000 (+/- 10%) spring Chinook salmon into the Warm Springs River (release year is two years after brood year). 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 451,634 juveniles released since 2014.

The hatchery has not been able to consistently meet the 750,000 (+/- 10%) juvenile release target using Warm Springs NFH stock fish. Looking at Warm Springs NFH stock releases (not including Round Butte or Parkdale stock releases), in the last 22 brood years (2000-2021), the hatchery has met the release target only six times, and never more than two years in a row (Figure 3). In the last nine years (brood years 2013-2021), the release target has been met only one time. The reasons for not meeting release goals have varied over the past two decades, with no single cause consistently accounting for the low release numbers. While summer-time water temperatures are not ideal for juvenile rearing, summer juvenile mortality has not been the main factor in not meeting release targets. Significant factors in not meeting release targets have included high adult broodstock mortality, poor eye-up, low numbers of adult returns, mechanical failures, operational failures, and potential disease issues in returning adults. A comprehensive review of hatchery production over the past 20+ years is needed to identify production issues and develop consistently achievable production goals.

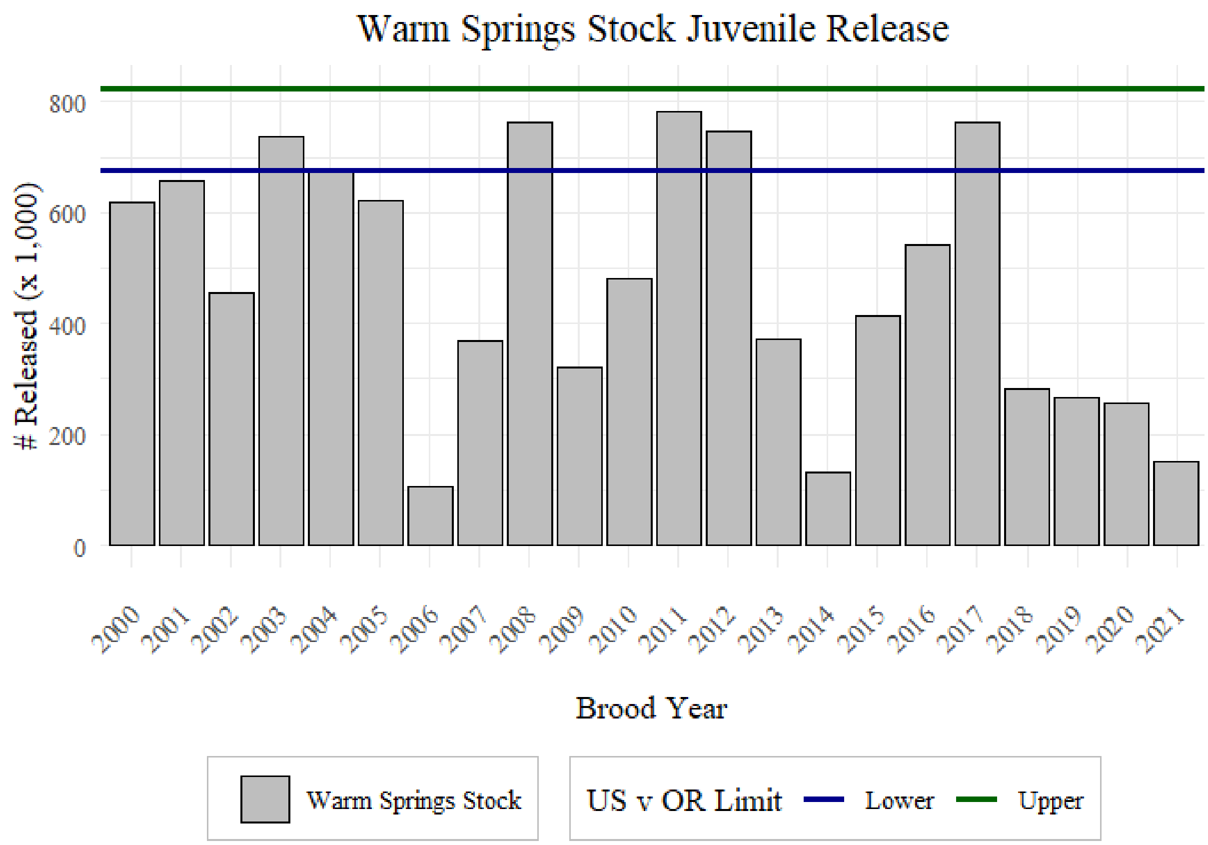

Figure 3. Warm Springs NFH stock releases (not including Round Butte or Parkdale stock releases) 2000-2021.

Since 2014, the facility has achieved a mean juvenile size of 24.9 fish/lb. at the time of release. While all juveniles are given an AD mark and CWT, the actual number of fish with marks and tags at release is estimated based on mark 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 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 Service's Columbia River Information System (CRiS) database at the Columbia River Fish and Wildlife Conservation Office (CRFWCO) and reported annually to the Regional Mark Information System Database (RMIS) [online database] (1977).

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 (BY17) 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 in 2019 was determined not to have a substantial effect on ESA-listed species above and beyond what was considered in the BiOp covering the WSNFH program (Rich Turner, 3/18/2019).

Beginning with BY20, wild origin adult returns have been held and spawned at the WSNFH. These wild fish are generally spawned into three groups (wild x wild [treated as wild], wild x hatchery [treated as wild], and wild x hatchery [treated as hatchery]. Wild and wild x hatchery crosses are kept separate during incubation and ponding until a decision is made on their final disposition. The BY20 and BY21 wild x hatchery cross juveniles were split 50:50 between hatchery production and left unmarked for the wild fish population.

The hatchery portion of the BY2021 wild x hatchery fish resulted in 35,844 (24% of the total 149,325) fish released in 2023 as part of the hatchery program.

Table 1. Annual hatchery program 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), and mean juvenile size at release. Data retrieved from CRiS SR80s File: 3/25/2024.

Release Year	Brood Year	Release Dates	Rel. Temp (°C)	Rel. Type	Mean Size (Fish/lb)	AD + CWT	AD Only	CWT Retention (%)	Total Released	Annual Total
2014	2012	31-Mar - 4-Apr	12.1	F	24	713,563	13,379	98	726,942	726,942
2015	2013	30, 31-Mar	8	F	28	344,834	26,621	93.1	371,455	371,455
2016	2014	30-Mar	10.6	F	22	129,349	3,682	93.5	133,031	133,031
2017	2015	30-Mar	6.7	F	24	396,864	17,451	95.8	414,315	533,714
	2015 (B)		5.6	F	30	112,460	6,939	94.2	119,399**	
2018	2016	29-Mar	7	F	22	533,560	7,881	98.9	541,441	541,441
2019	2017	3, 5-Apr	7.8	F	26	736,730	27,510	96.4	764,240	887,781
	2017 (A)	3-Apr	8.8	F	30	120,045	3,496	97.2	123,541*	
2020	2018	8-Apr	8.3	F	24.8	277,211	3,922	98.6	281,133	
	2018 (A)		8.3	F	24.3	228,470	1,840	99.2	230,310*	647,241
	2018 (B)		8.3	F	23.3	135,798	0	100.0	135,798**	
2021	2019	8-Apr	6.4	F	21.57	263,732	3,729	98.4	267,461	267,461
2022§	2020	9-Mar	5.6	F	27.7	242,346	3,862	98.4	246,208	257,953
2022§†	2020		5.6	F	27.7	11,561	184	98.4	11,745	
2023	2021	10-Apr	7.8	F	24.1	110,111	3,370	97	113,481	149,325
2023†	2021		7.8	F	24.7	32,592	3,252	91	35,844	
Mean by Stock	Warm Springs				24.4	344,768	10,440	96.3	355,209	
	Round Butte (A)				27.1	174,258	2,668	98.2	176,926*	
	Parkdale (B)				26.6	124,129	3,470	97.1	127,598**	
Total Annual Mean			**8.0**		**24.9**	**438,923**	**12,712**	**96.5**		**451,634**

*Left ventral clip to distinguish as Round Butte Stock

** Right ventral clip to distinguish as Parkdale Stock

§ Fish released early in 2022 due to BKD.

† Wild x hatchery mix fish

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 managed by Pacific States Marine Fisheries Commission 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 2014-2023, approximately 15,000 juvenile spring Chinook were tagged annually with PIT tags in late January or early February during their release year 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 2014, an average 15,322 juveniles have been PIT tagged at and released from WSNFH each year. The mean annual number of detections at BONN is 1,204, a detection rate of 7.7%. Average median juvenile travel time to BONN after release is approximately 24 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 12 days or less after release (10^{th} percentile). The majority of fish (90^{th} percentile) pass over BONN within 34 days after release.

At the start of PIT tagging operations in February 2022, the BY20 fish had clinical BKD. The added stress of crowding, handling, and tagging caused increased mortality and PIT tagging operations were cancelled. With less than 3,500 fish tagged and an early release, estimates for juvenile survival in 2022 and future adult returns for BY20 will not be as robust.

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. Release year is two years after brood year. Releases include Warm Springs Stock, Round Butte Stock (A), and Parkdale Stock (B). Data retrieved from PTAGIS: 3/25/2024

Release Year	# PIT Tagged	# Detected at BONN	% Detected	Mean (D)	Median (D)	Range (D)	10th	75th	90th
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	764	9.6	18	16	(4.5 - 44)	10	21	26
2020 (A)	6,566	594	9	18	18	(4.5 - 44)	10	21	25
2020 (B)	3,884	350	9	18	16	(4.5 - 43)	10	21	27
2021	14,986	1,585	10.6	18	19	(4.5 - 38)	12	21	24
2022*	3,424	52	1.5	44	45	(9.5 - 83)	12	57	64
2023	14,975	1,028	6.9	23	23	(6.5 - 50)	14	27	32
Mean by Stock									
Warm Springs	13,375	1,071	7.9	22	23		11	28	33
Round Butte (A)	4,332	377	8.3	24	24		16	28	32
Parkdale (B)	4,428	222	5.5	26	26		12	31	39
Total Annual Mean*	**15,322**	**1,204**	**7.7**	**23**	**24**		**12**	**29**	**34**

*Mean values do not include 2022 early release year.

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 4). 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 BY12 - BY21 (release years 2014 - 2023) ranged from 0.44 to 0.87 (Table 3; Figure 4). Mean values do not include BY20 due to the early release in 2022.

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:3/26/2024.

Release Year	Brood Year	Median Survival	95% Lower	95% Upper
2014	2012	0.63	0.49	0.78
2015	2013	0.51	0.43	0.59
2016	2014	0.63	0.48	1
2017	2015	0.79	0.49	1
2018	2016	0.68	0.41	1
2019	2017	0.62	0.49	0.8
2020	2018	0.87	0.59	1
2021	2019	0.65	0.49	0.86
2022*	2020	0.06	0.02	0.23
2023	2021	0.44	0.33	0.57
Mean*		**0.65**	**0.47**	**0.84**

* Mean values do not include 2022 early release year.

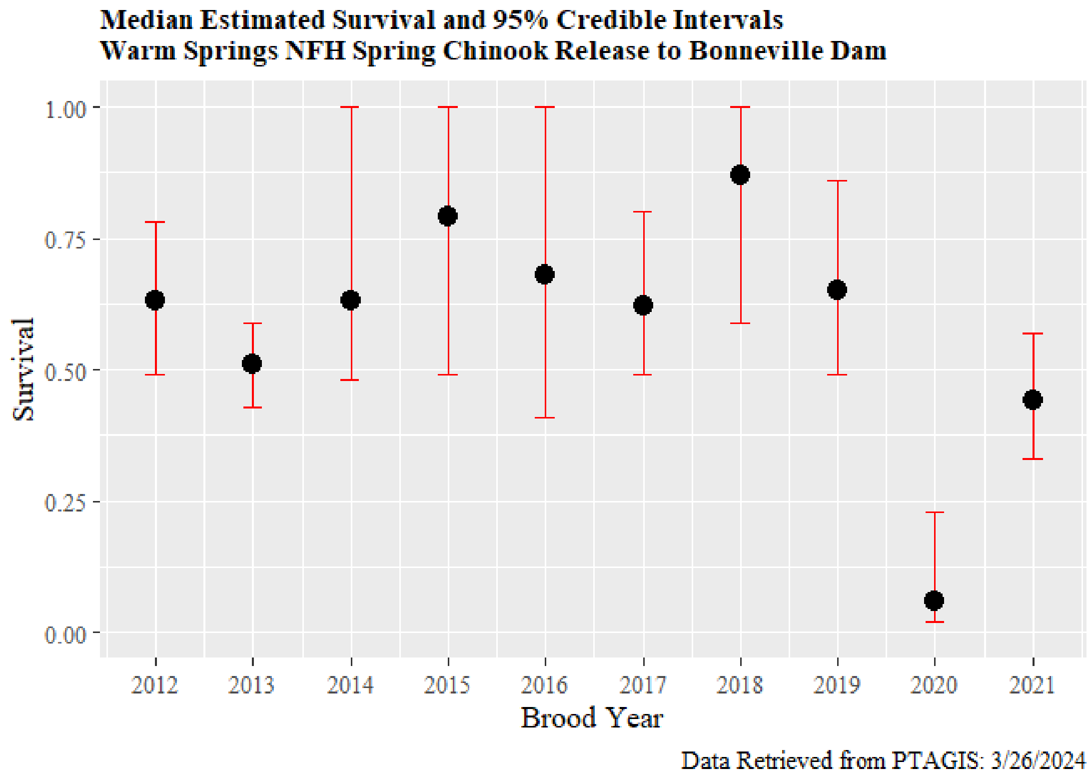

Figure 4. Juvenile Spring Chinook survival from release at Warm Springs NFH to Bonneville Dam (Brood Years 2012 - 2021). Estimates are median survival with 95% lower and upper credible intervals.

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). Coded Wire Tag codes from fish released in respective brood years are queried in RMIS to determine freshwater and ocean recoveries by fishery. At WSNFH, the number of hatchery returns and harvested adults fluctuates from year to year. Collectively, the facility has produced a mean of 2,446 adults annually since BY07 resulting in a mean smolt-to-adult survival rate (SAR) of 0.41% with 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. Hatchery return estimates include returns to Warm Springs NFH. Strays to non-federal hatcheries are included in the Total # of Adults. Adult returns are based on CWT recovery expansion data from RMIS. Due to delays in reporting to RMIS, CWT recoveries may be adjusted every year for accuracy. Data downloaded from RMIS TS1-Rec Report on 4/5/2024

Brood Year	Hatchery Returns	Columbia River Harvest	Ocean Harvest	Spawning Grounds	Total # Adults	Smolt-to-Adult Survival (%)
2007	2,938	508	1	0	3,447	0.59
2008	1,387	415	11	0	1,813	0.26
2009	1,366	73	5	0	1,444	0.27
2010	1,552	787	8	0	2,347	0.49
2011	7,031	1,068	29	0	8,125	1.04
2012	3,250	791	13	0	4,056	0.54
2013	1,371	197	9	0	1,576	0.42
2014	322	83	1	0	406	0.31
2015	313	19	1	0	333	0.06
2016	903	5	0	0	908	0.17
2017*	1,614	479	1	0	2,094	0.24
2018*	984	216	3	0	1,203	0.19
Mean*	**2,043**	**395**	**8**	**0**	**2,446**	**0.41**

*Due to delays in reporting to RMIS, returns for brood years 2017 – 2018 are not complete. Mean calculated for Brood Years 2007 - 2016

An average 892 CWTs have been recovered each year at Warm Springs NFH since 2014 (Table 5). The Warm Springs NFH spring Chinook program accounts for 99.3 percent of all recoveries; spring Chinook from other programs include Round Butte (0.6%); spring Chinook from other programs account for < 0.5% of all recoveries.

Table 5. Coded Wire Tag recoveries for all spring Chinook hatchery programs collected at Warm Springs NFH 2014 – 2023. Number of CWT recoveries are not expanded and do not reflect sample or tagging rates. Data retrieved from RMIS TD3 Report: 4/5/2024.

Return Year	CWT Recoveries	Hatchery Origin	% of Total Annual CWT Return
2014	1	Rapid River Hatchery	0.1
	3	Round Butte Hatchery	0.3
	982	Warm Springs NFH	99.6
2015	1	Little White Salmon NFH	0.1
	3	Round Butte Hatchery	0.1
	2,192	Warm Springs NFH	99.8
2016	1	Cle Elum Hatchery	0.1
	4	Round Butte Hatchery	0.3
	1,294	Warm Springs NFH	99.6
2017	11	Round Butte Hatchery	1.2
	1	Klickitat Hatchery	0.1
	879	Warm Springs NFH	98.7
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	98.4
2020	6	Round Butte Hatchery	1.3
	2	Sawtooth Hatchery	0.4
	443	Warm Springs NFH	98.0
2021	807	Warm Springs NFH	99.0
	7	Round Butte Hatchery	1.0
2022	958	Warm Springs NFH	99.7
	3	Round Butte Hatchery	0.3
2023	757	Warm Springs NFH	99.0
	9	Round Butte Hatchery	1.0
Mean	**892**		

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 (≥ Age 3). 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. Data retrieved from PTAGIS: 3/5/2024

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Bonneville Expansion	95% CI	Hat. Return	Hat. Return/Bonn. Expansion (%)
2014	May-05	Apr-05	Jun-21	136	5,180	(4,058 - 6,711)	1,711	33
2015	Apr-27	Mar-20	Jul-04	195	10,348	(8,691 - 12,483)	6,634	64
2016	May-07	Apr-06	Jul-01	142	6,724	(5,517 - 8,119)	2,778	41
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)	371	100
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)	1,747	57
2022	May-14	Apr-01	Jul-14	66	2,157	(1,261 - 2,993)	1,224	57
2023	May-09	Apr-02	Jun-14	82	1,533	(1,123 - 1,751)	1,226	80
Mean	**May-08**	**Apr-13**	**Jun-25**	**83**	**3,223**		**1,824**	**67**

Since Return Year 2014, 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-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 (≥ Age 3). 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. Data retrieved from PTAGIS: 3/26/2024

Return Year	Median Passage Date	First Detection Date	Last Detection Date	# of Fish Detected	Ladder Expansion	95% CI	Hat. Return	Hat. Return /Ladder Expansion (%)
2014	May-22	Apr-24	Jul-27	79	3,015	(2,186 - 4,270)	1,711	57
2015	May-15	Apr-18	Sep-07	138	7,310	(5,933 - 9,123)	6,634	91
2016	May-25	May-03	Sep-06	59	2,788	(2,026 - 3,499)	2,778	100
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	(-- - --)	371	229
2020	May-26	Apr-14	Aug-16	12	505	(174 - 711)	542	107
2021	May-20	May-01	Jun-09	31	1,791	(1,202 - 2,562)	1,747	98
2022	Jun-01	May-04	Jul-10	34	1,005	(561 - 1,520)	1,224	122
2023	May-25	May-12	Jul-02	65	1,213	(870 - 1,434)	1,226	101
Mean	**May-25**	**May-03**	**Jul-28**	**49**	**1,893**		**1,824**	**121**

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). Service staff use CWT recoveries and scale sampling to age fish. Since return year 2014, approximately 90% of adults have returned to the facility at Age-4, approximately 9% have returned as jacks at Age-3, and 1% have returned at Age-5. No Age-6 returns have been documented (Table 9). The facility has a mean of 1,824 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 WSNFH by *brood year* for Warm Springs River Stock released at WSNFH. CRiS Age Composition Report run on: 4/9/2024.

Brood Year	Age-3	Age-4	Age-5	Age-6	Total # Adults
2008	457	872	32	0	1,361
2009	32	1,008	5	0	1,045
2010	246	1,438	38	0	1,722
2011	269	6,201	83	0	6,552
2012	395	2,660	40	0	3,095
2013	36	1,509	2	0	1,547
2014	199	243	5	0	447
2015	15	346	8	0	369
2016	20	373	3	0	396
2017	161	1,677	33	0	1,871
2018*	67	1,003	19	--	--
2019*	188	1,167	--	--	--
2020*	40	--	--	--	--
Mean	**163**	**1,541**	**24**		**1,841**

*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 WSNFH and estimated age structure by *return year* for Warm Springs River Stock released at WSNFH. CRiS Age Composition Report run on: 4/9/2024

Return Year	Age-3	Age-4	Age-5	Age-6	Total # Adults
2014	269	1,438	5	0	1,711
2015	395	6,201	38	0	6,634
2016	36	2,660	83	0	2,778
2017	199	1,509	40	0	1,748
2018	15	243	2	0	260
2019	20	346	5	0	371
2020	161	373	8	0	542
2021	67	1,677	3	0	1,747
2022	188	1,003	33	0	1,224
2023	40	1,167	19	0	1,226
Mean	**139**	**1,662**	**24**		**1,824**

d) Hatchery Returns by Stock

Collecting CWTs provides additional information for multiple stocks released on station returning as adults to the hatchery (Silver, B.P. and Hand, D.M. 2024). Each stock has a unique CWT which can be used to calculate the age at return for each fish. The majority of adults from all stocks return to the facility at Age-4 (Table 10, Figure 5). A Chi-square test of independence was performed to examine the relationship between stock and returns to the hatchery for Brood Year 2018 when stock originating from Warm Springs, Round Butte, and Parkdale Hatcheries were reared and released at Warm Springs NFH. The relationship between these variables was significant, ($X^2_{(2,\ 641{,}482)} = 119.68$, $P < 0.001$). Returns differ by stock origin, adults from the Warm Springs stock return at a significantly higher percentage in all years (Table 10, Figure 6). For example, for every 100,000 juvenile fish released from each stock, approximately 140 Warm Springs, 70 Round Butte, or 50 Parkdale adults return to the hatchery on average.

For BY09, the return percentage of the Round Butte stock was 65% lower than the Warm Springs stock. For BY15, return percentage of the Parkdale stock was 71% percent lower than the Warm Springs stock. For BY17, return percentage of the Round Butte stock was 67% lower than the Warm Springs stock. Returns for BY18 Round Butte and Parkdale Hatchery stocks were 46% and 64%, respectively, lower than the WSNFH-stock.

Table 10: Proportion by age at return and return percentage to WSNFH for Warm Springs, Parkdale, and Round Butte stock releases. Data is based on unexpanded CWT recoveries of fish returning by stock and brood year. Data retrieved from CRFWCO marking files and RMIS: 3/26/2024.

Stock	Brood Year	Total CWT Released	Total CWT Return	Age-2 % of Return (n)	Age-3 % of Return (n)	Age-4 % of Return (n)	Age 5 % of Return (n)	Return Percentage (Return/Release) (95% CI)
Round Butte	2009	216,162	136	0	2.2% (3)	97.8% (133)	0	0.06% (0.05 -0.07%)
Warm Springs	2009	311,296	544	0.2% (1)	4.0% (22)	95.0 % (517)	0.7% (4)	0.17% (0.16 -0.19%)
Parkdale	2015	112,460	20	0	0	90.0% (18)	10.0% (2)	0.02% (0.01 -0.03%)
Warm Springs	2015	396,864	294	0.3% (1)	4.4% (13)	93.5% (275)	1.7% (5)	0.07% (0.07 -0.08%)
Round Butte	2017	120,045	38	0	15.8% (6)	78.9% (30)	5.3% (2)	0.03% (0.02 -0.04%)
Warm Springs	2017	736,730	678	0.4% (3)	17.3% (117)	78.5% (532)	3.8% (26)	0.09% (0.09 -0.10%)
Parkdale	2018	135,798	109	6.3% (7)	2.8% (3)	88.1% (96)	2.8% (3)	0.08% (0.07 -0.10%)
Round Butte	2018	228,471	263	1.5% (4)	5.7% (15)	91.3% (240)	1.5% (4)	0.12% (0.10 -0.13%)
Warm Springs	2018	277,213	611	2.5% (15)	9.3% (57)	87.2% (533)	1.0% (6)	0.22% (0.20 -0.24%)
Parkdale								**0.05%**
Round Butte								**0.07%**
Warm Springs								**0.14%**

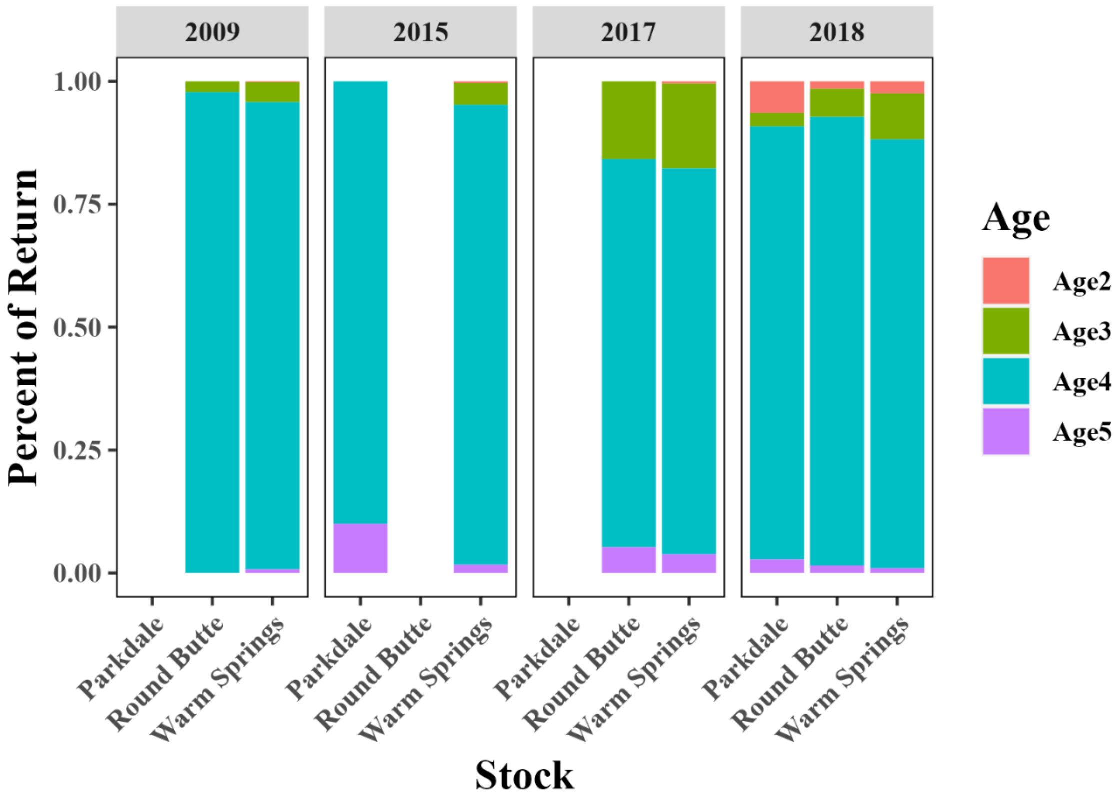

Figure 5. Age-at-return proportion for stocks reared and released from WSNFH, by brood year.

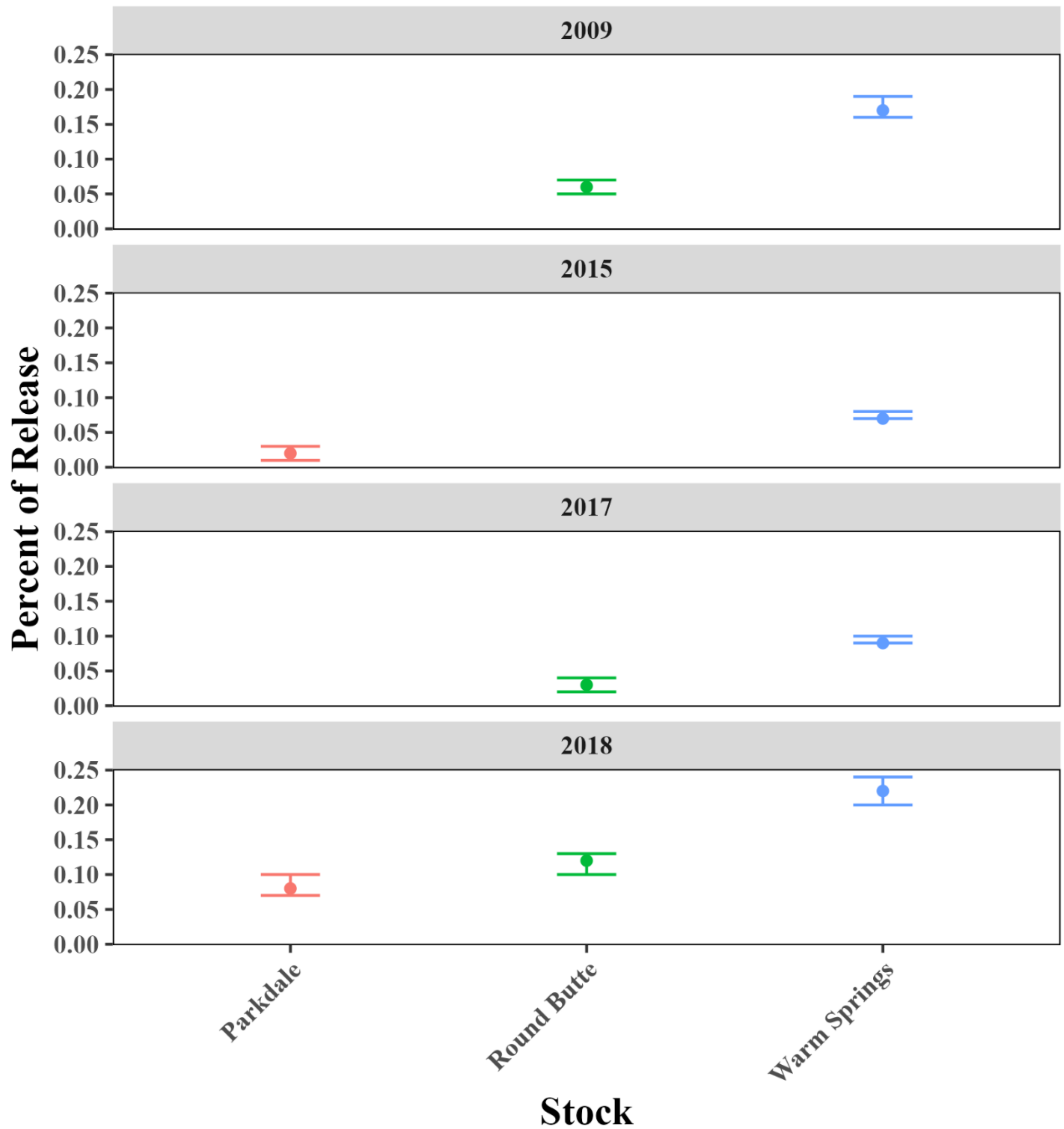

Figure 6. Return rate (percent of release returning to WSNFH) for stocks reared and released from WSNFH by brood year.

e) External Mark Accuracy by Stock

In 2018, low Warm Springs stock adult returns led to WSNFH requesting and receiving eggs from both Parkdale Hatchery and Round Butte Hatchery to augment hatchery production. Each stock received a unique CWT code and differential fin marks (ADLV/ADRV/AD) to identify their stock of origin when they returned to the hatchery as adults.

Based on visual identification of adult returns at the hatchery and subsequent reading of coded-wire tags there was an overall 11% error rate in visual identification of stocks by fin marks. Of the total 92 visual call errors, 85 (92%) were RBH and PFH stocks misidentified as WSNFH stock (Table 11).

- Error rate was lowest for Warm Springs fish (2%), of the 498 coded-wire tagged Warm Springs fish that returned as adults, 491 (99%) were identified correctly (AD clip); 7 (1%) were misidentified as Round Butte (ADLV clip) and zero were misidentified as Parkdale (ADRV clip). The seven incorrectly identified WSNFH-stock fish were surplused.
- Error rate for Round Butte fish was (24%), of the 222 Round Butte coded-wire tagged fish that returned as adults, 168 (76%) were identified correctly (ADLV clip); 9 (4%) were misidentified as Parkdale (ADRV clip) and 45 (20%) were misidentified as Warm Springs (AD clip) fish. Five males and three females were spawned, eleven were surplused, and twenty-six died in the brood ponds.
- Error rate was highest for Parkdale fish (35%), Of the 89 Parkdale coded-wire tagged fish that returned as adults, 58 (65%) were identified correctly (ADRV clip); 8 (9%) were misidentified as Round Butte fish (ADLV clip), and 23 (26%) were misidentified as Warm Springs (AD clip) fish. Three males were spawned, six were surplused, and fourteen died in the brood ponds.

Table 11. External mark identification accuracy for BY18 (release year 2020) Warm Springs, Round Butte, and Parkdale stock returning to the WSNFH as adults. Data retrieved from CriS Biosample File 3/12/2024.

CWT Stock	Visual Call AD Only WSNFH	Visual Call ADLV RBH	Visual Call ADRV PFH	Total Return	Incorrectly Identified by External Mark	Error Rate
WSNFH	**491**	7	0	498	7	2%
RBH	45	**168**	9	222	54	24%
PFH	23	8	**58**	89	31	35%
Total	**559**	**183**	**67**	**809**	**92**	**11%**

f) 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 12).

Table 12. Deschutes harvest estimates of wild and WSNFH spring Chinook salmon 2014 - 2023. 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. Data retrieved from ODFW and Round Butte Hatchery return data 3/26/2024

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
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	--	--	--
2022*	0	0	0	0	0	0	28	7	35
2023*	0	0	0	0	0	0	40	1	41
Mean	**0**	**0**	**5**	**0**	**145**	**21**	**175**	**10**	**398**

* No Sport Harvest 2019 - 2023; limited Tribal harvest 2020 - 2023.

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., no external marks), held for broodstock, or surplused (known hatchery fish) and given to tribal representatives for distribution. Disposition of fish depends on number of returns, their condition, and origin (Tables 13 and 14).

Table 13. Disposition of hatchery (all stocks) and wild spring Chinook salmon at Warm Springs NFH, 2014 - 2023. Numbers include spring Chinook salmon adults (age 4-5) and jacks (age 3) that were surplused 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. Unresolved data discrepancies in 2019, 2020, and 2021 Fish Removal files. Data retrieved from CRFWCO CriS Fish Removal file: 4/5/2024 .

Return Year	Hat. Upstream	Hat. Surplus Donated	Hat. Surplus Dump	Hat. Brood	Hat. Transfer	Hat. Mort.	Hat. Total	Wild Upstream	Wild Brood	Wild Mort	Wild Green	Wild Surplus	Wild Total
2014	0	996	0	194	35‡	486	1,711	761	0	6	0	0	767
2015	78	4,901	145	615*	0	188	6,635	1,369	0	12	0	0	1,381
2016	0	1,550	3	758†	323§	150	2,778	335	0	13	0	0	348
2017	--	--	--	747	--	80	1,748	--	--	--	0	0	193
2018	1	5	0	206	0	47	260	247	0	0	0	0	247
2019	0	0	31	252	0	96	379	204	0	0	0	0	204
2020	3	0	70	360	0	79	566	10	35	5	0	0	50
2021	352^	159	73	166	426	570	1,746	67	78	34	3	1	183
2022	0	663	23	191	0	347	1,224	184	29	84	2	0	299
2023	239	353	40	429	0	181	1,242	87	55	19	2	0	163
Mean	**75**	**959**	**44**	**392**	**87**	**222**	**1,829**	**363**	**22**	**19**	**1**	**0**	**384**

*All fish spawned at Little White Salmon NFH in 2015.
†645 fish spawned at Little White Salmon NFH in 2016.
‡Transferred to ODFW for research. §Transferred to Round Butte, CTWSRO, PGE.
¶No data recorded for other uses of fish in 2017.
^Fish were transferred to CTWSRO (352) or Round Butte Hatchery (12) and outplanted upstream

Table 14: Adult Spring Chinook passed at WSNFH or trucked upstream each year to spawn naturally. Data from CRiS Fish Removal file 3/26/2024

Return Year	Origin	Upstream Passage Method	Females	Males	Jacks	Unknown	Total	Annual Total
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
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	
2022	Wild	Trucked	126	45	7	0	178	184
	Wild	Passed	2	1	3	0	6	
2023	Wild	Trucked	55	32	0	0	87	326
	Hatchery	Trucked	128	97	12	0	237	
	Hatchery	Passed	1	1	0	0	2	

2023 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 2023, an estimated 164 wild and 1,280 hatchery Warm Springs River spring Chinook (Tables 15 and 16) and 905 Round Butte hatchery spring Chinook (Table 17) are estimated to have returned to the Deschutes River.

There was limited tribal harvest and no sport harvest in 2023. The Tribal fishery harvested an estimated 68 fish by platform & hook and line (Table 18).

Table 15. Run reconstruction of *wild* spring Chinook salmon from the Warm Springs River, 2023. 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). Run reconstruction performed 12/21/2023.

Location	Wild Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To WSNFH	Upstream of WSNFH	5	82	0	82	87
To WSNFH	WSNFH Broodstock	3	52	0	52	55
To WSNFH	DIPS/Jumpouts/killed	1	19	0	19	20
To WSNFH	Surplus/Green	0	2	0	2	2
To WSNFH	Total	9	155	0	155	164
Harvest	Tribal	0	0	0	0	0
Below WSNFH	Spawned	0	0	0	0	0
Total Estimated Return		**9**	**155**	**0**	**155**	**164**

Table 16. Run reconstruction of *hatchery* spring Chinook salmon from the Warm Springs River, 2023.There was no sport harvest and limited Tribal harvest in 2023. WSNFH harvest was estimated as 29% of jack and 60% of adult harvest. Run reconstruction performed 12/21/2023.

Location	Hatchery Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To WSNFH	Upstream of WSNFH	12	217	9	226	238
To WSNFH	Surplus	20	357	16	373	393
To WSNFH	Strays (from RB)	2	7	0	7	9
To WSNFH	Mortality	1	176	1	177	178
To WSNFH	Spawned/Green	3	424	3	427	430
To WSNFH	Total	38	1,181	29	1,210	1,248
Harvest	Tribal	1	38	2	40	41
Total Estimated Return		39	1,219	31	1,250	1,289
Total Estimated Return (excluding AdLV or AdRV)		**37**	**1,212**	**31**	**1,243**	**1,280**

Table 17. Run reconstruction of *hatchery* spring Chinook salmon from the Round Butte Hatchery, 2023. There was no sport harvest and limited Tribal harvest in 2023. Aging based on size (AD only fish); age 4 est @ 97% of adult fish. Run reconstruction performed 12/21/2023.

Location	Hatchery Stock Disposition	Age 3	Age 4	Age 5	Total 4 + 5	Total
To Pelton Trap	Hatchery	89	765	24	789	878
Harvest	Tribal	1	25	1	26	27
Total Estimated Return (RB Stock)		**90**	**790**	**25**	**815**	**905**

Table 18. Deschutes-Sherars Falls Spring Chinook Harvest Estimates, 2023. Run reconstruction performed 12/21/2023.

Harvest	Total Jacks	Total Adults	WSNFH Jacks	WSNFH Adults	RBH Jacks	RBH Adults	Wild Jacks	Wild Adults
Sport*	0	0	0	0	0	0	0	0
Tribal†	2	66	1	40	1	26	0	0
Total	**2**	**66**	**1**	**40**	**1**	**26**	**0**	**0**

*No sport harvest in 2023

†Platform & hook and line 2023

Wild Spring Chinook Management

Wild Adult Return

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 13). 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 the remaining 40 wild fish for holding and spawning at the hatchery.

Since 2021, the wild fish plan has been to collect 60 female and 40 male wild adults (as determined by ultrasound) for on-hatchery spawning and rearing; excess wild adults are be trucked upstream of the hatchery to naturally spawn. Broodstock held on station are injected with antibiotics.

In 2023, a total of 163 wild fish returned to the hatchery. Of the 76 wild fish held for broodstock, 19 fish died before spawning, 2 fish were green females, and 55 were spawned (Table 19, Figure 7). Between May 8 and August 10, 87 wild fish were trucked upstream and outplanted by the CTWSRO. An ultrasound was used to distinguish 55 females and 32 males before they were outplanted.

The wild-origin broodstock were sexed by ultrasound, injected with Draxxin, and distributed among the three brood ponds (the earliest arrivals in pond 1, the latest in pond 4). Spawning took place between August 21st and September 9th and occurred in 3 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 8). 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 is 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 in a 2x2 spawning matrix with hatchery females (Figure 8). Offspring from these wild x hatchery crosses are 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, or use all for hatchery production).

Monitoring wild adult returns at the hatchery provides information on sex ratios, length information, and age structure based on scale samples. In 2023, approximately 94% of wild adults collected at the facility were Age-4 (n = 154) and 6% were jacks at Age-3 (n = 10), zero Age-5 fish were documented (Table 20).

Table 19. Total number of wild adult spring Chinook returns to WSNFH in 2023, estimated age structure, and disposition. Data from CRiS Age Composition Report 3/27/2024

	Total Adult Return	Passed Upstream	Surplused	Green	Mortality	Spawned
Male	64	32	0	0	10	22
Female	99	55	0	2	9	33
Unknown	0	0	0	0	0	0
Total	**163**	**87**	**0**	**2**	**19**	**55**

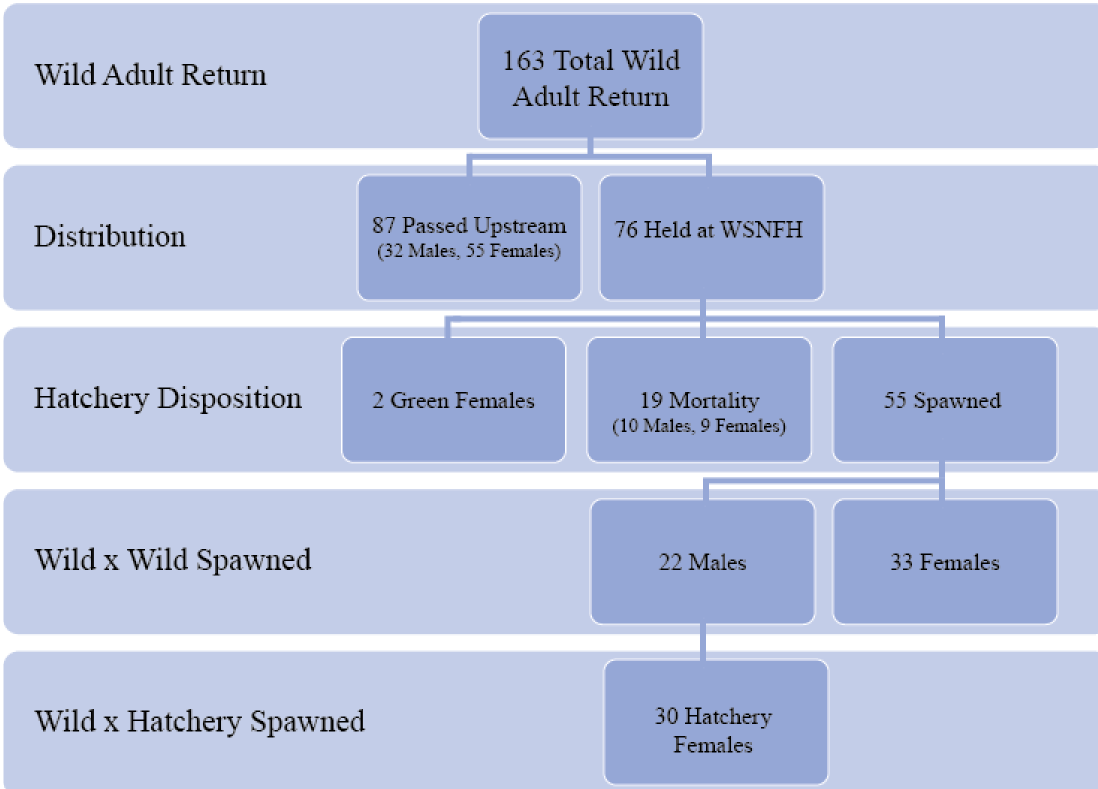

Figure 7. Wild adult spring Chinook returns to WSNFH and their distribution. Eighty-seven fish were passed upstream, and fifty-five fish were spawned at the hatchery. An additional 30 hatchery females were spawned with wild males to integrate wild fish genetics into the hatchery population.

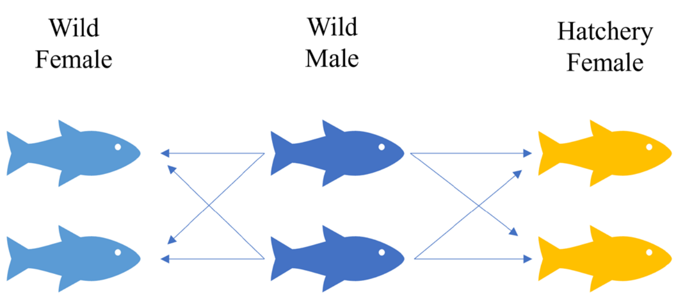

Figure 8. A 2x2 spawning matrix was used to increase wild adult spring Chinook family groups and genetic diversity. Each wild female's eggs were spawned with 2 wild males. Excess milt from each wild male was also spawned with two hatchery females in a 2x2 spawning matrix.

Table 20. Estimated age structure of wild adult spring Chinook returns to Warm Springs NFH based on scale samples of wild returns used for brood stock. Data from CRiS Age Composition Report 3/27/2024

Return Year	Age-3	Age-4	Age-5	Total # Adults
2020	5	40	5	50
2021	9	172	3	184
2022	15	284	0	299
2023	10	154	0	164
Mean	**10**	**162**	**2**	**174**

Wild Juvenile Release

Approximately 37K BY21 juveniles were released as wild fish (the unmarked, untagged wild component of the wild x hatchery crosses) on April 10, 2023 (Table 21). The CTWS BNR previously released 85,533 wild BY21 fingerlings (unmarked, untagged offspring of wild origin parents) in May 2022 in locations in the upper Warm Springs River Basin instead of transporting to LWSNFH for summer rearing (Table 21). The wild x hatchery crosses were held behind for potential PIT tagging in spring of 2023, however none of these fish were PIT tagged prior to release.

Table 21. Annual wild juvenile spring Chinook release dates. Data includes release location, number released and lifestage. Data retrieved from CRiS SR80s File: 3/27/2024.

Brood Year	Release Year	Release Date(s)	Release Location	Release Number	Lifestage
2020	2022	9-Mar	Warm Springs NFH	52,600	Yearling
2021	2022	5/17-5/24	Upper Warm Springs River Basin	85,533	Fingerling
2021	2023	10-Apr	Warm Springs NFH	37,411	Yearling

2024 Run Forecast

Warm Springs River Wild stock

The mean forecasted adult (Age-4 and Age-5) return ranges from 158 to 352 wild fish to the mouth of the Deschutes River (Table 22). There is approximately a 40% chance that the adult return will be less than 100 fish.

Warm Springs NFH program

The mean forecasted adult (Age-4 and Age-5) return ranges from 318 to 790 hatchery fish to the mouth of the Deschutes River (Table 22). There is approximately a 45% to 55% chance that the return will be less than 500 hatchery fish. In 2024, Age-4 returns will be from the BY20 release, which was released in early March 2022 due to BKD outbreak. Low survival of BY20 is expected.

Table 22. Forecast Model Predictions of Spring Chinook Salmon Returns to the Deschutes River in 2024 based on Hand and Haeseker -Hand, David M. and Haeseker, Steven L. (2011) Run date as of: 12/19/2023

Return	Std Reg (All Data)	Std Reg (10 yr Data)	Return Ratio (10 yr Data)	% Age Model (10 yr Data)
Wild Age 4	327	178	232	140
Wild Age 5	25	35	21	18
Wild Total	352	213	253	158
Wild Prob. >100 adults return	**57%**	**57%**	**60%**	**60%**

Return	Std Reg	LN Reg	Return Ratio (All Data)	% Age Model (All Data)
WSNFH Age 4	737	427	383	258
WSNFH Age 5	53	44	65	60
WSNFH Total	790	471	448	318
WSNFH Prob. <500 adults return	**45%**	**50%**	**50%**	**55%**

Return	Std Reg	LN Reg	Return Ratio (All Data)	% Age Model (All Data)
RBH Age 4	802	500	255	221
RBH Age 5	33	18	46	46
RBH Total	**835**	**518**	**301**	**267**

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 (Smith et al., 2016; Smith 2018). 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. Results from release of Parkdale and Round Butte stock fish from WSNFH indicate 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 provides additional information on the similarities and differences (Silver, B.P. and Hand, D.M. 2024). All juvenile or egg transfers from Round Butte Hatchery to Warm Springs NFH are marked with AD+CWT+LV; all juvenile or egg transfers from Parkdale 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 (LWSNFH) for spawning and temporary rearing before being transferred back to WSNFH (Table 23).

Due to elevated water temperatures at WSNFH in 2015 and 2021, the USFWS and CTWSRO-Bureau of Natural Resources (BNR) Hatchery Evaluation Team decided to move fish off station to LWSNFH. Those moves occurred as ‘emergency’ actions under less-than-ideal conditions (air temperatures over 100° F and water temperatures approaching 70° F). In anticipation of the reoccurring increased temperatures in the Warm Springs River, the regular transfer of WSNFH juveniles to LWSNFH began in 2022. The proactive transfer of juvenile fish to another facility between May and September is necessary to avoid chronic and acute thermal stress when temperatures can exceed optimal rearing conditions in the summer months. Rearing fish for the best animal welfare in more favorable conditions is intended to maximize survival and reduce the need for multiple antibiotic treatments. During this time, the LWSNFH has available space and conditions for 560,000 fish until adaptive modifications are made to in-basin rearing facilities.

The CTWSRO-BNR decided to release the BY21 wild source subyearling in May of 2022 in locations in the upper Warm Springs River basin instead of transporting the wild source juveniles to LWSNFH for summer rearing. Fish transfer took place over two weeks in mid-May of 2022.

Table 23. 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 Salmon NFH.

Transfer Year	Transfer Dates	Brood Year	Stock	Lifestage	Transfer From	Transfer To	Total # Transferred
2015	Spring	–	WS	Adults	WS	LW	680
		–	WS	Adults	WS	RB	708
	Summer	2014	WS	Juveniles	WS	LW	133,031
	November	2015	WS	Eggs	LW	WS	926,679
			WS	Eggs	RB	WS	401,954
2016	Spring	2015	P	Juveniles	P	WS	130,000
			RB	Juveniles	RB	WS	45,000
	Summer	2015	WS, RB, P	Juveniles	WS	LW	450,000
	July	–	WS	Adults	WS	LW	--
	November	2016	WS	Eggs	LW	WS	--
2017	June	–	WS	Adults	WS	LW	--
	Fall	2017	RB	Eggs	RB	WS	--
2018	September	2018	P	Eggs	P	WS	153,538
			RB	Eggs	RB	WS	249,186
2019	April	2018	RB	Juveniles	RB	WS	15,000
2021	May	–	RB	Adults (AD/LV)	WS	RB	128
	May	–	WS	Adults (AD)	WS	RB	286
	May - July	–	WS	Adults (AD)	WS	Upstream	352
		–	WS	Adults (Wild)			18
	June	2020	WS	Juveniles	WS	LW	300,000
	Fall	2021	WS	Eggs	WS	WSU	200
	October	2020	WS	Juveniles	LW	WS	300,000
2022	May	2021	WS	Juveniles	WS	LW	200,000
			WS-Mix	Juveniles			38,000
			Wild	Juveniles	WS	Upstream	85,533
	October	2021	WS	Juveniles	LW	WS	200,000
			WS-Mix	Juveniles			38,000
		2022	RB	Eggs	RB	WS	60,763
			P	Eggs	P	WS	87,830
2023	May	2022	WS	Juveniles	WS	LW	147,000
			RB	Juveniles			52,000
			P	Juveniles			79,000
			Wild	Juveniles			31,000
	September	2022	WS	Juveniles	LW	WS	147,000
			RB	Juveniles			52,000
			P	Juveniles			79,000
			Wild	Juveniles			31,000

- **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 age 5 were segregated and not included in Warm Springs broodstock (see 2010 note).
- **2013** - In 2009, the hatchery spawned Warm Springs NFH stock males (~63) with Round Butte stock females (no data on how many females). Adult returns in 2013 included these Round Butte-Warm Springs NFH 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 – June approximately 701 Warm Springs stock adults (BY15) were transferred to Round Butte State Fish Hatchery to meet Round Butte program shortfalls.
    - Summer - Warm Springs juveniles were moved to LWSNFH due to high temperatures in the Warm Springs River.
    - July - The remaining Warm Springs stock adults were transferred from WSNFH to Little White Salmon 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.
    - At spawning, Little White Salmon NFH transferred 926,679 green eggs to WSNFH. There was an unexplained egg loss with an estimated mortality of 47% (~491,143 eggs survived).
    - November - ~450,000 Warm Springs stock fertilized eggs 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 (Figure 9).

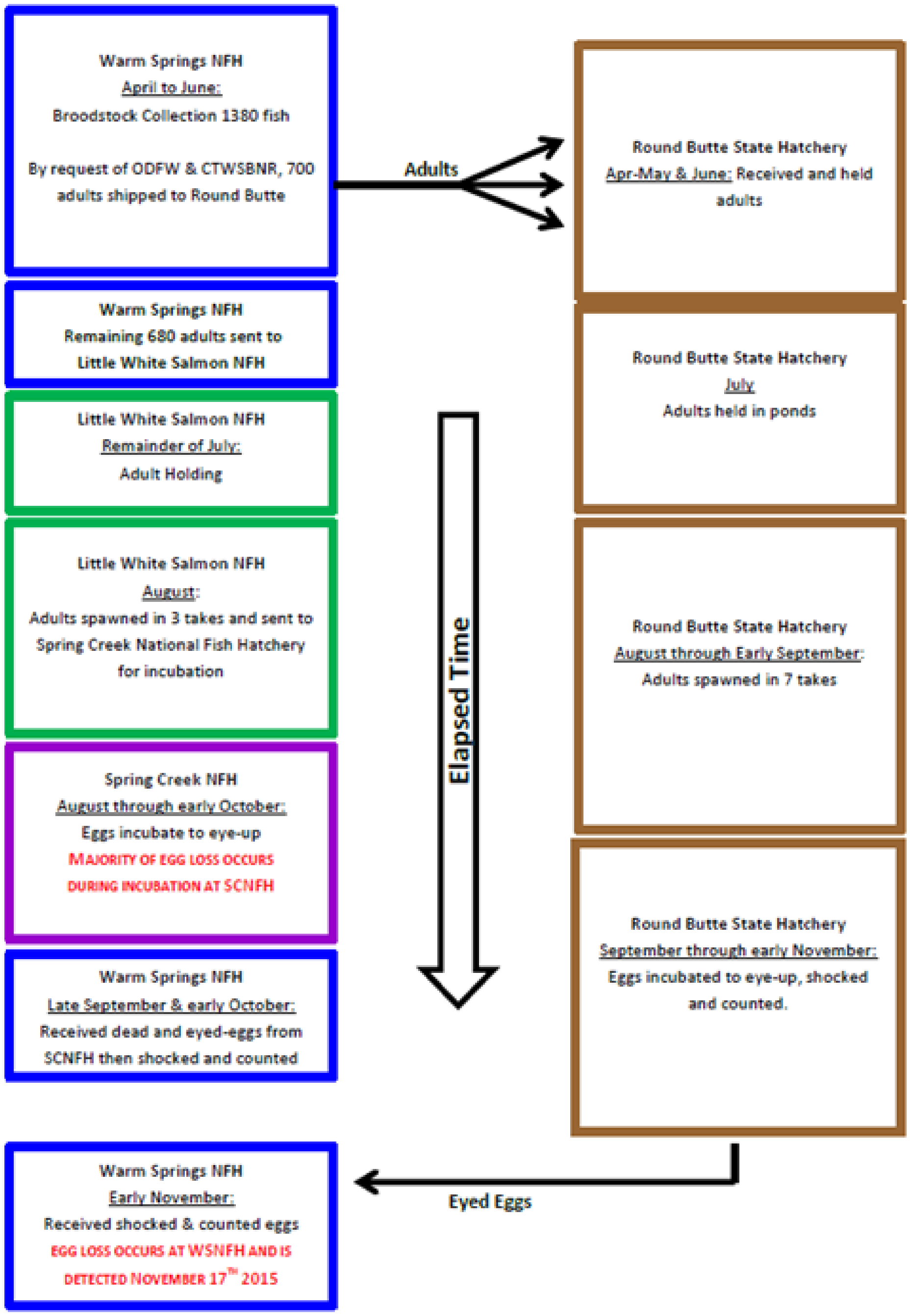

Figure 9. Transfers of Warm Springs NFH stock, April – November 2015 from Thompson and Goodwin 2016.

- **2016** - Hatchery records are incomplete/inconsistent for BY16 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.
  - Spring - ~ 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 Salmon NFH was higher than the fish that remained at WSNFH.
- **2017** - Due to concerns of another year of high egg loss, the hatchery requested surplus BY17 Spring Chinook salmon eggs from Round Butte state 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 NFH 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. At release in 2020, 281,133 WSNFH stock, 135,798 Parkdale stock, and 230,310 Round Butte stock fish were released from BY18 (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 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 (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 (Frejie 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**
  - May:
    - 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 Hatchery to supplement their low returns.
    - Round Butte Hatchery submitted a formal request for 220 Warm Springs Stock adults. 100 (50 pair, 1:1 male:female) for Round Butte Hatchery and 120 (60 pair, 1:1 male:female) for Parkdale Hatchery for a total request of 220 fish. Warm Springs NFH gave all Warm Springs Fish Ad/LV and AD transferred to Round Butte a dorsal fin punch to help with RMIS reporting. Adults recovered from Round Butte with CWTs must report the correct return location.
    - Hatchery Warm Springs stock fish were trucked upstream by CTWSRO to naturally spawn since all 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 Tribe was willing to take the risk of mortality of the fish because they would add nutrients to the river.
  - June:
    - The Tribes had concerns about holding all wild on station until July 15th, however, USFWS wanted to represent entire run in the spawning and held some back. Surplus wild fish above what was needed for spawning (60 females and 40 males) were removed from the holding pond and trucked upstream on 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
    - One week before the record heat wave on June 26, 2021, the Warm Springs HET recommended immediate transfer (within three days of decision) of fish 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 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 averaged 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.
  - Juvenile fish were trucked to LWSNFH for the summer where temperatures would be lower. The wild fish from 2 raceways were transferred Saturday afternoon. Sunday morning the second load contained three raceways of fish. By Sunday at 10 am, the last three raceways were transported to LWSNFH. On Monday, 6/28, the Warm Springs River temperature was 77.7 F and raceways were 78.9 F. There was some mortality Monday morning, but they are looking better by Wednesday 6/30. Lessons learned are to 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.
  - CTWSRO Requested an additional 75 (25 females and 50 males) hatchery Warm Springs NFH stock to be transferred to Round Butte to fill Parkdale shortfall. This request was approved because it was from the Tribe and because fish sent to Round Butte 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).
  - Three 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.
- July:
  - Eighteen 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.
  - October: BY20 juveniles were transferred back to Warm Springs.

- **2022**
  - May:
    - 5/9: BY21 juvenile hatchery-origin fish and the unmarked, untagged portion of the hatchery wild mixes were proactively trucked to LWSNFH for summer rearing where water temperatures would be lower.
    - 5/17 – 5/24: The CTWSRO-BNR released the natural-origin BY21 fish in locations in the upper Warm Springs River basin instead of transporting to LWSNFH for summer rearing.

- September:
  - 9/29: BY21 juveniles were transferred back to Warm Springs NFH.
- October:
  - Low Warm Springs NFH stock adult survival in 2022 led to WSNFH requesting and receiving eggs from both Parkdale and Round Butte Hatcheries to augment hatchery production. These BY22 fish were segregated according to their source and in 2023 received both an adipose clip and left ventral clip (Round Butte) or right ventral clip (Parkdale) to distinguish them from the Warm Springs NFH stock upon their return and be excluded from the broodstock.

- 2023
  - May: All BY22 juvenile hatchery-origin fish, wild-origin fish, and the hatchery wild mixes were proactively trucked to LWSNFH for summer rearing where water temperatures would be lower. Parkdale and Round Butte fish were ventrally marked.
  - September: BY22 juveniles were transferred back to Warm Springs NFH.

Other Fish counted and passed above Warm Springs NFH

Except for steelhead, counts of other species of fish are intermittent and may not necessarily reflect total number of fish each year. Numbers of whitefish and suckers passed upstream of the ladder declined between 2018 and 2020 and have increased in recent years. Coho numbers have been above average four of the last five years.

A Lamprey Passage Structure (LPS) was installed at the fish ladder in 2018. Since then, 111 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 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. 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. That year, three PIT tagged lamprey were detected at the PIT array, all three detections had corresponding video detections on the camera system. Future PIT tagging of adult lamprey by the CTWSRO will allow for additional truthing.

The number of stray hatchery steelhead counted at the fish ladder at WSNFH increased beginning in 1987 but has 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 10.8% (range of 1.6% to 24.1%) of the total number of steelhead counted at the ladder (Table 24).

Table 24. Counts of wild Steelhead, hatchery Steelhead, Fall Chinook (wild and hatchery combined), Coho (wild and hatchery combined), Rainbow Trout, Bull Trout, Whitefish, Sucker, and Pacific Lamprey counted at the Warm Springs NFH fish ladder 2014 - 2023. Except for Steelhead, counts are intermittent and may not necessarily reflect total number of fish in a given year. Data retrieved from CRiS Adult Entry File: 12/19/2023.

Year	Wild Steelhead	Hatchery Steelhead	Fall/Summer Chinook	Coho	Rainbow Trout	Bull Trout	Whitefish	Sucker	Pacific Lamprey
2014	201	40	3	365	18	1	197	521	0
2015	373	34	0	3	17	1	783	471	0
2016	279	34	0	190	22	1	11	239	0
2017	262	8	0	264	7	0	52	539	0
2018	60	1	0	2	9	1	13	250	13*
2019	24	4	0	443	7	0	1	36	25*
2020	52	7	6	747	14	1	13	391	4*
2021	85	27	1	556	17	5	108	159	20*
2022	6	1	0	605	7	1	52	401	25*
2023	127	4	4	1299	12	3	27	708	24*
Mean	**147**	**16**	**1**	**447**	**13**	**1**	**126**	**372**	**11**

* Pacific Lamprey counted in LPS

An analysis of PTAGIS detections since 2008 showed steelhead were detected in the WSNFH ladder a median 10 (range 1 - 140) times a day over a median 2 (range 1- 40) days suggesting steelhead do not linger in the ladder if they are not captured by the trap (Figure 10). In 2023, we added a video camera to monitor summer steelhead and spring Chinook movements at the trap and in the catch pond. The trap “fingers were also modified to prevent gaps left behind when fish enter the trap which can create a space for fish to exit. We observed numerous attempts to exit the catch pond by swimming at the trap “fingers” underscoring the need to empty the trap on a daily basis.

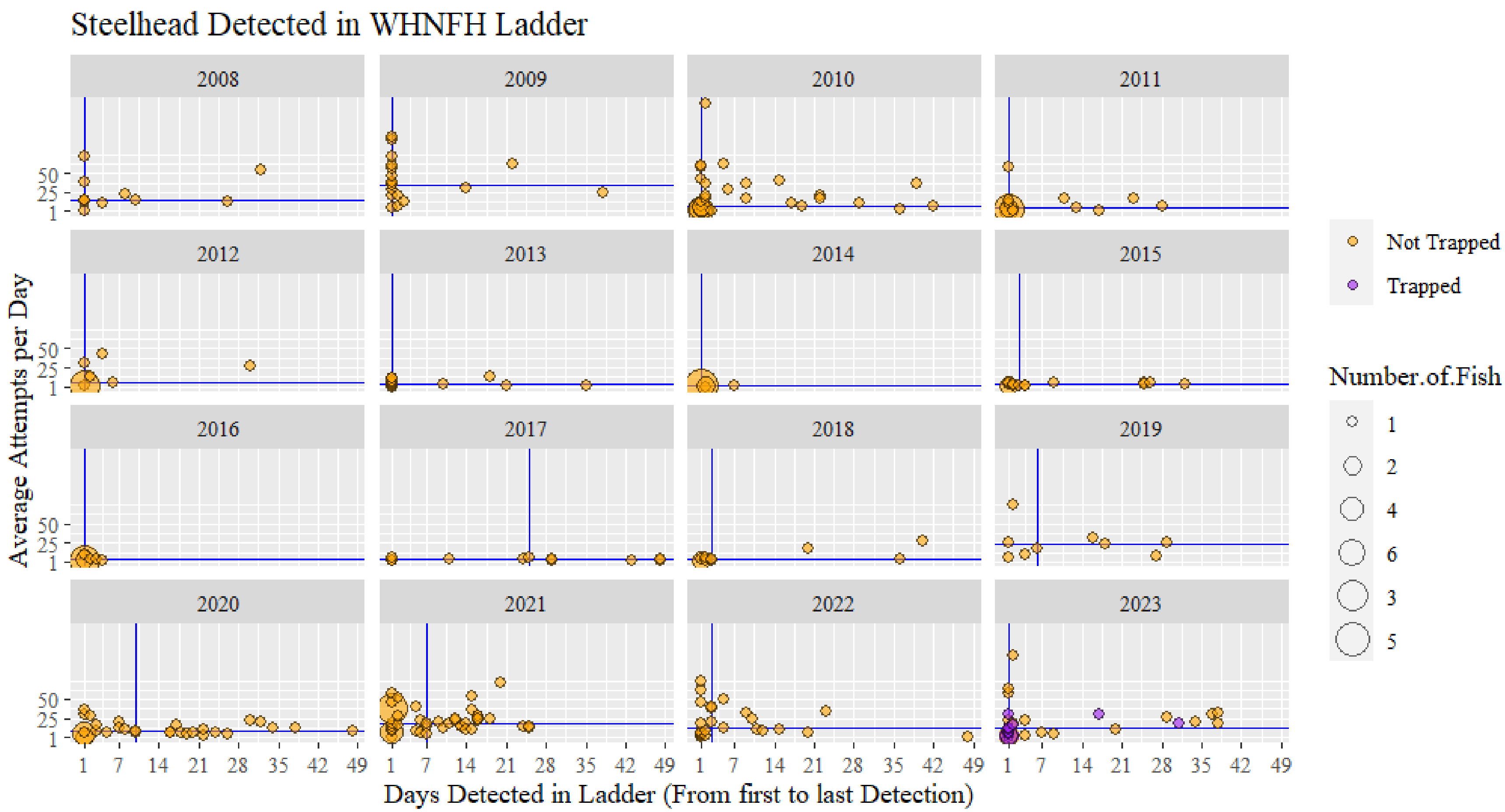

Figure 10. Average number of detections each day and days of detection per fish in the Warm Springs NFH ladder. The size of the circle indicates the number of fish exhibiting the same number of average attempts per day and days detected. Blue lines indicate annual median. Detections of PIT tagged fish collected from the trap and passed upstream were reported by the CTWSR BNR in 2023.

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 For 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
- **2024** – **Error! Hyperlink reference not valid.** (Silver, B.P. and Hand, D.M. 2024) Performance of Warm Springs, Round Butte, and Parkdale stock reared and released from Warm Springs NFH was assessed. Fish were monitored for size, condition factor, precocial rate, survival, migration timing, size, age structure, and accuracy of external mark identification. On-station survival and growth did not show significant differences, however, return timing and survival was earlier and higher for WSNFH stock fish. This

evaluation provides managers with a better understanding of the short and long-term benefits and risks of supplementing the Warm Springs NFH program with non-Warm Springs stock fish during years of production shortfalls.

Summary and Future Studies

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 a CWT and adipose fin clip, non-WSNFH stocks have been differentially marked with a ventral clip, and a subsample are PIT Tagged 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 BY05, 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, the Service 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 10 and as late as September 24, the average first date of spawning is August 23. In 2019, the first date of spawning was September 5th, four days after the previous latest start of spawning in 2010. Higher intensity daylight LED lights were installed over each pond and simulate the day length needed to cue future spawning. All fish have been spawned between August 19 and September 24 since 2019.

The facility has produced a mean hatchery smolt-to-adult survival rate that can exceed the target SAR of 0.39% at times but it is variable year to year (mean = 0.41 [95% CI 0.22, 0.61]). Due to low wild fish returns (<1,000 fish), wild fish were not regularly incorporated into the hatchery broodstock. The threshold 1,000 returning wild fish was 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 2024 forecast for WSNFH stock adult returns (model estimates of 318 to 790 Age 4 and 5 fish) indicate that it will be a struggle to meet the hatchery's broodstock needs. Round Butte Hatchery may also have trouble meeting broodstock needs with model estimates of 267 to 835

Age 4 and 5 fish. While the wild fish forecast estimate is an improvement over 2020 (158 - 352 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, WSNFH receives spring Chinook eggs and juveniles from the Round Butte State Fish Hatchery and/or CTWSRO's Parkdale Hatchery. Juvenile Parkdale and Round Butte sourced fish released from WSNFH are differentially marked (left or right ventral fin) to distinguish them from Warm Springs broodstock in subsequent years. Ventrally marked fish are excluded from spawning with Warm Springs stock but can still be inadvertently spawned with Warm Springs stock if the ventral fin grows back. For BY18, there was an overall 11% error rate when identifying stocks by fin marks. Inadvertent inclusion in the hatchery broodstock may increase as the number and frequency of transfers from outside the Warm Springs population increases, potentially posing a genetic risk to the Warm Springs stock (Smith 2018). The majority of adults from all stocks return to the facility at Age-4. However, the percentage of fish that return to the hatchery as adults is significantly greater for the Warm Springs stock. Although, no difference in survival of ventrally marked versus unmarked fish at Warm Springs NFH (Olson, D.E., and Cates, B.C. 1998), some research suggests removal of a ventral fin may reduce survival in other salmonids. Fin removal activities increase physiological stress (Sharpe, C.S. and Thompson, D. A. and Blankenship, H.L. and Schreck, C.B. 1998) or may lead to reduced long-term survival (Nicola, S.J. and Cordone, A.J. 1973). Future transfers are contingent upon availability and only after consultation and concurrence of CTWSRO and the Service.

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, sucker, and Pacific lamprey. These fish are counted and passed upstream or made available to the CTWSRO. Wild fish counts at WSNFH of summer steelhead have declined in recent years and are of concern. In 2023, the Warm Springs NFH trap and ladder was monitored to evaluate if it is functioning properly or if there are any infrastructure problems that could cause migrational delay. We observed fish taking numerous attempts to exit the pond back through the trap which underlines the need to move fish quickly out of the catch pond and either pass upstream, surplus, or hold for brood stock.

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,
- Add another PIT antenna to the cross channel to monitor fish entering and possibly exiting the trap, explore the possibility of creating eddies in the cross channel leading into the trap to prevent steelhead from turning around,
- 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

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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.

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Appendix A

A summary of on-station hatchery notes for 2023 (i.e., feeding changes, ponding, unique issues, etc.)

Warm Springs NFH injected thiamine into arriving broodstock (males and females) on recommendation of Pacific Region Fish Health. This was a veterinarian recommended injection for animal welfare reasons including potential of low thiamine due to changes in diet in the ocean phase of the fish. While *C. shasta* and ich are responsible for the majority of prespawn mortality, thiamine is intended to help survival to spawning, improve egg eye up, and survival to feeding. There is a thiamine working group that would like to test differences to gain a better understanding of path moving forward.

Additionally, the CTWSRO Council requested wild females be injected with thiamine and to release hatchery fish upstream.

The disease load and early release of BY20 fish are expected to impact smolt to adult return survival. Age three fish from the BY20 release returned in 2023, providing an early indicator of survival from release. The 2023 jack return was the fourth lowest in ten years.

Temperature monitoring – Loggers were downloaded on November 13, 2023 from the three water temperature monitoring sites on at the lamprey pump intake in the WSNFH building, hatchery intake in Warm Springs River and hatchery outfall in Warm Springs River. The hatchery outfall loggers are installed in the hatchery outfall structure. The ambient air temperature logger is installed on the opposite side of the building (- Kristofor Kannarr, Hydrologist, Water Resources Branch