2022 Grande Ronde and Imnaha River basin Spring Chinook Salmon Hatchery Review

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Contents

INTRODUCTION AND BACKGROUND

This paper provides background information, program development history, and assessment of program performance of the Grande Ronde spring and Imnaha basin spring-summer Chinook salmon *Oncorhynchus tshawytscha* Lower Snake River Compensation Plan (LSRCP) hatchery programs. We briefly review important development benchmarks from program initiation in 1982 through the 2010 Independent Scientific Review Panel (ISRP) review and discuss important changes between 2010 and present (2022). The Grande Ronde Basin hatchery spring Chinook salmon production programs are also known as the Grande Ronde Endemic Supplementation Program (GRESP) program. The GRESP program was developed in 1994 and includes Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and Lostine Rivers spring Chinook salmon programs. The Imnaha hatchery program was established from wild spring-summer broodstock collected from the Imnaha River beginning in1982. The GRESP and Imnaha programs are co-managed by the Oregon Department of Fish and Wildlife (ODFW), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Nez Perce Tribe (NPT), and the U.S. Fish and Wildlife Service (USFWS). The central production facility for the GRESP and Imnaha hatchery programs is the ODFW operated Lookingglass Fish Hatchery (LFH) which was constructed in 1982 at rkm 3.7 on Lookingglass Creek (Figure 1).

The Grande Ronde and Imnaha river basins are in Northeast Oregon and originate in the Wallowa and Blue mountains. The Grande Ronde River flows 340 km from the headwaters to the confluence with the Snake River at rkm 271. Historically, the six primary production areas in the Grande Ronde Basin, included the Wenaha, Minam, Lostine, Wallowa-Lostine, and the Upper Grande Ronde rivers and Lookingglass and Catherine creeks (Figure 1). The Imnaha River originates in high elevation areas of the Eastern Wallowa Mountains and the plateau between the Wallowa River drainage and Hells Canyon. The Imnaha River enters the Snake River at rkm 309.9. Historically, the two primary production areas for spring-summer Chinook salmon included the upper mainstem of the Imnaha River and Big Sheep Creek. The six Grande Ronde Basin and two Imnaha Basin populations have been identified by the Interior Columbia Basin Technical Recovery Team (ICTRT) as independent populations, each with specific population viability criteria and complete viability assessments (ICTRT 2007; NMFS 2017).

The U.S. Fish and Wildlife Services (USFWS) Lower Snake River Compensation Plan (LSRCP) program began in the late 1970's to mitigate for lost production in the Columbia and Snake Rivers that was attributed to construction of the four Lower Snake River dams. Historically, both the Grande Ronde and Imnaha basins supported diverse and robust populations of Chinook salmon that supported tribal and recreational fisheries through both basins. The depressed status of these populations led to the closure of recreational fisheries in the mid-1970s, and since then, both tribal and recreational fishery opportunities have been limited.

The LSRCP established annual adult (i.e., ages 3-6) mitigation, brood year specific smolt-to-adult return (SAR) and total adult survival rate (SAS) goals as well as annual smolt production goals to compensate for the estimated annual loss of 48% of the adult production to the mitigation area (Table 1). The assumption was that the remaining 52% of adult production would be achieved by naturally spawning Chinook salmon populations. For Oregon LSRCP programs, the adult (ages 3-6) production and smolt-to-adult return goals to the compensation area represent the required performance to the area above Lower Granite Dam. The total adult and smolt-to-adult survival (SAS) rate goal of 3.25% was determined based on an assumed catch to escapement ratio of four-to-one that existed prior to construction of the dams. The LSRCP

smolt production goals are 900,000 and 490,000 in the Grande Ronde and Imnaha River basins, respectively.

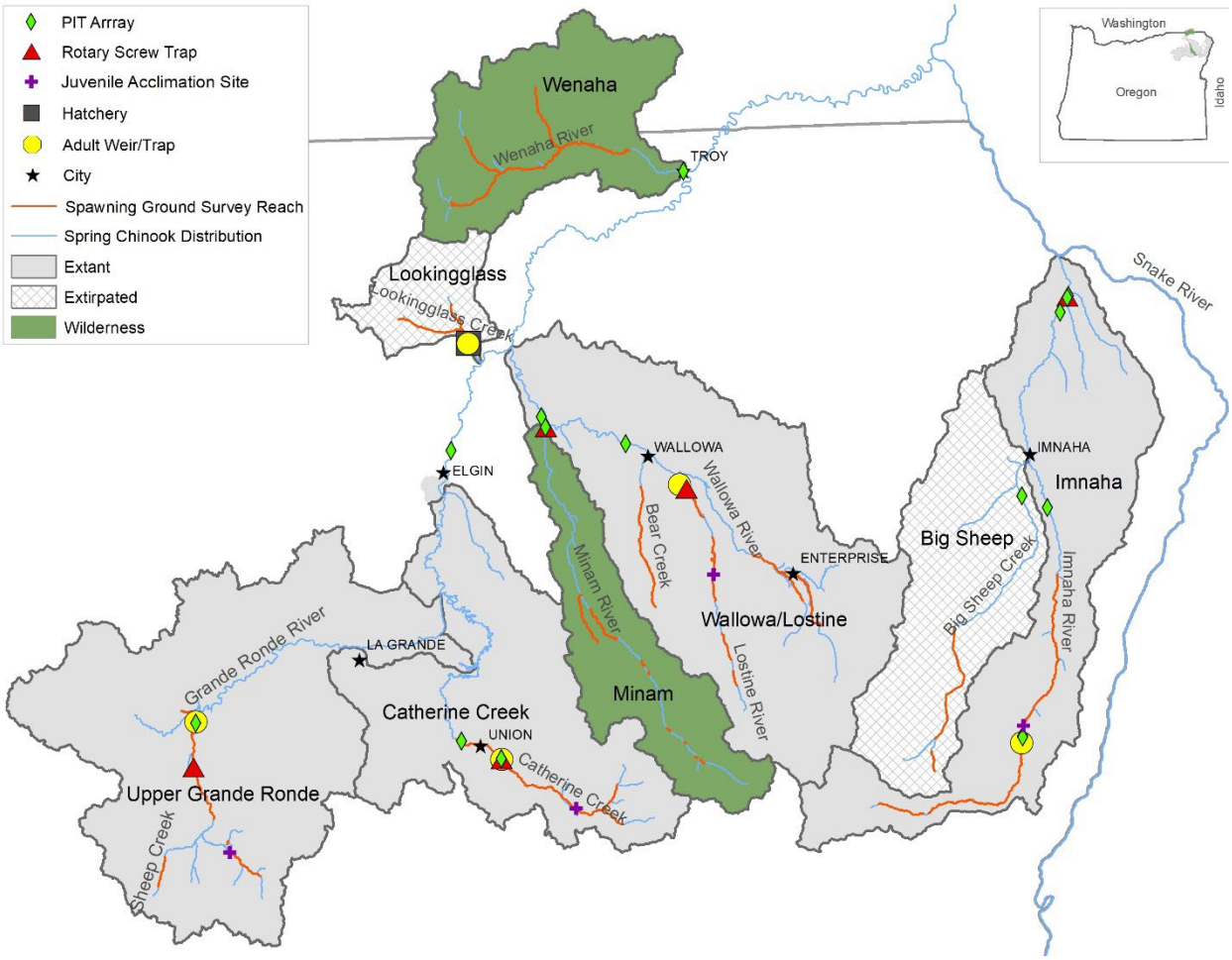

Figure 1-Map of the Grande Ronde and Imnaha River basin Major Population Groups identifying the Independent Populations of Snake River Spring/Summer Chinook salmon identified by the Interior Columbia Basin Technical Recovery Team. Important hatchery infrastructure such as adult weirs juvenile acclimation faculties, and locations of juvenile rotary screw traps, in-stream PIT tag arrays, and the extent of Chinook spawning ground surveys are also mapped. Lookingglass Fish Hatchery is the central adult spawning and smolt rearing facility.

Table 1. Lower Snake River Compensation Plan mitigation goals for Oregon's spring Chinook salmon in the Grande Ronde and Imnaha River basins. Adult and survival goals are expressed for returns to the compensation area and total catch plus escapement goals below Lower Granite Dam.

	Grande Ronde Basin	Imnaha Basin
Compensation Area (i.e., above Lower Granite Dam)		
Annual smolt goal	900,000	490,000
Annual production (Lbs.)	45,000	24,500
Annual adult goal	5,820	3,210
Brood year smolt-to-adult return rate	0.65%	0.65%
Total Catch and Escapement below Lower Granite Dam (4:1 harvest objective)		
Annual adult goal	29,100	16,050
Brood year smolt-to-adult survival	3.25%	3.25%

Program development

Initially, the hatchery program development was centered around juvenile releases into the Grande Ronde Basin (i.e., Lookingglass Creek) and the Imnaha River (Figure 2). The Grande Ronde River Basin Chinook Salmon program originally started using non-endemic broodstock sources (Carmichael et al. 2010a) and the Imnaha conventional program was founded from wild caught broodstock (Carmichael et al. 2010b). When considering options for broodstock sources in the Grande Ronde Basin in the late 1970s, managers believed there were too few natural-origin fish available in the basin to meet broodstock needs. To initiate broodstock development, BY 1978 Rapid River stock smolts were released into Lookingglass Creek (Table 2). The use of Rapid River stock was discontinued from BY 1980 – 84 due to disease and availability. Carson stock, imported from the Willamette River Hatchery Program, was used in the interim. Rapid River stocks was again used from BYs 1985 –1999 until it was phased out. During this time most, releases into the Grande Ronde Basin occurred at LFH. However, supplementation releases of pre-smolts and smolts occurred in Catherine Creek and Upper Grande Ronde River for BYs 1980 –1988 and surplus Carson stock adults were outplanted into Catherine Creek, Upper Grande Ronde River and the Wallowa River from 1987 – 1989 (Carmichael et al. 2010a).

Several factors led to discontinuing the non-endemic stocks used in the Grande Ronde Basin. Broadly, evaluations by ODFW suggested poor overall performance indexed by low recruits per spawner (R:S) in nature and low numbers of hatchery adult returns (i.e., low SAS and SAR rates), stray rates into unsuplemented streams were high, there were important policy influences, and no progress had been made in re-establishing fisheries. As reviewed by Carmichael et al. 2010a, from 1987 – 2001 the annual adult (ages 3-6) returns to the compensation area were below the mitigation goal of 5,820 adults with the highest return reaching 42% of the goal. Also, the SAR goal of 0.65% was reached in only two of thirteen years for the 1985-1997 brood years. In nature, the number of natural origin spawners continued to reach critically low levels with R:S below 1 for spawning years 1986 – 1993 and only exceeded 0.5 twice in eight years. Poor adult performance resulted in the inability to consistently reestablish either sport or tribal fishing opportunities. The few years that fishing opportunities provided, they occurred in restricted locations.

Table 2. History of spring Chinook salmon broodstock sources used in the Grande Ronde basin spring Chinook hatchery program, 1978-2020 brood years (BY). Captive Broodstock Program (CBS); Conventional Hatchery Program (CHP).

Brood year	Stock Source
1978	Rapid River
1980-84	Carson / Willamette Hatchery
1985-87	Carson/ Lookingglass Hatchery Rapid River Idaho
1988	Rapid River / Idaho
1989	Carson/ Lookingglass Hatchery Rapid River Idaho
1990-99	Rapid River/ Lookingglass Hatchery
1994-95	Captive broodstock (CBS) program initiated in the Grande ronde Basin.
1997	Conventional Hatchery Program (CHP) initiated in Catherine Creek, Upper Grande Ronde, and Lostine River. The BY1997 Lostine River CHP smolt released into the Lostine River in 2000.
1999	BY 1999 Rapid River smolts released into Lookingglass Creek for the last time in 2001.
2001	First BY of CHP smolts released into the Upper Grande Ronde River and Catherine Creek in 2003.
2002	The BY2002 Catherine Creek CBS smolts released into Lookingglass Creek in 2004.
2011	BY 2011 was the last release of CBS smolts into Catherine Creek and the Lostine River in 2013.
2013	BY 2013 was the last release of CBS smolts into the Upper Grande Ronde River in 2015.
2001-present	Annual production and releases of CHP smolts into Catherine Creek, the Upper Grande Ronde, and Lostine River.

We assess the success of meeting the management objective of maintaining endemic wild populations of spring Chinook salmon in the Minam and Wenaha rivers by monitoring the proportion of natural spawners that were hatchery strays. We found that most hatchery spawners in the Minam and Wenaha rivers were from LFH releases, and in these unsuplemented streams, stray rates were high, exceeding 25% in some years (Carmichael et al. 2010a). These high stray rates were contrary to several important policies. In 1990, Oregon adopted a Wild-Fish Management Policy guideline which established criteria for the maximum acceptable level of non-local origin hatchery spawners in natural populations. In 1992, natural spring Chinook populations were listed initially as endangered and later as threatened by the National Marine Fisheries Services (NMFS) under the Endangered Species Act (ESA). Given the high proportion of stray hatchery spawners throughout the basin, the hatchery program was operating well outside the ODFW Wild Fish Policy criteria and was generating outcomes that were inconsistent with ESA recovery and sound conservation principles.

Ultimately, the wild fish policies, ESA listing, and overall poor performance of the non-endemic broodstock led to a restructuring of the Grande Ronde basin hatchery program. In 1994, fisheries co-managers, ODFW, NPT, CTUIR, and USFWS implemented the GRESP program for hatchery production of spring Chinook populations in Catherine Creek, the Upper Grande Ronde River, and the Lostine River. The goal of this program is to prevent population extinction, reverse the decline in stock abundance, and ensure a high probability of population persistence as well as maintain production mandates for LSRCP (2010) and US v. Oregon (2018). To achieve program goals, the GRESP focused on using endemic stocks and contained

two components: the Captive Broodstock (CBS; discontinued BPA projects 199801001, 199800106, and 200740400) and the Conventional Hatchery Program (CHP). Captive broodstock were founded from juveniles captured in nature and raised to the adult stage entirely in-hatchery. Adults raised in captivity were spawned and the offspring from these adults were reared in captivity to the smolt stage and then released into nature to emigrate to the ocean and return as adults. Conventional broodstock is created from endemic wild adults captured in nature and spawned at a hatchery. These offspring are released into nature as smolts, and when the adult hatchery fish return, they are kept for subsequent hatchery spawning with wild adults and other conventional production. Overall, given the uncertainties associated with supplementation, a diversified risk management approach was employed that leveraged the sliding scale management framework (see sliding scales in this document). Also, it was agreed that wild fish management sanctuaries would be maintained in the Minam and Wenaha river populations. Concurrent with GRESP re-structuring was establishment of specific LSRCP adult production and smolt release goals for Catherine Creek, the Upper Grande Ronde, the Lostine River, and Lookingglass Creek (Table 3). In the early 2000's, the extirpated Lookingglass Creek population was re-established using progeny from the Catherine Creek stock of the CBS Program, and with subsequent returns of CHP adults from Catherine Creek and returns to Lookingglass Creek.

Table 3. Population specific mitigation goals for Grande Ronde spring Chinook salmon and Imnaha River spring-summer Chinook salmon. Adult and survival goals are expressed for returns to the compensation area and total catch plus escapement goals below Lower Granite Dam.

	Smolts	Smolt size (fish/lb)	Compensation Area adult returns	SAR (%)	Coastwide harvest objective (4:1)	Total Adults Produced	SAS (%)
Grande Ronde Basin							
Catherine Creek	150,000	20-25	970	0.65	3,880	4,850	3.25
Upper Grande Ronde	250,000	20-25	1,617	0.65	6,468	8,085	3.25
Lookinglass Creek	250,000	20-25	1,617	0.65	6,468	8,085	3.25
Lostine River	250,000	20-25	1,617	0.65	6,468	8,085	3.25
Imnaha Basin							
Imnaha River	490,000	20-25	3,210	0.65	12,840	16,050	3.25

In the Imnaha Basin, the uniqueness of the Imnaha spring-summer Chinook salmon population was recognized prior to initiating the hatchery program. Therefore, it was decided to only use endemic local broodstock for the hatchery program in concert with a sliding scale broodstock management plan that has been modified several times during program development (Carmichael et al. 2010b). Due to rearing space limitations and changes to the preferred smolt rearing density criteria at LFH, various interim smolt release goals have been adopted for the Imnaha program. Briefly, the interim goal was 360,000 for BYs 2000-2010, and 420,000 from BYs 2011-2013. The smolt goal for the Imnaha program is 490,000 (BYs 1983-1999 and 2014-present).

Overall, adapting hatchery operations from the late 1990's through the early 2000's to accommodate both conventional and captive broodstock for all five supplemented stocks was complex (Figure 3). Implementation required the use of additional hatchery facilities and transport of adults and smolts to and from various locations. With the short-term goals of preventing extinction initially realized in the Grande Ronde Basin and establishment of

successful conventional programs, the captive broodstock program was phased out. The last smolts from the CBS program were released into the Lostine River and Catherine Creek in 2011 (BY2009) and the Upper Grande Ronde in 2013 (BY 2011). The current convention production programs for both the Grande Ronde Basin (i.,e, GRESP) and Imnaha programs are simpler (Figure 4).

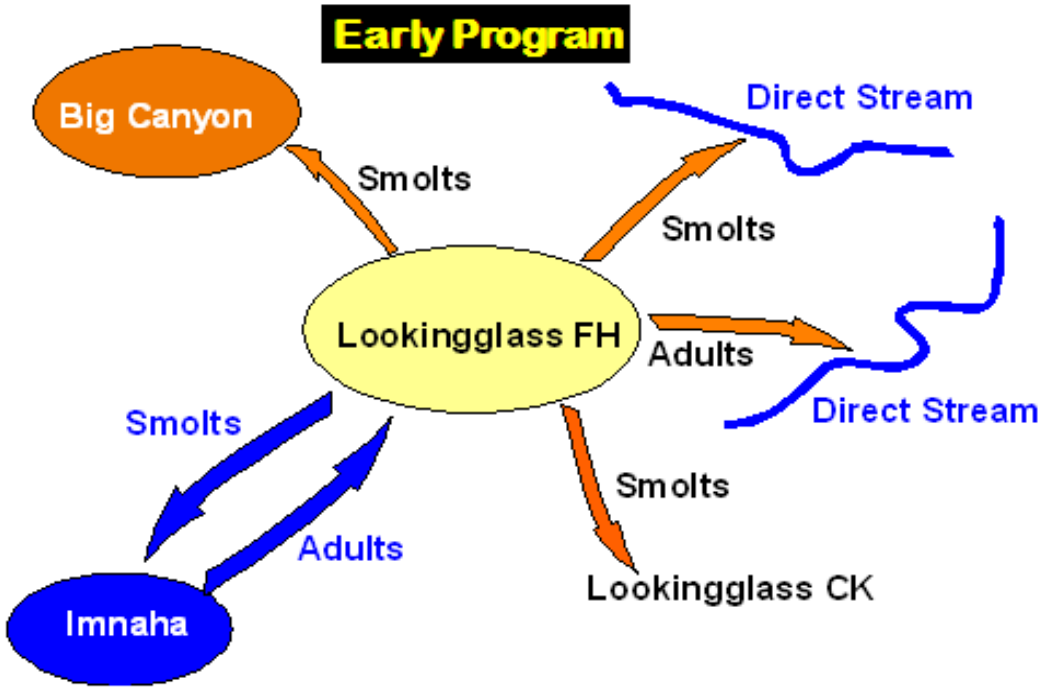

Figure 2. Diagram representing initial hatchery program operations for spring Chinook salmon in the Grande Ronde and Imnaha River basins from 1982-the late 1990's.

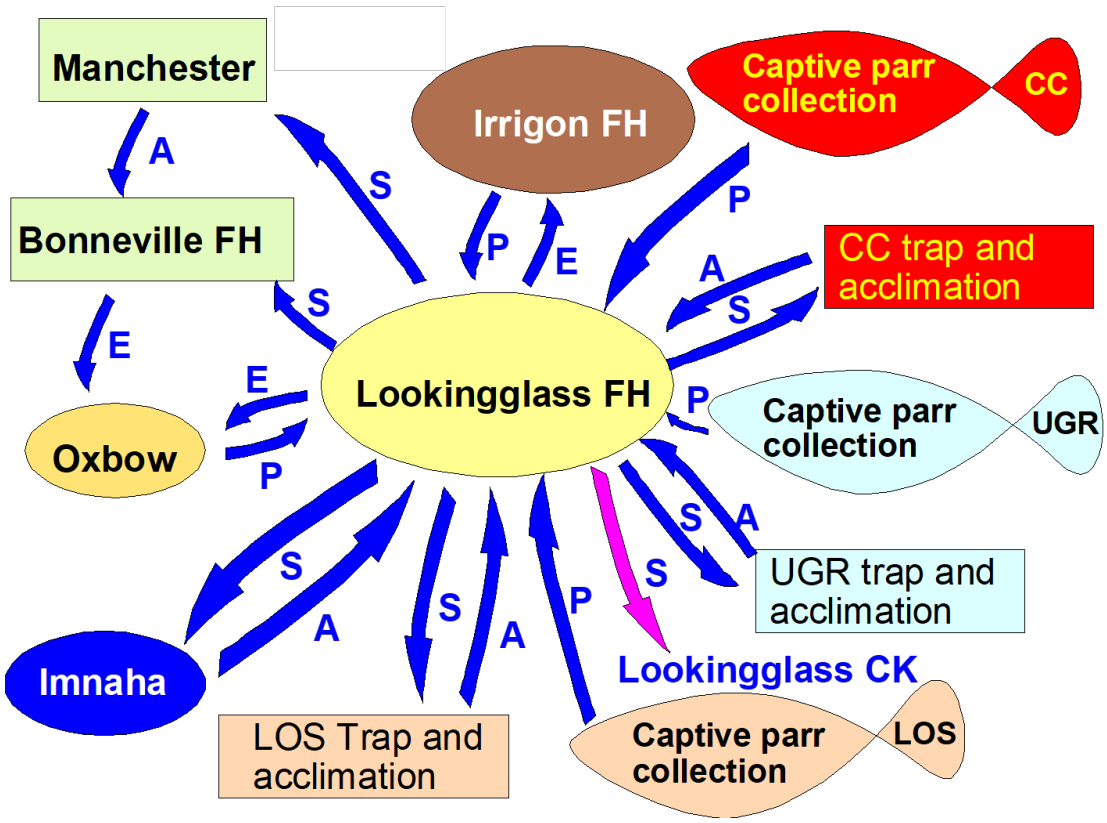

Figure 3. Northeast Oregon Chinook salmon hatchery program operational schematic illustrating the complexity of implementing conventional and captive broodstock programs for five population specific hatchery programs. This schematic represents the time from the late 1990's to about 2009.

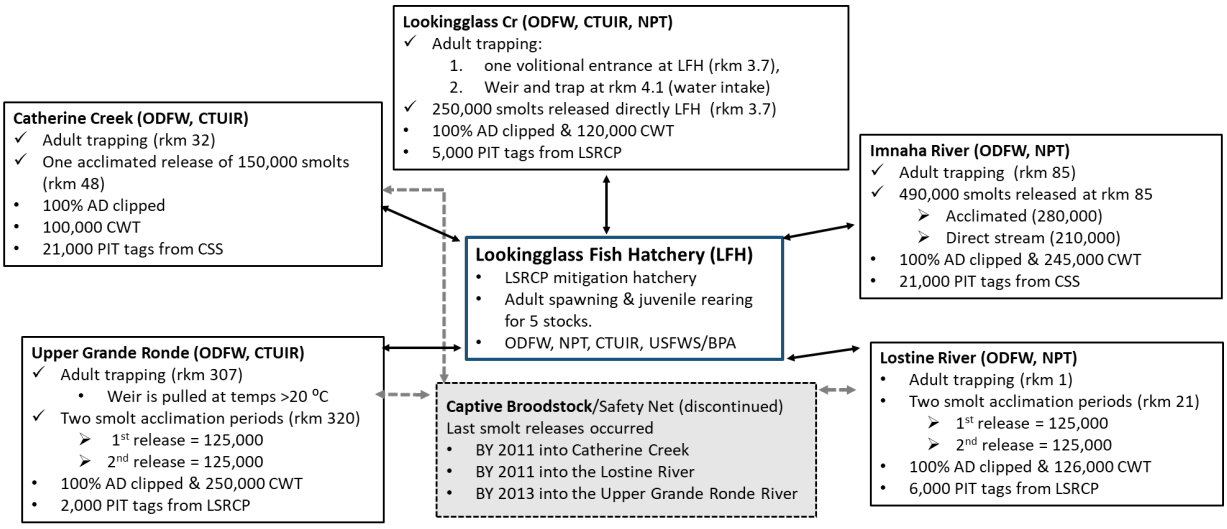

Figure 4. Diagram representing conventional hatchery program operations for five specific Chinook salmon populations in the Grande Ronde and Imnaha River basins from about 2013 to present. BPA = Bonneville Power Administration, BY = Brood Year, CTUIR = Confederated Tribes of the Umatilla Indian Reservation, NPT = Nez Perce Tribe, USFW = U.S. Fish and Wildlife Service.

Management Goals and Evaluation objectives

To operate the hatchery programs, co-managers in the Grande Ronde and Imnaha basins are guided by four primary management goals: recover natural populations, ensure a high probability of population persistence, restore sport and tribal fisheries, and minimize risk of potential negative effects of artificial production. The implementation has been guided by nine priority management objectives:

1) Prevent extinction of the Grande Ronde and Imnaha basin salmon populations.
2) Establish adequate broodstock to meet annual production needs.
3) Establish an annual return to the mitigation area of 5,820 Grande Ronde Basin hatchery spring Chinook and 3,210 Imnaha Basin spring-summer Chinook.
4) Provide a demographic foundation to rebuild from after the key limiting factors and threats are addressed.
5) Maintain and enhance natural production while maintaining long term fitness.
6) Maintain genetic and life history characteristics of the natural population.
7) Operate the hatchery program so that the genetic and life history characteristics of hatchery fish mimic wild fish.
8) Re-establish historical tribal and recreational fisheries.
9) Maintain endemic wild populations of spring Chinook salmon in the Minam and Wenaha rivers.

A comprehensive research, monitoring, and evaluation (RM&E) program has been underway since 1984. The RM&E objectives are:

1) Document and assess fish culture and hatchery operation practices and performance.
2) Determine optimum rearing and release strategies
3) Determine total catch and escapement, smolt survival, smolt-to-adult survival, and assess if adult production meets mitigation goals
4) Compare recruits-per-spawner (R/S) for hatchery and natural origin fish
5) Assess response in natural population abundance and productivity (adult R/S, smolts-per-spawner) to supplementation.
6) Assess and compare life history characteristics (age structure, run timing, sex ratio, smolt migration, fecundity) of hatchery and natural fish.
7) Determine the success of maintaining genetic integrity of endemic wild spring Chinook salmon in the Minam and Wenaha rivers.
8) Assess success in restoring fisheries.
9) Coordinate project activities and disseminate results.

Partnerships

Numerous agencies and projects contribute to implementing hatchery programs and the Research, Monitoring, and Evaluation (RM&E) for Grande Ronde and Imnaha basin Chinook salmon (Figure 5). These partnerships are a key component of meeting RM&E objective 9. As an example, during the recent Review of Anadromous Fish and Habitat Hatchery Projects completed by the Independent Scientific Review Panel (ISRP 2021), we have identified eight projects funded by the Bonneville Power Administration (BPA) that directly and indirectly support six management and four evaluation objectives for the LSRCP hatchery program (Table 4). Dedication by all the project partners to monitor naturally produced juveniles and adults in

the Grande Ronde and Imnaha basins allows us to evaluate efforts to restore natural spawning populations of spring Chinook Salmon in the Grande Ronde Basin and Imnaha basins. Overall, the LSRCP program serves as a central hub for a network of projects that enable successful implementation (Figure 5). The diverse portfolio of funding sources, projects, agencies, and individuals that contribute to this collaborative effort have provided the energy and creativity required to implement and adaptively manage the Grande Ronde and Imnaha hatchery programs. The diverse portfolio of collaborators also ensures stability when personnel or funding fluctuate on any single project.

Table 4. List of projects funded by the Bonneville Power Administration (BPA) that were reviewed during the 2021 Northwest Power and Conservation Council Anadromous Fish Habitat and Hatchery Review and their association with the Lower Snake River Compensation Plan (LSRCP). CTUIR = Confederated Tribes of the Umatilla Indian Reservation, NPT = Nez Perce Tribe, ODFW = Oregon Department of Fish and Wildlife, CRITFC = Columbia River Inter-tribal Fish Commission.

ID	Title	Proponent	Final ISRP Review Criteria	Link to LSRP spring and summer Chinook salmon programs
Supports Hatchery Production and Monitoring and Evaluation Objectives				
199800702	Grande Ronde Supplementation: Lostine River Operation and Maintenance and Monitoring and Evaluation	NPT	Conditional	Adult trapping and broodstock collection, hatchery spawning, and smolt rearing and releases from the Lostine River acclimation sites. Monitors post-release performance of hatchery juveniles and adults. Assists with adult escapement monitoring for the Imnaha, Wallowa-Lostine and Minam River populations.
199800703	Grande Ronde Supplementation O&M on Catherine Creek and upper Grande Ronde River	CTUIR	Meets	Adult trapping and broodstock collection, hatchery spawning, and smolt rearing and releases from acclimation sites on Catherine Creek and Upper Grande Ronde hatchery program.
Supports Monitoring and Evaluation Objectives				
199202604	Grande Ronde Salmonid Life Cycle Monitoring Project	ODFW	Meets	Natural production monitoring (e.g., smolts/spawner) in the Grande Ronde Basin. Catherine Creek, Upper Grande Ronde, Lostine River, Minam River. Data is used to benchmark hatchery performance in mimicking natural populations.
199701501	Imnaha River Steelhead Status and Smolt Monitoring	NPT	Meets	Natural production monitoring (e.g., natural smolt equivalents) for spring Chinook salmon in the Imnaha basin.
198909600	Genetic Monitoring and Evaluation (M&E) Program for Salmon and Steelhead	NOAA	Not reviewed in 2021	Relative Reproductive Success for the Catherine Creek and Lostine River hatchery programs.
200708300	Grande Ronde Supplementation Monitoring and Evaluation (M&E) on Catherine Creek/Upper Grande Ronde River	CTUIR	Conditional	Monitors post-release performance of hatchery juveniles and adults for the Catherine Creek and Upper Grande Ronde hatchery programs.

200900900	Basinwide Supplementation Evaluation Project	CRITFC	Meets	Relative Reproductive success for reestablishing natural production in Lookingglass Creek.
201005700	Snake Basin Anadromous Assessments	NPT	Meets	Supports maintenance of instream PIT tag interrogation sites in the Grande Ronde and Imnaha basins. The PIT arrays are used for a variety of in-season management decisions for adult salmon and to track juvenile performance (e.g., juvenile survival, travel time)..
201003100	IDFG Genetic Monitoring of Snake River Steelhead and Chinook Salmon	IDFG	Meets	Genetic samples for all hatchery stocks spawned at Lookingglass have been collected for the PBT baseline since 2008.

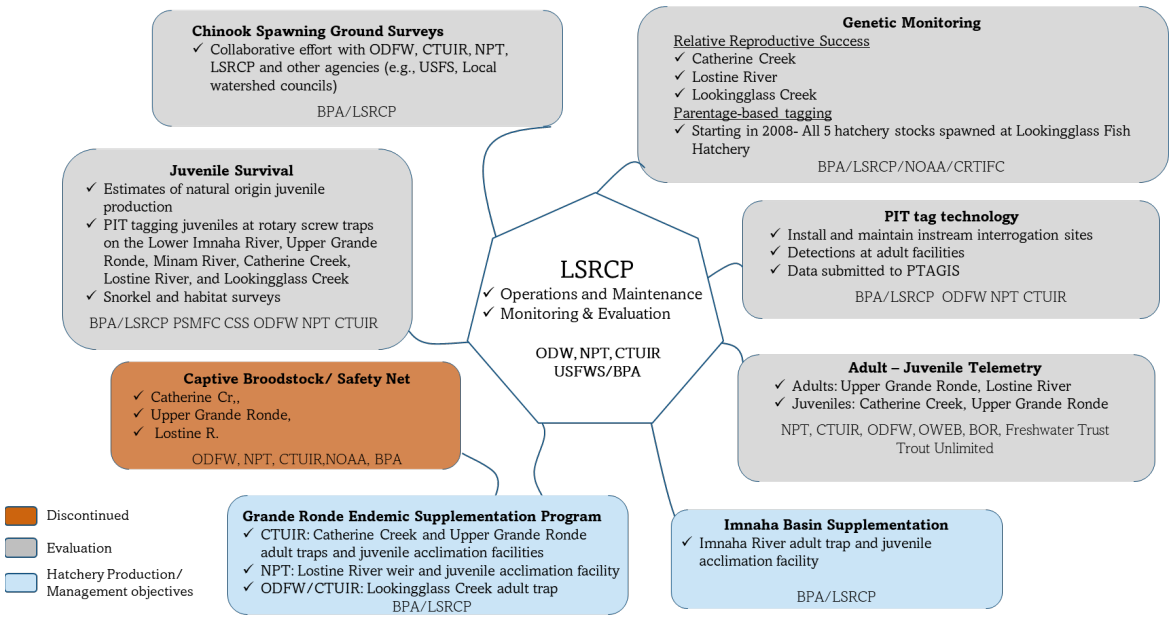

Figure 5. Grande Ronde and Imnaha River basin Chinook salmon hatchery program organization.

Sliding scales

Variably allocating natural and hatchery fish to broodstock, natural production and harvest via a "sliding scale" manages the levels of integration and interaction between hatchery and natural populations. The sliding scale management framework is based on the theory that at low population levels, the greatest risk to population persistence is demographic. At low population levels, fewer constraints are placed on the genetic risks imposed by hatchery program because the short-term goal is population persistence, and the desire is to rapidly boost population levels. As population levels increase, the demographic risks are of less concern and more constraints are placed on the hatchery program to control for potential genetic risks of artificial propagation. For example, when the GRESP program in the Grande Ronde Basin was developed, captive broodstock were viewed as higher risk than conventional broodstock so captive broodstock progeny were not allowed to be retained for broodstock. To prevent the collection of captive

broodstock offspring being used in subsequent hatchery broodstock collections, captive and conventional offspring were uniquely marked to allow identification at the adult stage. Therefore, phasing out the captive broodstock programs represents success because it reflects progress in preventing extinction, ensuring population persistence, and the CHPs currently employed are hypothesized to have lower potential negative effects to natural populations.

Determining management levels for the populations specific sliding scales is an adaptive management process done annually for the Annual Operating Plan (e.g., 2022 Chinook AOP). Initially, planning begins with pre-season estimates of naturally returning adults to each population. Each year, managers monitor stock specific in-season run development using PIT tag derived population estimates at mainstem Columbia and Snake River dams in concert with basin-wide weekly coordination meetings to inform sliding scale management. The sliding scale is not used in the upper Grande Ronde River where a very aggressive level of supplementation is being applied (Table 6). Sliding scales for Catherine Creek, the Lostine River, and Imnaha river programs have varying levels of complexity (for example, Table 6-7) and pages 34-26 in the 2022 Chinook AOP).

Table 5. Sliding scale for management of the Upper Grande Ronde (UGR) and Catherine Creek adult returns and broodstock collection.

Estimated total adult escapement to the Catherine Creek mouth (hatchery plus natural) [a]	Ratio of hatchery to natural adults at the mouth	Maximum % of natural adults to retain for broodstock	% of conventional hatchery adults to retain for broodstock [b]	% of adults released above the weir that can be of hatchery origin	Minimum % of broodstock of natural origin	% Strays allowed above the weir [c]
UGR	Any	Up to 50	Up to 100	Up to 100	[d]	≤5
Catherine creek						
<250	Any	40	40	[d]	[d]	≤5
251-500	Any	20	20	≤70	≥20	≤5
>500	Any	≤20	d	≤50	≥30	≤5

[a] *Pre-season estimate of total escapement*
[b] *Conventional hatchery adults only, all captive brood adults released to spawn naturally or outplanted*
[c] *For hatchery adults originating from different gene conservation groups (Rapid River stock or strays from outside the Grande Ronde basin)*
[d] *Not decision factor at this level of escapement, percentage determined by other criteria*
[e] *Not to exceed 150,000 smolt production*

Table 6. Sliding scale broodstock and natural escapement management plan for the Imnaha River spring/summer Chinook salmon hatchery program.

Total escapement to river	Maximum % natural retained for broodstock	% Hatchery above weir	Minimum % of natural-origin broodstock
>15	0	NA	NA
15-159	50	NA	NA
150-299	40	70	20
300-499	40	60	25
500-999	30/40*	50	30
1000-1499	30/40*	40/30*	40
1500-1999	25	25	50
>2000	25	<10*	100

** 3 consecutive years with Minimum Abundance Threshold ≥ 1000*

Progress to date

The overall management goals for the LSRCP hatchery programs revolve around the principle that these programs should be operated to meet both mitigation (e.g., adult returns and harvest) and conservation goals (i.e., ensuring population persistence and enhancement). This proposal will highlight the nine RM&E objectives previously presented in achieving those various mitigation and conservation goals.

Objective 1. Document and assess fish culture and hatchery operation practices and performance

Adult broodstock collection is determined annually by co-managers at the Annual Operations Plan (AOP) meeting (e.g., 2022 Chinook AOP). Broodstock collection is based on the sliding scales for each population (see pages 34-36 in the 2022 Chinook AOP) which are set using pre-season return estimates of natural origin adults. The broodstock needs for each stock are calculated annually and limited in the ESA section 10 permits for each stock. The ESA permits numbers are as follows: Upper Grande Ronde River (permit #18033), Catherine Creek (permit #18034), Lookingglass Creek (permit #18035) and Lostine River (permit #18036). Historically, a five-year rolling average of fecundity, egg to smolt survival, and in-hatchery pre-spawning mortality was used to determine the number of females to be collected and spawned to achieve the current egg collection goal. However, in 2019 a three-year rolling average, that better reflected the variation in the size of the returning fish, was implemented and will be used in the future. The number of males to be collected is paired with the females.

Fecundity

Fecundity of female salmon directly affects the number of fish needed to be taken for broodstock to meet smolt release goals. Lower fecundities of fish results in a higher number of fish being removed from the river and being spawned at the hatchery. Fecundity is typically a function of size of fish. Larger females tend to produce more eggs, hence older females tend to produce more eggs. Smaller average size of females returning can affect the number of eggs that will be available in nature once salmon have spawned.

The number of hatchery and natural females successfully spawned for conventional broodstock at Lookingglass Fish Hatchery from 2009-2021 varied over time (Table 8.1). For the Catherine Creek program, which has a smolt production goal of 150,000 smolts, the mean number of females successfully spawned since 2009 is 46 (range 38-59). The Lookingglass Creek, Lostine River, and Upper Grande Ronde smolt production goal is 250,000. The mean number of successfully spawned females is 71 (range 26-84), 70 (range 57-76), and 72 (range 39-85) for the Lookingglass Creek, Lostine River, and Upper Grande Ronde programs, respectively.

Mean fecundity (i.e., number of green eggs per female) for both hatchery and natural adults varies annually (Figure 6.1). For age 4 and age 5 adult Chinook spawned at Lookingglass Fish Hatchery, mean fecundity for age 5 fish is generally greater than age 4 fish (Figure 6.2). For all stocks, there is a significant ($P<0.01$) positive linear relationship between size and fecundity (ODFW, unpublished data). Over the last three years, mean fecundity for spawned hatchery females is 3,588, 4,409, 3,809, 4,333, and 3,566 for the Catherine Creek, Imnaha River, Lookingglass, Lostine River, and Upper Grande Ronde programs, respectively. The most recent 3-year average fecundity for natural origin females is 3,484, 4,188, 3,698, 4,405, and 3,589 for the Catherine Creek, Imnaha River, Lookingglass, Lostine River, and Upper Grande Ronde programs, respectively.

Age structure for successfully spawned females at Lookingglass is predominately age 4. From 2009 to 2021, the only program to spawn over 30% age 5 females is the Lostine River in 2013 and 2019 (Figure 6.3). The Upper Grande Ronde program has never exceeded 14% age 5 females (Figure 6.3). The Lookingglass program has never spawned > 20% age 5 females and the Imnaha river program has only spawned >20% age 5 females in three years, 2012-2013 and 2017. In the last 5 years, zero age 5 females were spawned for the Catherine Creek program in 2018, 2020, and 2021; zero were spawned in the Lookingglass program in 2018; and zero were spawned in the Upper Grande Ronde Program in 2021.

Table 8.1. The number of successfully spawned natural and hatchery females, mean fecundity, and proportion natural origin broodstock (pNOB) for the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde conventional production at Lookingglass Fish Hatchery, brood years 2009-2021.

		Natural		Hatchery		
Stock	Brood Year	N	Mean Fecundity	N	Mean Fecundity	pNOB
Catherine Creek	2009	13	3,638	30	3,932	0.39
	2010	11	3,922	31	4,299	0.40
	2011	19	3,661	20	4,033	0.41
	2012	23	3,608	22	3,987	0.53
	2013	26	3,818	23	3,776	0.58
	2014	25	4,074	19	4,557	0.57
	2015	20	4,545	33	4,309	0.54
	2016	22	4,075	16	3,980	0.57
	2017	11	3,698	34	3,912	0.31
	2018	9	3,260	37	3,756	0.26
	2019	11	3,629	33	3,661	0.32

Stock	Brood Year	Natural		Hatchery		pNOB
		N	Mean Fecundity	N	Mean Fecundity	
	2020	27	3,480	28	3,261	0.50
	2021	12	3,656	47	3,530	0.26
Average		**18**	**3,774**	**29**	**3,923**	
Imnaha River	2009	34	4,722	75	4,705	0.28
	2010	32	4,641	78	4,742	0.28
	2011	25	4,569	80	4,766	0.27
	2012	38	4,533	71	4,464	0.29
	2013	18	4,670	69	4,436	0.24
	2014	40	4,489	100	4,423	0.31
	2015	36	4,811	100	4,473	0.32
	2016	39	4,511	96	4,196	0.37
	2017	37	4,636	94	4,786	0.34
	2018	28	4,075	85	3,958	0.28
	2019	26	4,546	113	4,089	0.24
	2020	25	4,089	110	4,057	0.28
	2021	28	4,591	107	4,417	0.27
Average		**31**	**4,529**	**91**	**4,424**	
Lookingglass Creek	2009	19	3,937	7	3,832	0.77
	2010	20	4,133	55	3,955	0.37
	2011	29	4,002	50	4,138	0.46
	2012	24	3,547	57	3,725	0.34
	2013	15	3,853	52	3,691	0.26
	2014	24	3,901	58	3,980	0.35
	2015	27	3,599	48	3,450	0.29
	2016	21	3,794	56	3,449	0.34
	2017	8	4,457	37	3,566	0.21
	2018	10	3,454	70	3,563	0.19
	2019	7	3,837	69	3,914	0.12
	2020	5	3,908	74	3,641	0.12
	2021	6	3,682	78	3,540	0.12
Average		**17**	**3,854**	**55**	**3,727**	
Lostine River	2009	25	4,551	32	4,660	0.31
	2010	19	4,191	57	4,427	0.33
	2011	24	4,499	40	4,861	0.37
	2012	15	4,407	47	4,343	0.32
	2013	30	4,269	39	4,274	0.37
	2014	26	4,307	48	4,224	0.38
	2015	26	4,304	46	4,493	0.40
	2016	20	4,426	54	4,281	0.29
	2017	11	4,771	63	4,344	0.18
	2018	14	3,465	59	3,796	0.26
	2019	15	4,649	58	4,468	0.25

Stock	Brood Year	Natural		Hatchery		pNOB
		N	Mean Fecundity	N	Mean Fecundity	
	2020	18	3,982	55	4,437	0.25
	2021	12	4,368	62	4,308	0.25
Average		**20**	**4,322**	**51**	**4,378**	
Upper Grande Ronde R	2009	13	4,024	48	4,351	0.19
	2010	14	3,472	68	3,976	0.25
	2011	2	4,311	37	4,255	0.15
	2012	29	3,498	45	3,688	0.56
	2013	13	4,085	53	3,737	0.25
	2014	24	3,504	44	3,945	0.44
	2015	24	4,457	61	4,127	0.30
	2016	9	3,853	60	3,693	0.24
	2017	3	3,881	69	3,854	0.09
	2018	10	3,130	67	3,494	0.26
	2019	4	4,233	70	3,722	0.14
	2020	12	2,951	70	3,427	0.17
	2021	7	3,515	76	3,617	0.13
Average		**13**	**3,763**	**59**	**3,837**	0.19

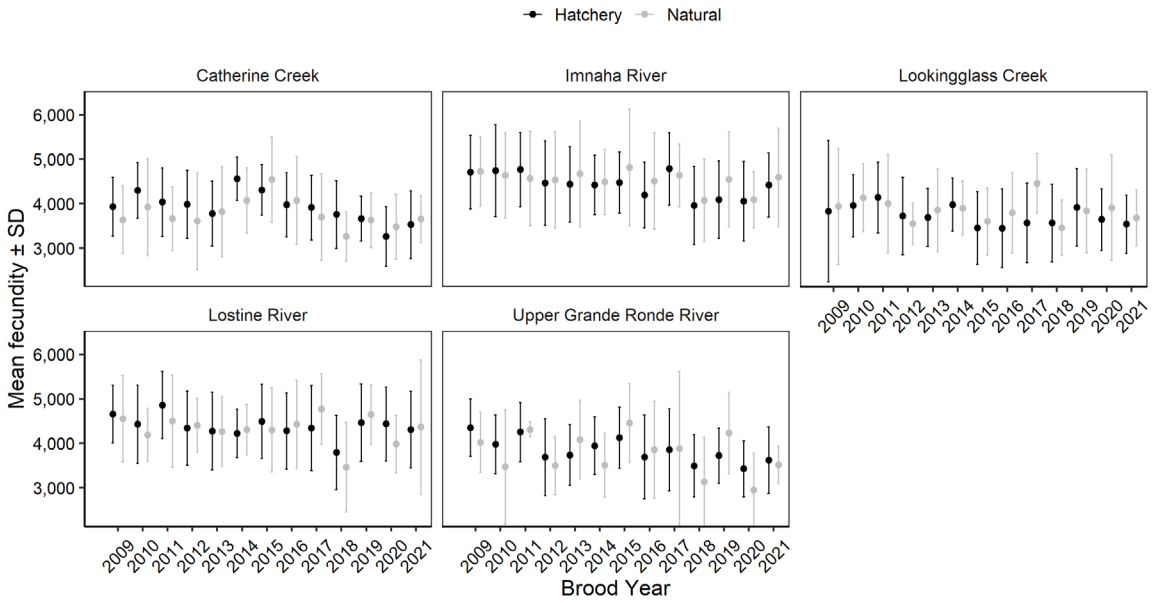

Figure 6.1 Mean fecundity (± 1 SD) for hatchery and natural origin spring Chinook salmon spawned at Lookingglass Fish Hatchery, brood years 2009 to 2021

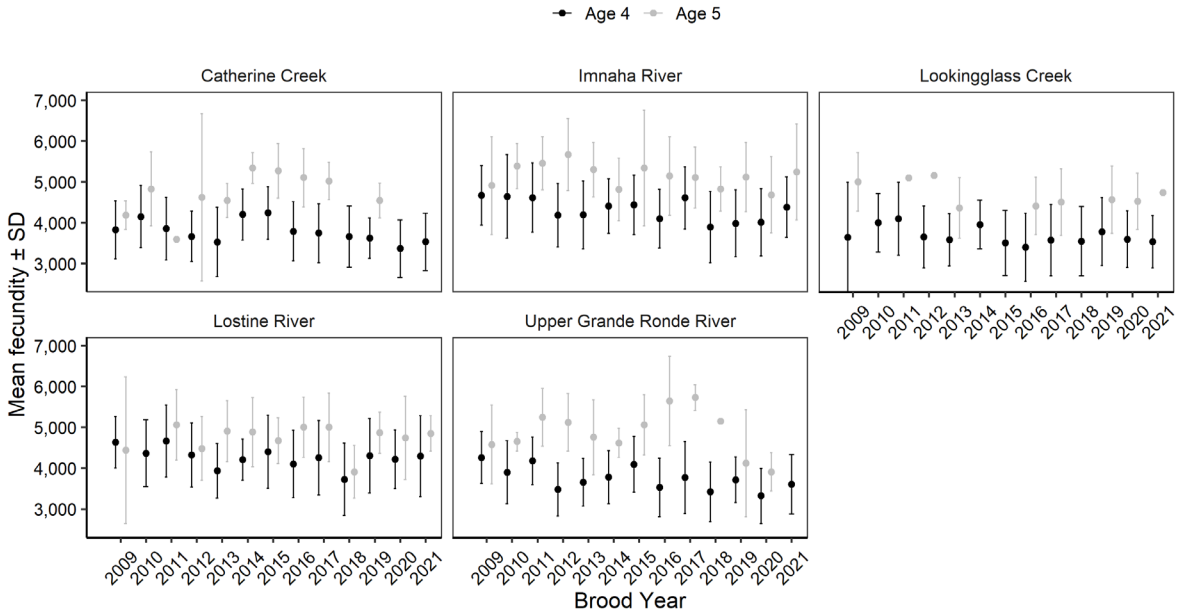

Figure 6.2 Mean fecundity (± 1 SD) for age 4 and age 5 spring Chinook salmon spawned at Lookingglass Fish Hatchery, brood years 2009 to 2021

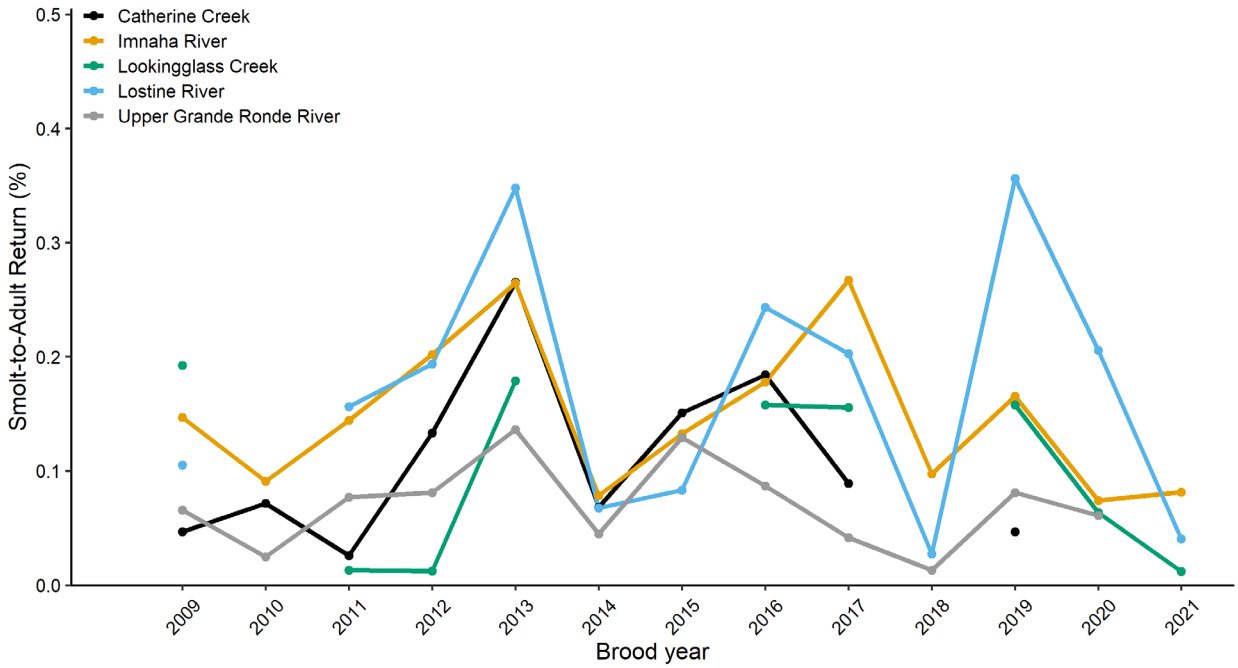

Figure 6.3. Proportion of age 5 females successfully spawned in the Catherine Creek, Imnaha River, Lookingglass creek, Lostine River, and Upper Grande Ronde conventional hatchery programs, brood years 2009-2021.

Green egg-to-smolt

The green egg-to- smolt survival for the conventionally produced spring Chinook salmon at Lookingglass Fish Hatchery is generally above 70% for all the programs (Figure 6.4). The low survival rate for BY 2009 observed in the Catherine Creek, Imnaha, and Lostine River programs is explained by two separate mortality events: 1) there was a fry mortality that resulted from an ice jam at the water intake on 17 December 2009; 2) the water flow to the Canadian rearing troughs was blocked by leaves that clogged the water filters on 3 June 2010 (Feldhaus et al. 2014).

Juvenile Disease Monitoring

The ODFW fish health lab routinely monitors for disease at Lookingglass Fish Hatchery. The monitoring plan and disease treatments are outline in Appendix B of the 2022 Chinook AOP. Fish health screens each female used in broodstock for *R. salmoninarum* the causative agent for bacterial kidney disease (BKD). To reduce the incidence of BKD in Chinook Salmon offspring, the ODFW Fish Health recommends that eggs from female Chinook Salmon with enzyme-linked immunosorbent assay (ELISA) optical density values ≥ 0.2 should be culled.

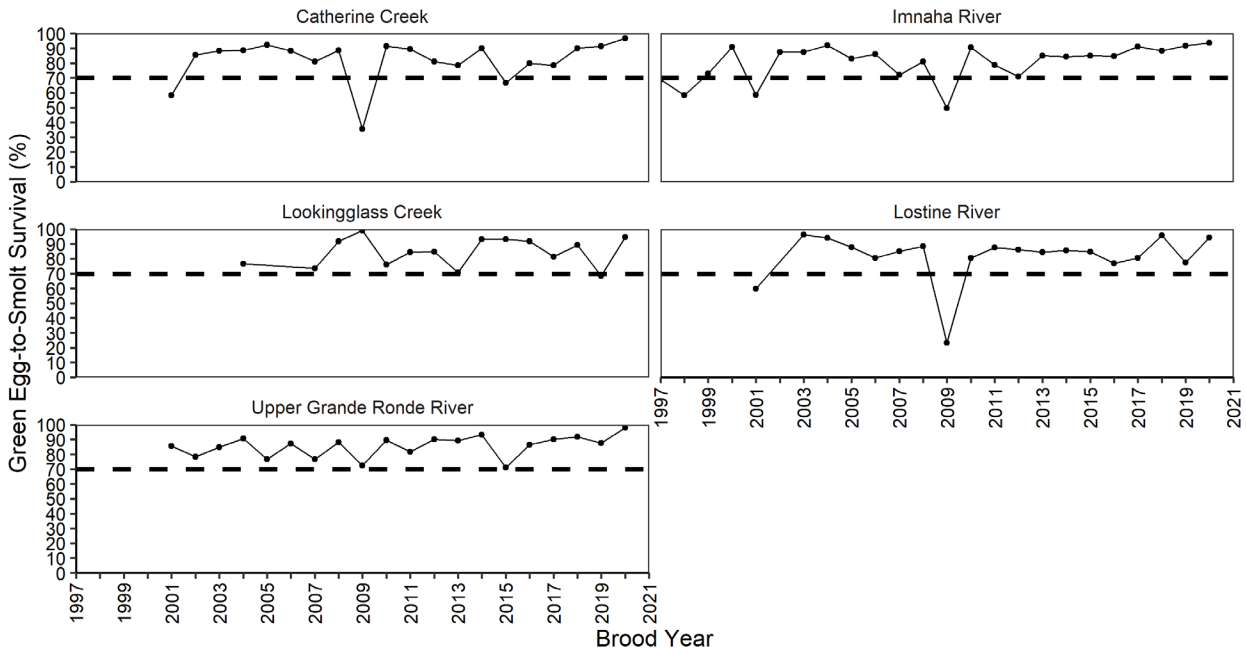

Figure 6.4. Green egg-to-smolt survival rates (%) for conventionally produced spring Chinook salmon at Lookingglass Fish Hatchery, brood years 1997-2021. The dashed line is the green egg-to-smolt survival rate goal of 70%.

Proportion of Natural Origin broodstock

The proportion of natural origin broodstock (pNOB) varies over time between hatchery programs and is influenced by sliding scale management (Table 8.1). For the integrated conventional hatchery programs at Lookingglass Fish hatchery, some males are spawned more than once. Also, pNOB can be calculated including or excluding jacks. For our summaries, we are calculating pNOB to include jacks and we account for males being used multiple times. Designation of hatchery or natural origin is based on the best available information for an individual fish after it was spawned (e.g., presence of a CWT, adipose fin clip, genetic determination, etc).

Across all our hatchery programs, low productivity in nature has created challenges in collecting natural origin broodstock. From 2009 to 2021, pNOB has ranged from 0.09 to 0.77 (Table 8.1; Figure 6.5). From 2009 to 2021, the mean pNOB values for each program were 0.43 for Catherine Creek, 0.29 for the Imnaha River, 0.30 for Lookingglass Creek, 0.31 for the Lostine River, and 0.25 for the Upper Grand Ronde River. Over the last 5 years, the mean pNOB for the Catherine Creek and Imnaha River programs remained ≥ 0.24, the Lostine River maintained pNOB ≥ 0.18, and the Lookingglass and Upper Grande Ronde program pNOB values were ≤ 0.12.

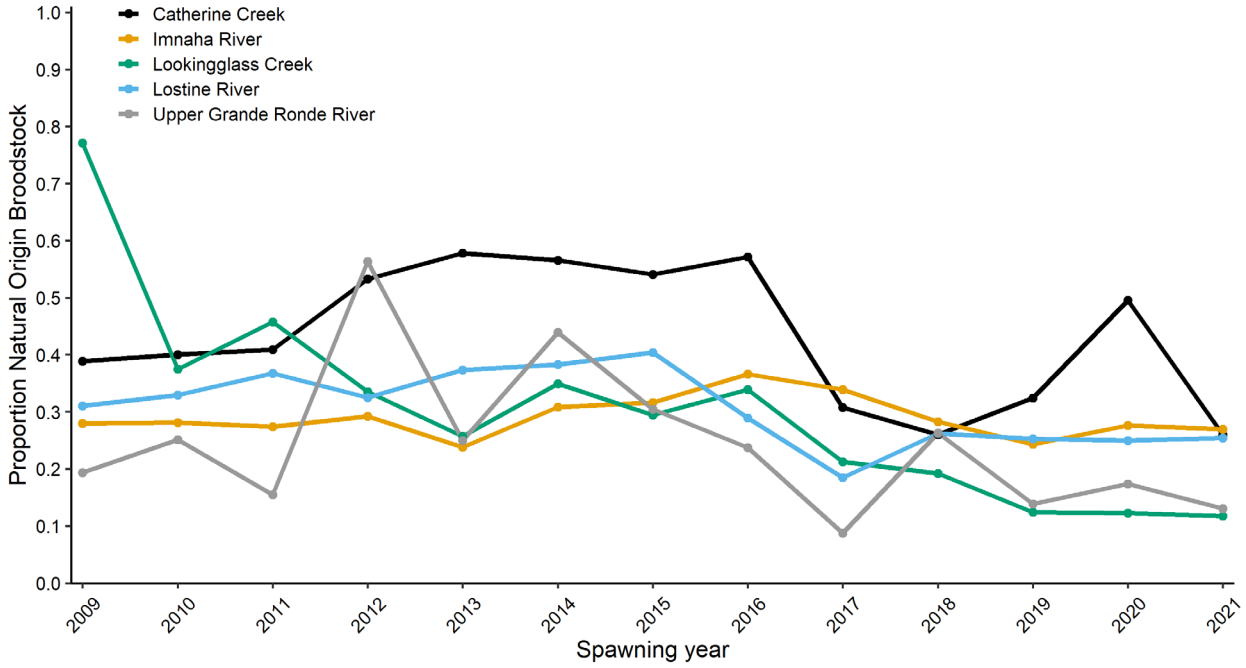

Figure 6.5. Proportion of natural origin broodstock in the Catherine Creek, Imnaha River, Lookingglass creek, Lostine River, and Upper Grande Ronde conventional hatchery programs, brood years 2009-2021.

Proportionate Natural Influence

The 2009 Hatchery Scientific Review (HSRG) proposed that the key to controlling genetic and ecological risks due to straying and fitness loss is to manage hatchery broodstock and natural spawning escapement in a way that allows the natural habitat, not the hatchery, to drive adaptation and productivity (HSRG 2009). Using the HSRG population designations, it was recommended that the Lostine River, Imnaha River, and Catherine Creek programs be designated as Primary populations and that the Lookingglass Creek and Upper Grande Ronde populations would be designated as Stabilizing. For integrated populations, the HSRG indicated that the pNOB should exceed the proportion of hatchery origin spawners in nature (pHOS) by a factor of two, corresponding to a proportionate natural influence of ≥ 0.67. For contributing populations, the recommendation was to maintain PNI ≥0.50. For both Primary and Contributing populations, the recommended pHOS in nature was < 0.3. For stabilizing populations, the HSRG did not develop a PNI criteria. We calculated PNI as PNI= pNOB/(pNOB + pHOSij). As described above, pNOB is based on successful spawners at Lookingglass Fish Hatchery, and accounts for adult males (age 3-5) spawned multiple times. The pHOSij is the estimated proportion of hatchery origin spawners in nature including jacks. For population specific summaries of pHOSij please see the summary for Objective 5 Figure 10.2 in this document.

For the 2009 to 2021 spawning years (i.e., brood years), the PNI goal of ≥ 0.67 for Primary populations has never been met for the Catherine Creek, Imnaha River, or Lostine river populations (Figure 6.6, Tables 8.2 and 8.3). Catherine Creek has exceeded the PNI criteria ≥ 0.5 for a Contributing population six times in the last 13 years. Lookingglass exceeded the criteria for a Contributing population one time, in 2009. Over the last 5 years (2017-2021), the mean PNI values were 0.33 (range =0.26 to 0.54), 0.29 (range = 0.24-0.35), 0.16 (range= 0.13 to 0.21),

0.25 (range = 0.21 to 0.27), and 0.18 (range = 0.10 to 0.27), for Catherine C reek, the Imnaha River, Lookingglass Creek, the Lostine River, and Upper Grande Ronde River, respectively.

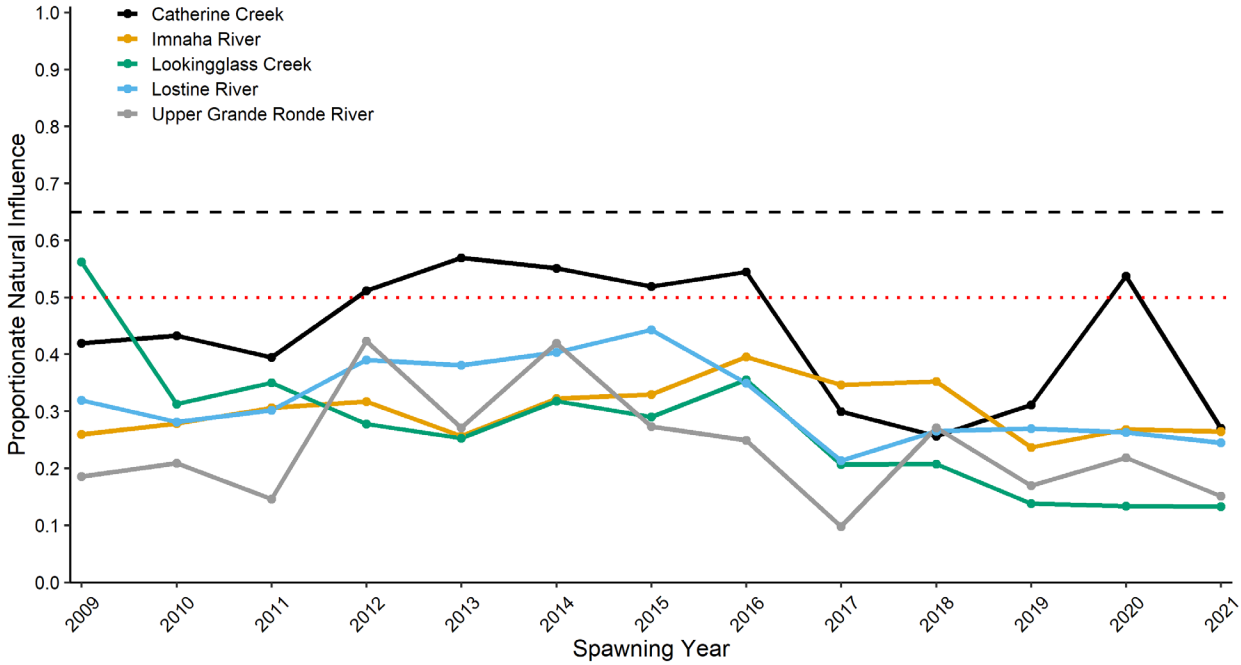

Figure 6.6. Proportionate natural influence (PNI) for the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde River populations, return years (spawning year) 2009 to 2021. The HSRG recommendations maintaining PNI ≥ 0.67 (black dashed line) for Primary populations and >0.5 (red dashed line) for Contributing populations.

Table 8.2. Vital statistics for natural spawning spring-summer Chinook salmon in the Imnaha River. pNOB = proportion natural origin broodstock including jacks; pHOSij= proportion hatchery origin spawners in nature including jacks; pNI = proportionate natural influence.

Year	pNOB	pHOSij	pNI
2009	0.28	0.80	0.26
2010	0.28	0.73	0.28
2011	0.27	0.62	0.31
2012	0.29	0.63	0.32
2013	0.24	0.69	0.26
2014	0.31	0.65	0.32
2015	0.32	0.64	0.33
2016	0.37	0.56	0.40
2017	0.34	0.64	0.35
2018	0.28	0.52	0.35
2019	0.24	0.78	0.24
2020	0.28	0.75	0.27
2021	0.27	0.75	0.26

Table 8.3. Vital statistics for natural spawning spring Chinook salmon in Catherine Creek, Lookingglass Creek, the Lostine River, and Upper Grande Ronde River. pNOB = proportion natural origin conventional broodstock including jacks; pHOSij= proportion hatchery origin spawners in nature including jacks; pNI = proportion natural influence. NA = not applicable. Note: vital statistic for Lookingglass Creek were only applied to the time period after the reintroduction of the Catherine Creek stock into Lookingglass Creek..

	Catherine Creek			Lookingglass Creek			Lostine River			Upper Grande Ronde R.		
Year	pNOB	pHOSij	pNI	pNOB	pNOSij	pNI	pNOB	pNOSij	pNI	pNOB	pNOSij	pNI
2009	0.39	0.54	0.42	0.77	0.60	0.56	0.31	0.66	0.32	0.19	0.85	0.19
2010	0.40	0.52	0.43	0.37	0.82	0.31	0.33	0.84	0.28	0.25	0.95	0.21
2011	0.41	0.63	0.39	0.46	0.85	0.35	0.37	0.85	0.30	0.15	0.90	0.15
2012	0.53	0.51	0.51	0.34	0.87	0.28	0.32	0.51	0.39	0.56	0.77	0.42
2013	0.58	0.44	0.57	0.26	0.76	0.25	0.37	0.61	0.38	0.25	0.67	0.27
2014	0.57	0.46	0.55	0.35	0.75	0.32	0.38	0.57	0.40	0.44	0.61	0.42
2015	0.54	0.50	0.52	0.29	0.72	0.29	0.40	0.51	0.44	0.30	0.81	0.27
2016	0.57	0.48	0.54	0.34	0.62	0.35	0.29	0.54	0.35	0.24	0.72	0.25
2017	0.31	0.72	0.30	0.21	0.82	0.21	0.18	0.68	0.21	0.09	0.81	0.10
2018	0.26	0.76	0.26	0.19	0.73	0.21	0.26	0.73	0.27	0.26	0.71	0.27
2019	0.32	0.72	0.31	0.12	0.78	0.14	0.25	0.69	0.27	0.14	0.68	0.17
2020	0.50	0.43	0.54	0.12	0.79	0.13	0.25	0.70	0.26	0.17	0.62	0.22
2021	0.26	0.70	0.27	0.12	0.77	0.13	0.25	0.78	0.24	0.13	0.73	0.15

Objective 2. Determine optimum rearing and release strategies

Smolt release goals

Long-term juvenile production goals for the Grande Ronde Basin remained at 150,000 smolts per year for Catherine Creek and 250,000 smolts per year for each of the Lookingglass Creek, Upper Grande Ronde River, and Lostine River populations (Table 3). Co-managers for the Grande Ronde and Imnaha programs use a ± 10% threshold to evaluate smolt release goals. The Catherine Creek smolt release goal was originally established at 250,000 and then changed in 2006 when co-managers agreed to reduce the goal to 150,000 and shift production to increase releases into Lookingglass Creek.

After shifting Grande Ronde basin hatchery production to endemic stocks in the late 1990s, it took several years to consistently meet smolt release goals (Figure 7.1). Prior to BY 2010, smolt production for the Catherine Creek, the Lostine River, and the Upper Grande Ronde programs utilized both the captive broodstock and conventional program. Even with two programs, smolt release goals (± 10%) prior to BY 2010 were only achieved in three of 12 years in Catherine Creek, four of twelve years in the Upper Grande Ronde, and six of 13 years in the Lostine River (Figure 7.1). The last captive smolts were released into the Upper Grande Ronde in 2013 (BY 2010). Smolts from the Catherine Creek captive program, a local Grande Ronde Basin stock, were used to begin a reintroduction program in Lookingglass Creek. From BYs 2010-2020, smolt release goals have been met or exceeded in nine of 11 BYs for Catherine Creek, eight of 11 years in the Upper Grande Ronde, and met 100% of the time in the Lostine River. In Lookingglass creek, smolt releases have been more variable with goals met or exceeded in eight of the last 16 years.

Prior to adopting an interim goal of 360,000 in 2000, the smolt release goal of 490,000 smolts into the Imnaha River was only achieved once in BY 1993 (Figure 7.2). Between BYs 2000 and 2009, the interim smolt release goals of 360,000 was met (± 10%) or exceeded in six of 10 years. The interim smolt release goal of 420,000 was met once between 2011 and 2013, and the goal of 490,000 has been met or exceeded in six of the last seven years. In part, failure to consistently meet smolt release goals has been attributed to the challenges faced by this program in operating the Imnaha weir to collect broodstock (see section on Weirs for more details).

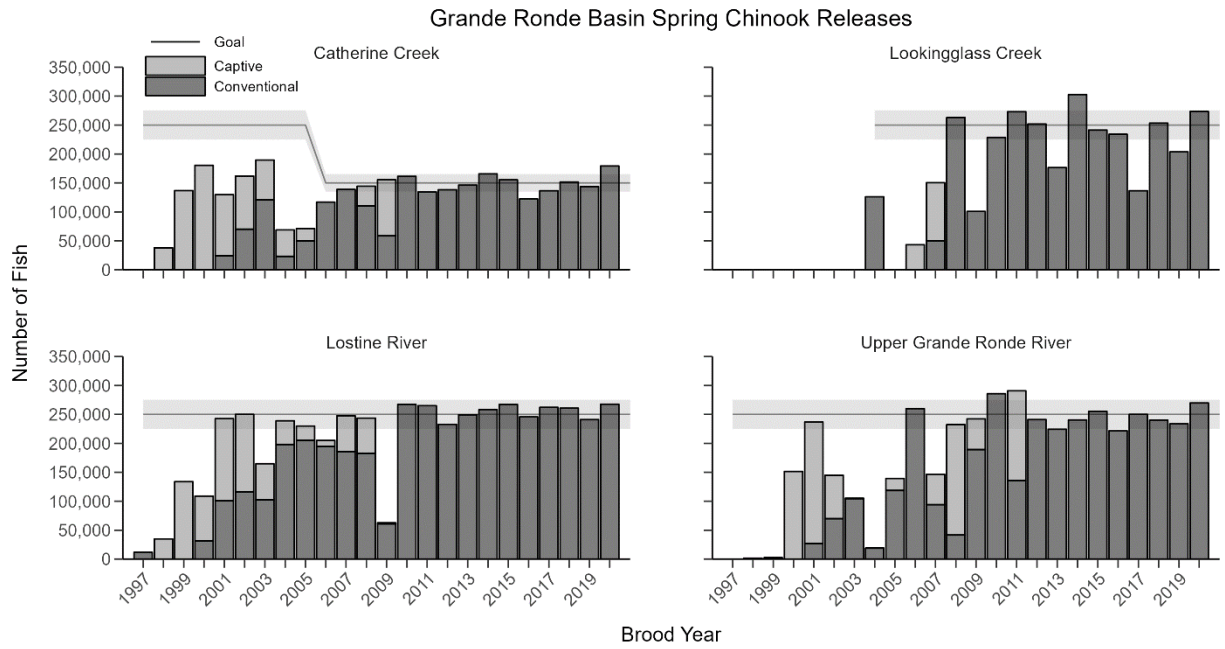

Figure 7.1. Chinook salmon hatchery smolt releases in Catherine Creek, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River compared to smolt release goals, 1997-2020 brood years. The shaded region around the smolt goal is ± 10%.

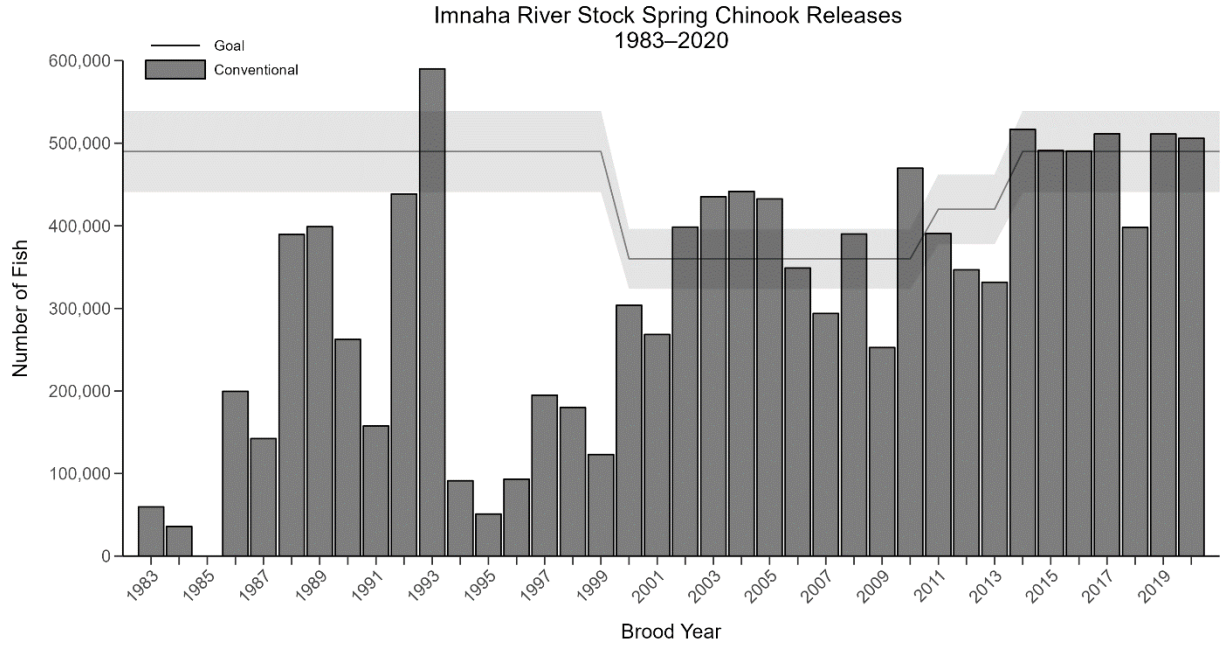

Figure 7.2. Chinook salmon hatchery smolt releases in the Imnaha River, 1983-2020 brood years. The shaded region around the smolt goal is ± 10%. The smolt release goal for the Imnaha program is 490,000 (BYs 1983-1999 and 2014-present) with interim smolt release goals of 360,000 (BYs 2000-2010), and 420,000 (BYs 2011-2013).

Smolt release strategies

The release size goal for all smolt reared at Lookingglass Fish Hatchery is 20-25 fish/lb (i.e., 18-23 g). This release size goal was established after early evaluations in the 1990's of large (30–38 g [12–15 fish/lb]) and small (18–23 g [20–25 fish/lb]) Imnaha program smolt releases found no differences in juvenile survival rates to Lower Granite Dam (LGD), or smolt-to-adult survival (SAS), smolt-to-adult return (SAR), or stray rates (Feldhaus et al. 2016).

After rearing at Lookingglass Fish Hatchery, smolts are transported to juvenile acclimation facilities on Catherine Creek, the Upper Grande Ronde, Lostine River, and Imnaha River in late March or early April (see Table 3 in the 2022 Chinook AOP). For a more complete overview of the juvenile facilities on Catherine Creek and the Upper Grande Ronde please see BPA project #199800703 (Figures 2 and 3 in 199800703). The juvenile acclimation facilities on the Upper Grande Ronde River and the Lostine River are not large enough to acclimate 250,000 smolts at one time, so there are two different periods of acclimation and release (see Table 3 in the 2022 Chinook AOP). Although two different acclimation periods were previously utilized in Catherine Creek at the beginning of the supplementation period, for the last 10 years there has been a single acclimation period. Smolts reared for Lookingglass Creek are released directly from the hatchery facility at rkm 3.7. Up until BY 2018 (smolt migration year 2020), it was typical to volitionally release smolts from Lookingglass Fish Hatchery starting April 1st and force the remainder out around April 15th.

During smolt acclimation, managers have utilized a combination of acclimation of several days or weeks followed by either volitional or forced releases (Figures 7.3–7.7 showing release timing). Starting with release year 2018 (BY2016) in the Lostine River, managers switched to force-out only releases (Figure 7.5) to provide flexibility to adjust release dates and provide downstream screw trap operators increased predictability of when large numbers of hatchery fish were going to arrive. A similar shift from acclimated to direct releases also occurred starting with release year 2019 (BY 2017) on Catherine Creek and the Upper Grande Ronde (Figure 7.3 and 7.4) and release year 2020 (BY 2018) on the Imnaha River (Figure 7.6) and Lookingglass Creek (Figure 7.7).

Beginning with BY2010, managers have relied on a combination of acclimation and direct stream releases for Imnaha River hatchery smolts. Prior to BY2010, smolts were generally only direct stream released when they were sick, and managers did not desire to acclimate the sick fish in the Imnaha acclimation pond with healthy fish. In general, about 280,000 smolts are acclimated and the remainder (210,000) are direct stream releases. We evaluated the acclimated and direct stream releases from BY 2010-2014. Results from this evaluation did not find any significant difference in juvenile survival to LGD or in SAS, SAR, or stray rates (ODFW, unpublished data, Joseph Feldhaus, personal communication).

This decision to shift to forced releases was made for several reasons. First, prior analysis of juvenile survival from release sites to Lower Granite Dam suggested minimal post-release performance between smolts that were volitionally released or forced out at the end of acclimation (ODFW and NPT, unpublished data). Secondly, except for smolts released directly into Lookingglass Creek, hatchery smolt releases into the Catherine Creek, the Upper Grande Ronde River, Lostine River, and Imnaha River all occur above rotary screw traps used to monitor naturally produced emigrants (see BPA project #s 199202604 and 199701501). One objective of hatchery smolt releases is to mimic the emigration timing of natural smolts. In a few instances, the unpredictability of smolt emigration has resulted in mortality events at rotary screw traps which subsequently caused the screw trap operations to be stopped, preventing

monitoring of the natural population. Another consideration is that with recently flatlined budgets, we are beginning to lack the required resources for extended hours operating screw traps during volitional hatchery releases and the predictability of hatchery releases has been beneficial. Finally, managers also want to manipulate time smolt arrival at Lower Granite Dam to coincide with barging so that smolts can benefit from the potential survival advantages of barging vs run of the river.

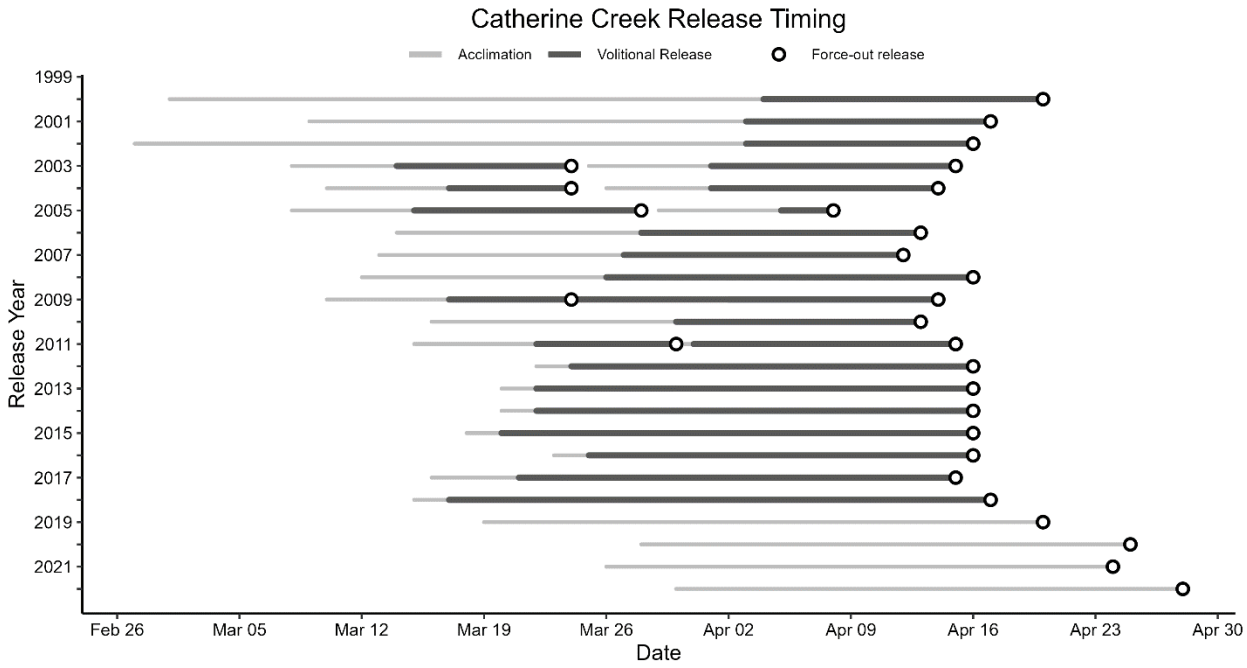

Figure 7.3. Catherine Creek acclimation site Chinook smolt release strategies and timing, smolt release years 2000-2022.

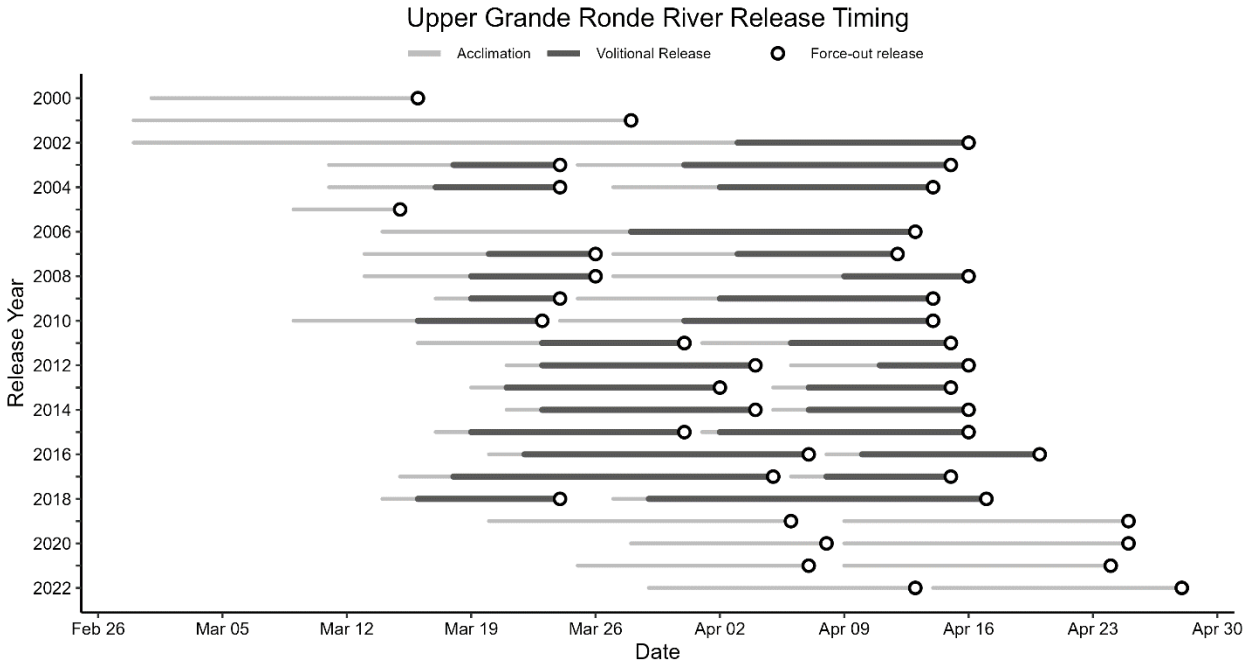

Figure 7.4. Upper Grande Ronde River acclimation site Chinook smolt release strategies and timing, smolt release years 2000-2022.

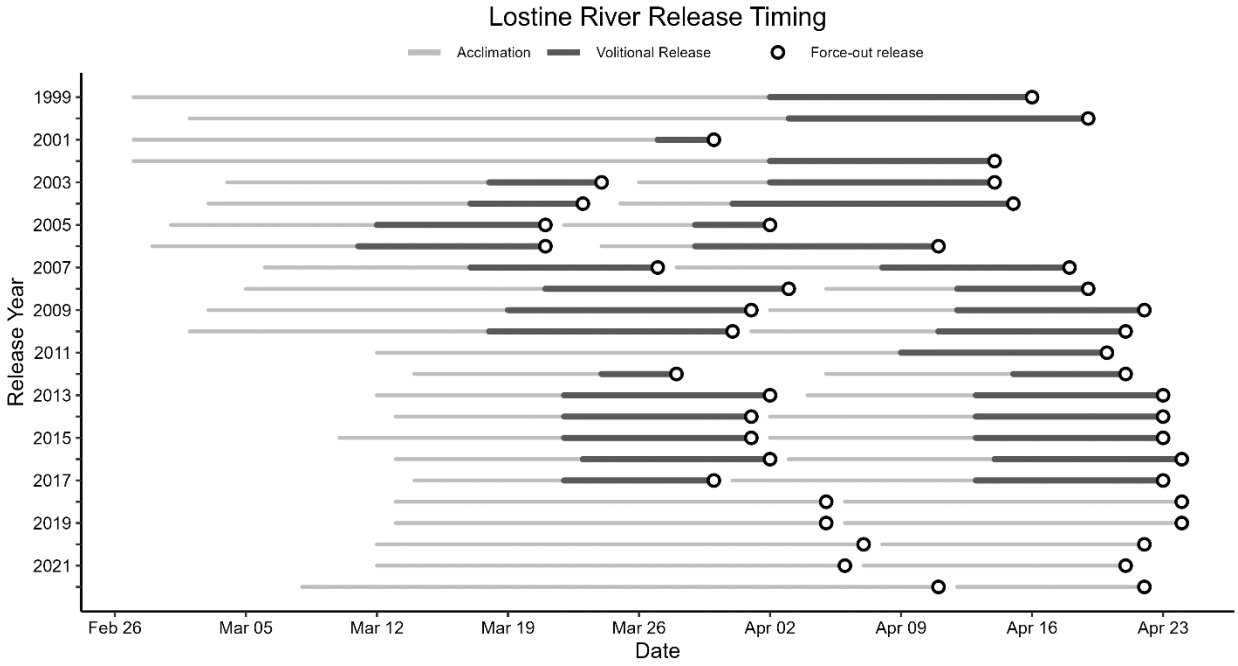

Figure 7.5. Lostine River acclimation site Chinook smolt release strategies and timing, smolt release years 1999-2022.

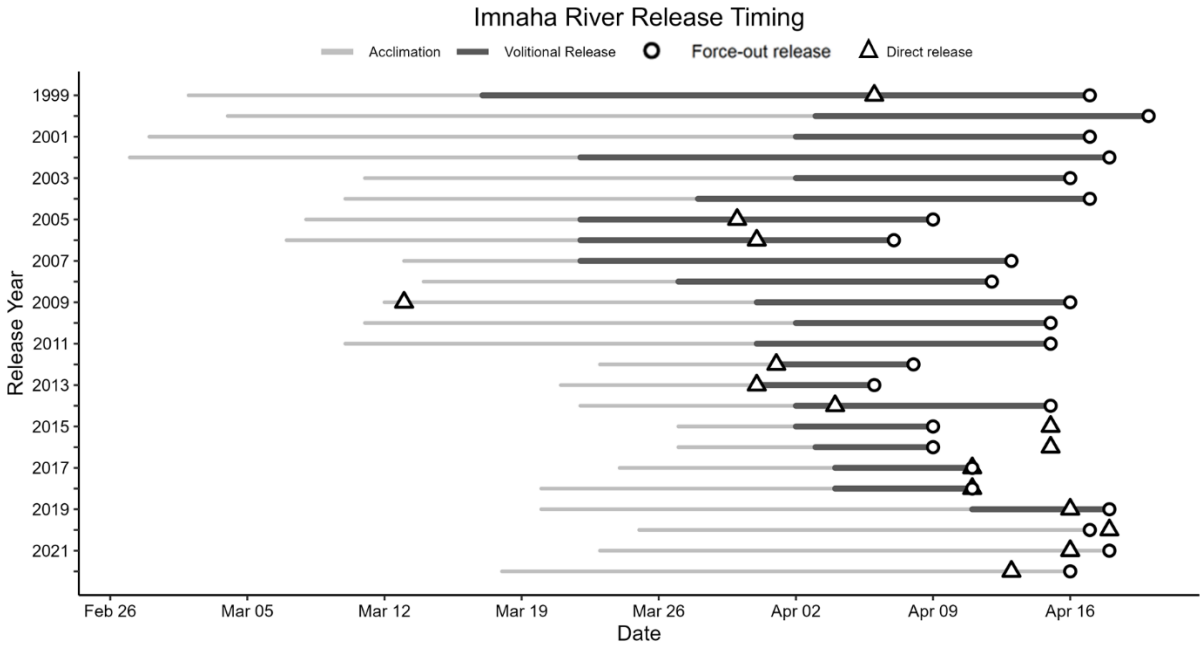

Figure 7.6. Imnaha river acclimation site Chinook smolt release strategies and timing, smolt release years 1999-2022.

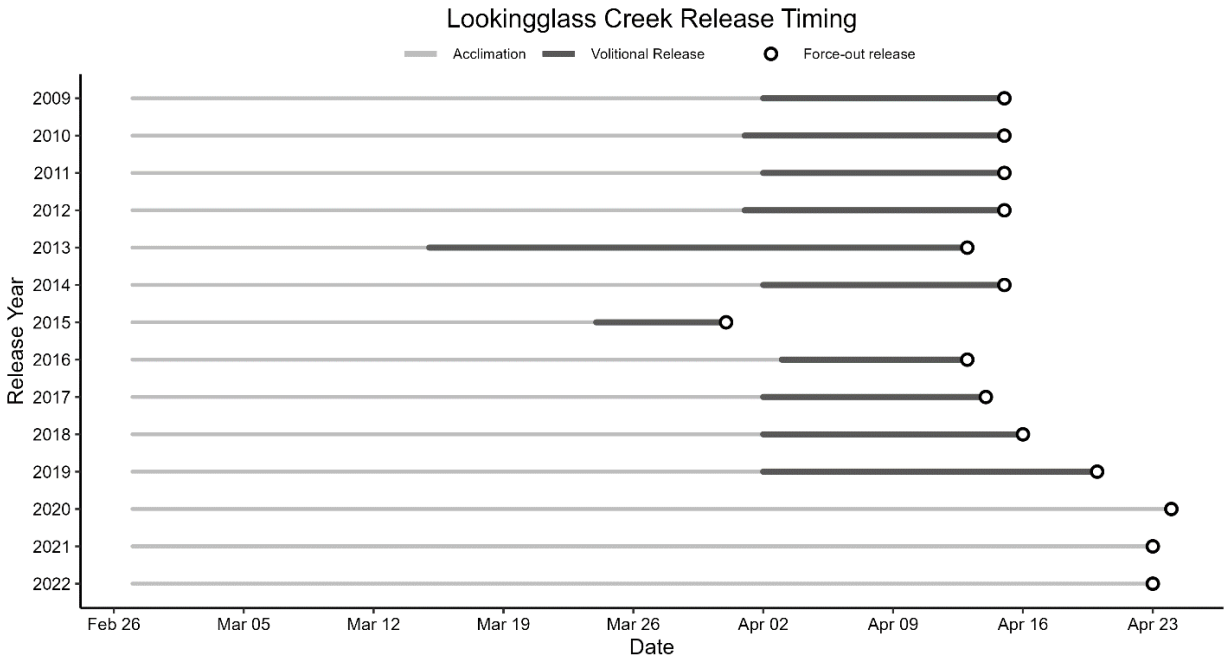

Figure 7.7. Imnaha river acclimation site Chinook smolt release strategies and timing, smolt release years 1999-2022.

Juvenile survival to Lower Granite Dam

Annually, 55,000 hatchery smolts are PIT tagged at Lookingglass Fish Hatchery in October, 5-6 months prior to release (2022 Chinook AOP). We use the PIT-tagged hatchery smolts for each release to determine apparent survival from the release site to Lower Granite Dam (LGD) using a Cormack-Jolly-Seber model for each hatchery smolt release group (Figure 7.8). In general, the survival of hatchery smolts released into the Imnaha River and Lookingglass creek is ≥ 65%. For smolts released from BYs 2009-2016 from the conventional program production, the mean survival rates to LGD were 31%, 42%, and 60% for Catherine Creek, Upper Grande Ronde, and Lostine River releases, respectively. The overall patterns in mean juvenile survival to Lower Granite Dam for the natural origin spring migrants from populations in Catherine Creek (39%), the Upper Grande Ronde (42%), and the Lostine River (62%) show a similar pattern to that observed in the spring hatchery releases (Figure 7.9).

Over the program history, for both captive and conventional smolt production, juvenile survival from release to LGD for smolts released in late April is significantly greater than for the early March smolt releases into Catherine Creek, the Upper Grande Ronde, and Lostine River (P <0.01, R^2 >0.38; Figure 7.10). The date of first release is not a significant predictor of juvenile survival to LGD from Lookingglass Creek (P = 0.43, R^2 = 0.04) or the Imnaha River (P = 0.12, R^2 = 0.05).

Figure 7.8. Mean apparent survival of PIT-tagged hatchery juvenile Chinook salmon produced from conventional program production released into Catherine Creek, the Imnaha River, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River.

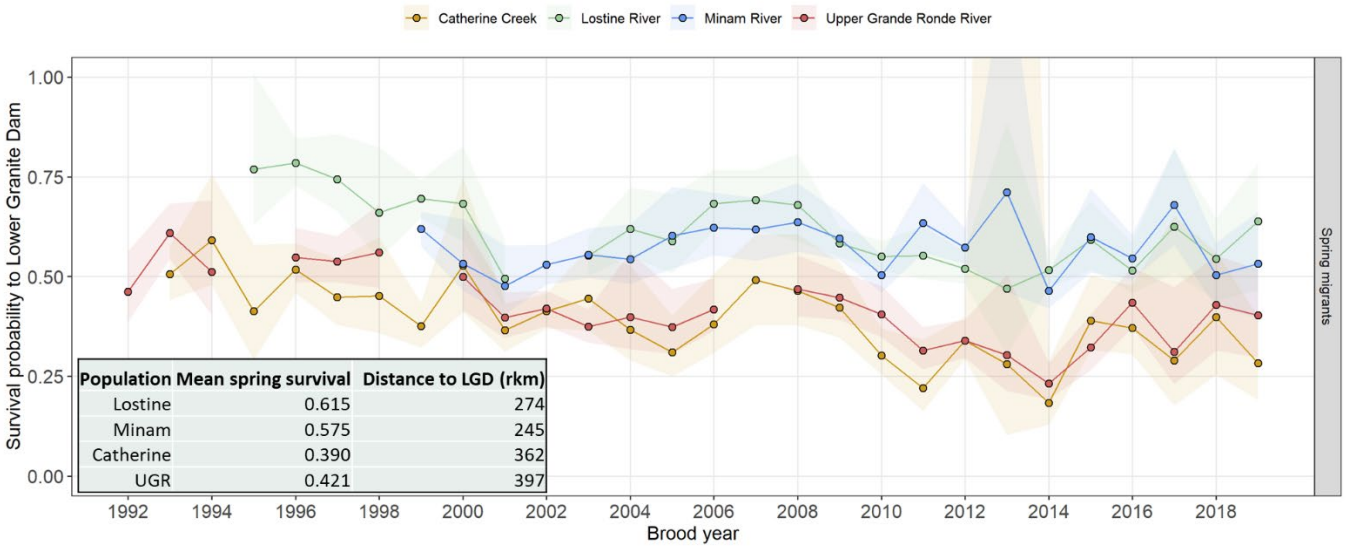

Figure 7.9. Mean apparent survival probability (± 95% CI) for naturally produced spring migrants emigrating from the Lostine River, Minam River, Catherine creek, and the Upper Grande Ronde River (UGR), brood years 1992-2018.

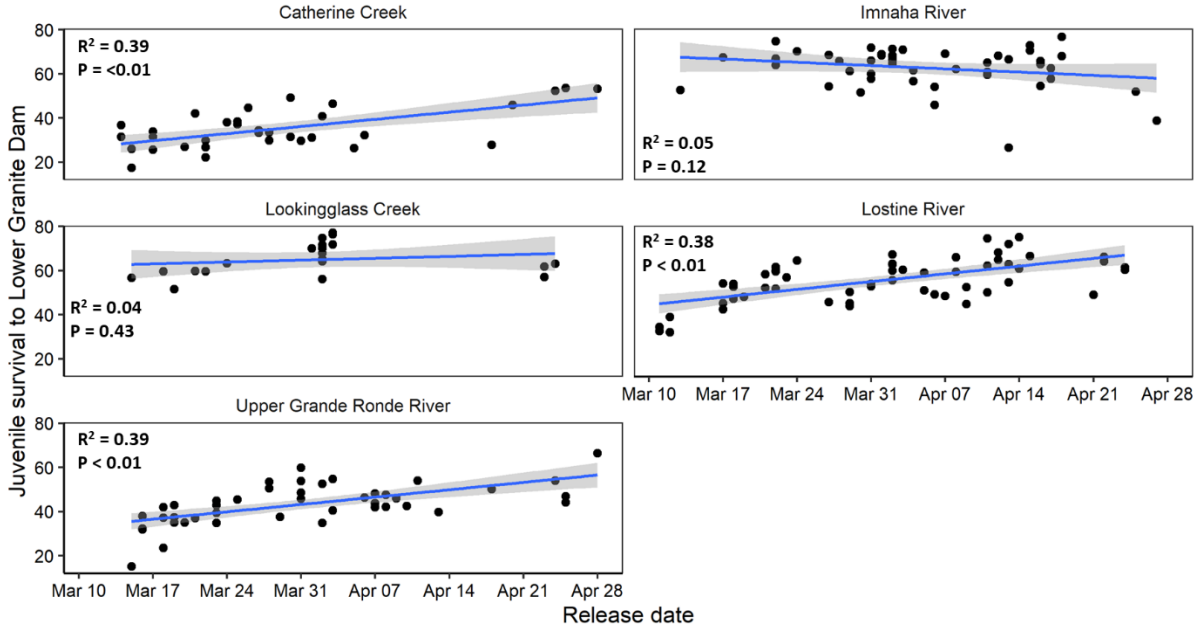

Figure 7.10. Release date compared to estimated juvenile survival rate (%) to Lower Granite Dam for captive and conventional smolts released into Catherine Creek and the Upper Grande Ronde River (BYs 1998-2020, the Imnaha River (BY 1991-2020), the Lostine River (BY 1997-2020), and Lookingglass Creek (BYs 2002-2004, 2006-2020). For volitional releases, release date is the first release date. The shaded area around the linear regression line is a 95% confidence interval.

Objective 3. Determine total catch and escapement, smolt survival, smolt-to-adult survival, and assess if adult production meets mitigation goals.

Escapement estimation for Catherine Creek, the Imnaha River, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde is comprised of several components. First, tributary escapement above each weir is derived using a Lincoln-Peterson mark-recapture estimate. At each weir, every adult passed upstream of a weir is marked by punching a hole in either the left or right opercular plate with a hole punch (see 2022 Chinook AOP). On the Chinook spawning ground surveys, surveyors examine each carcass to record the presence or absence of the operculum mark. For each river, the known number of fish passed upstream (M), the number of OP marked carcasses (R) and the number of carcasses found without an OP mark are used to estimate the number of salmon above the weir.

Secondly, below weir salmon population estimates for each population are estimated by using an annual fish/redd estimate multiplied by the total number of redds found below each weir. The above weir fish/redd estimate is derived from the above weir population estimate divided by the above weir redd count. Total return to each river is the sum of the above weir estimate, the number of fish removed at each weir (e.g., broodstock, foodbank), the number of fish spawning below each weir, and the estimated number of fish harvested in sport and tribal fisheries.

We use CWT recoveries and estimated recovery rates from the Pacific State RMIS database to estimate harvest and stray rates above and below Lower Granite Dam (LGD). Therefore, estimated returns to the compensation area are the sum of the above weir tributary estimates and the CWT derived estimates for salmon recovered above LGD but outside the Grande Ronde and Imnaha basins. The total adult returns over LGD are used to define the smolt-to-adult return (SAR) rate. Total adult production is the estimated compensation return plus the CWT derived stray and harvest rates below LGD, and ocean harvest. Therefore, the estimated total adult production is used to define the smolt-to-adult survival (SAS) rate. For both SAR and SAR calculations, we use the number of hatchery smolts released into each population.

Catch and Escapement

Over the last 10 completed brood (2007-2016), ocean harvest was less than 1% of the overall adult production for any individual program (Table 9.1). On average, 13.3% of the total adult production estimated from CWT recoveries is accounted for in Columbia River tribal, commercial, and sport fisheries. Recoveries of stray Chinook salmon from these programs outside of the mainstem Columbia and Snake River fisheries below LGD is rare and typically represents less than 1% of the overall production. On average, 80% of the total adult production is accounted for in the terminal populations (i.e., escapement to river). Our CWT based recoveries suggest that above LGD, an average of 2% of the Imnaha river program production is recovered outside of the Imnaha Basin. Within the Grande Ronde basin programs, the average recovery rate above LGD but outside the Grande Ronde Basin is 9%, 11,7%, 6.2%, and 2.8% for the Catherine Creek, Upper Grande Ronde, Lookingglass, and Lostine River programs.

Table 9.1. Catch and escarpment distribution (%) of Catherine Creek, Upper Grande Ronde, Imnaha River, Lookingglass, and Lostine River spring and summer Chinook salmon, brood years 2007-2016.

Recovery Location Percent of total	Brood Year										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
Catherine Creek											
Ocean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.2
Columbia River											
Tribal Net	5.9	0.9	0.0	1.5	3.0	6.8	0.3	0.4	0.0	0.0	1.9
Commercial	3.4	1.1	2.1	2.4	2.2	2.4	1.4	0.4	0.0	0.0	1.5
Sport	5.8	10.5	7.0	6.7	3.2	8.0	25.5	13.2	0.0	0.0	8.0
Snake River											
Stray below LGD	0.2	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Stray-above LGD	10.2	6.9	5.7	9.4	2.7	15.3	5.6	4.9	8.4	2.0	7.1
Sport	0.2	3.7	2.6	3.0	2.0	0.7	0.0	3.0	1.2	2.5	1.9
Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Escapement to River	74.2	76.8	82.0	77.0	86.8	66.7	67.1	78.1	88.5	95.4	79.3
Upper Grande Ronde											
Ocean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.1
Columbia River											
Tribal Net	6.5	1.7	0.1	3.6	4.2	0.9	12.0	0.0	0.0	0.0	2.9
Commercial	0.6	2.2	0.0	2.9	0.8	4.8	0.0	1.2	1.4	0.0	1.4
Sport	2.8	11.3	1.4	5.1	4.0	13.0	6.8	11.1	6.2	0.0	6.2
Snake River											
Stray below LGD	0.0	0.2	0.0	0.1	0.0	0.3	0.0	0.0	0.9	0.0	0.2
Stray-above LGD	4.2	6.2	14.0	6.4	6.0	23.3	20.0	15.2	3.8	0.4	9.9
Sport	0.0	1.7	0.9	1.7	0.0	0.6	1.8	4.3	4.7	2.2	1.8
Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Escapement to River	85.8	76.6	83.5	80.3	85.1	57.1	59.3	67.1	83.0	97.4	77.5
Imnaha River											
Ocean	0.1	0.2	0.0	0.0	0.3	0.2	0.4	1.3	0.5	0.2	0.3
Columbia River											
Tribal Net	14.2	6.1	2.6	9.8	19.6	9.0	6.1	0.3	1.7	0.0	6.9
Commercial	3.5	0.8	3.0	2.1	4.2	2.6	0.4	0.3	0.0	0.0	1.7
Sport	11.9	19.9	8.4	9.9	8.3	8.1	5.9	6.7	0.7	0.0	8.0
Snake River											
Stray below LGD	0.4	0.1	1.5	0.5	0.7	0.6	0.0	0.6	0.0	0.0	0.4
Stray-above LGD	0.0	0.3	0.1	0.2	0.0	0.0	0.1	0.0	6.5	0.0	0.7
Sport	0.0	0.0	3.7	1.6	0.9	0.3	0.2	2.9	0.4	0.2	1.0
Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ocean	69.9	72.5	80.8	76.0	66.0	79.3	86.9	87.9	90.2	99.7	80.9

Recovery Location Percent of total	Brood Year										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
Lookingglass Creek											
Ocean	0.0	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Columbia River											
Tribal Net	4.3	3.7	2.0	4.5	4.1	5.5	0.0	0.0	0.0	0.0	2.4
Commercial	1.7	2.3	2.1	2.2	2.4	3.4	1.1	0.2	0.0	0.0	1.5
Sport	5.4	10.1	6.4	9.5	14.6	9.9	11.0	13.8	8.9	0.0	9.0
Snake River											
Stray below LGD	0.1	0.9	1.2	0.1	0.0	0.3	0.0	0.2	0.0	0.4	0.3
Stray-above LGD	18.2	0.5	9.4	7.4	1.5	3.3	2.2	6.9	0.6	0.6	5.0
Sport	1.4	2.7	0.0	0.7	0.2	1.3	0.0	2.7	0.0	1.2	1.0
Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Escapement to River	69.0	79.2	78.5	75.4	77.2	76.3	85.7	76.3	90.6	97.8	80.6
Lostine River											
Ocean	0.3	0.4	0.0	0.8	0.5	0.4	3.8	0.0	0.4	0.2	0.7
Columbia River											
Tribal Net	9.8	4.9	0.8	12.4	23.1	8.6	0.0	3.5	2.4	0.0	6.5
Commercial	1.6	0.7	0.8	1.0	4.4	2.7	0.0	0.2	0.0	0.0	1.1
Sport	7.4	9.6	0.0	8.0	13.0	7.1	4.4	8.8	3.8	0.0	6.2
Snake River											
Stray below LGD	0.4	0.4	0.4	0.9	0.2	0.5	1.1	0.3	0.6	0.2	0.5
Stray-above LGD	1.3	3.5	9.8	0.9	3.3	1.6	2.8	0.2	0.0	0.0	2.3
Sport	0.1	0.0	0.0	1.8	0.1	0.0	0.0	2.1	0.4	0.0	0.4
Tribal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Escapement to River	79.2	80.4	88.2	74.1	55.5	79.0	87.9	84.8	92.3	99.6	82.1

Total adult production and smolt-to-adult survival rates

Hatchery adult returns have never achieved the LSRCP total catch and escapement production goals of 29,100 Grande Ronde Basin spring Chinook and 16,050 Imnaha Basin spring-summer Chinook salmon (Figure 8.1) or the smolt-to-adult survival (SAS) rate goal of 3.25% (Figure 8.2, Figure 8.3). For completed BYs 2000-2016, the highest mean SAS rate for the conventional production programs was 0.93% for the Lostine River and the lowest was 0.49% for Catherine Creek. For this same period, mean SAS rates were 0.91%, 0.61%, and 0.53% for the Imnaha River, Lookingglass Creek, and Upper Grande Ronde programs, respectively. The mean SAS rates for the conventional program production are generally higher than the captive program (Figure 8.3).

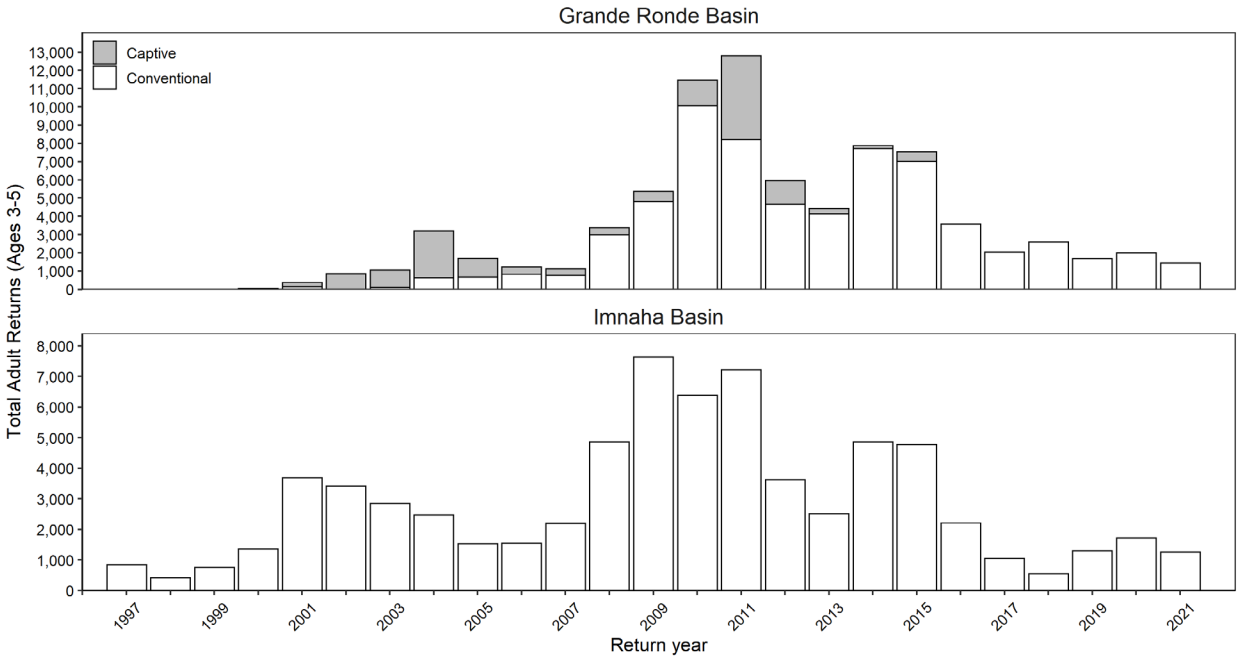

Figure 8.1. Total adult production compared to the LSRCP mitigation goals of 16,050 and 29,100 returns produced from Grande Ronde and Imnaha basin Chinook salmon, respectively.

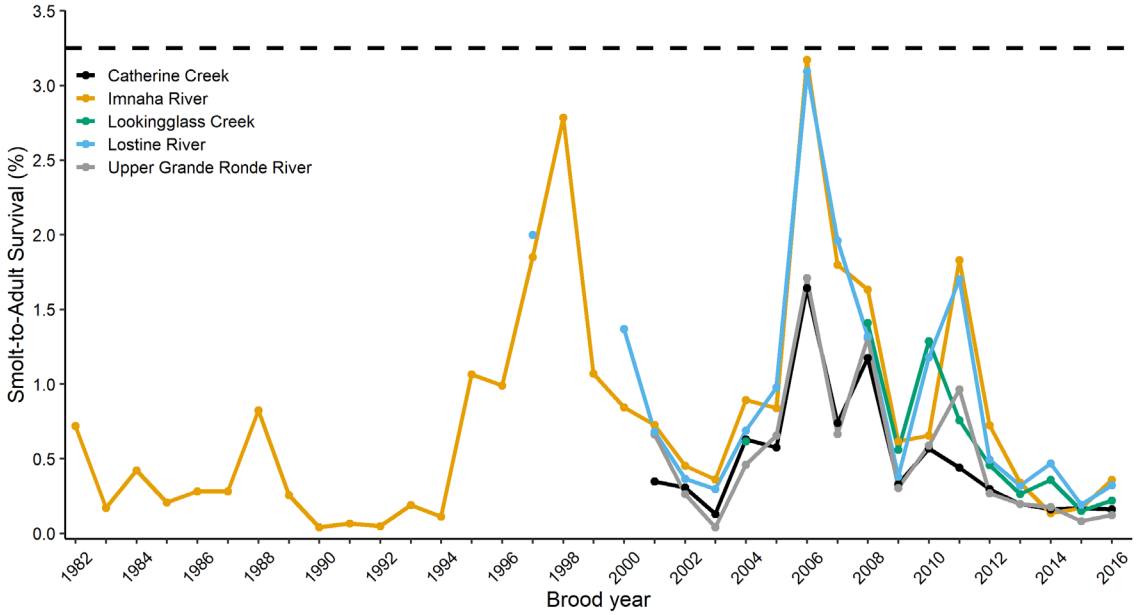

Figure 8.2. Smolt-to-adult survival (SAR) rates for conventional hatchery smolt production compared to the LSRCP compensation smolt-to-adult survival goal (i.e., 4:1 catch to escapement ratio) of 3.25% for endemic Catherine Creek, Imnaha River, Lookingglass Creek (note: limited to reintroduction with Catherine Creek stock), Lostine River, and Upper Grande Ronde River populations.

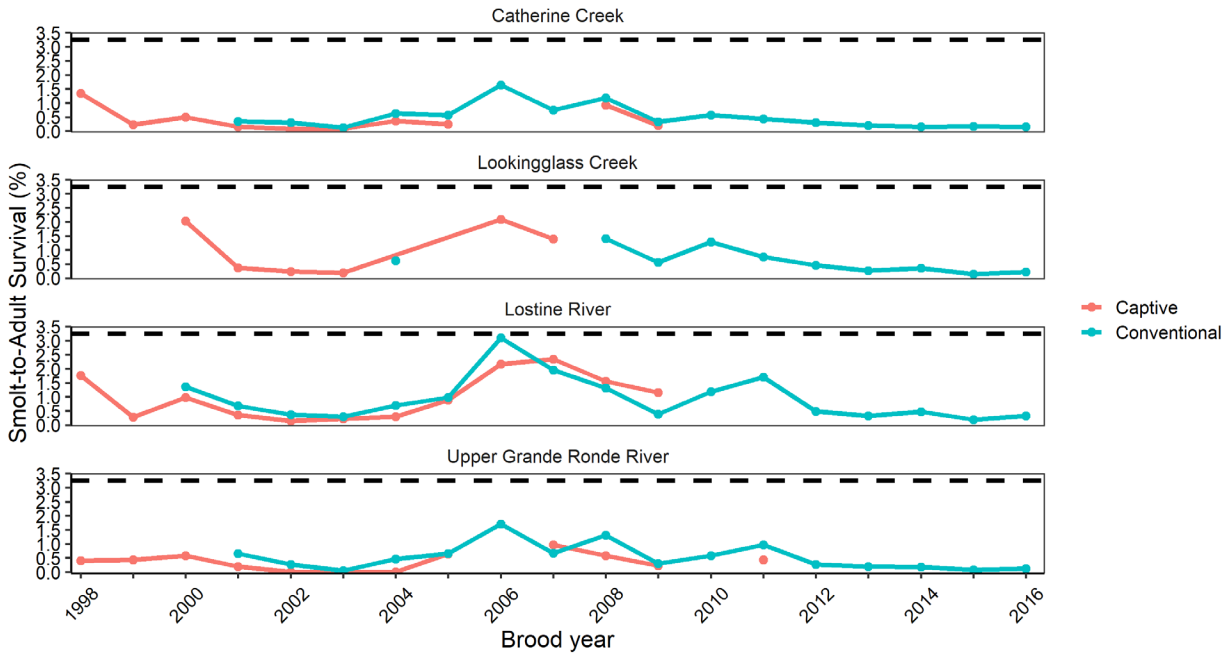

Figure 8.3. Smolt-to-adult survival rates for captive and conventional program smolts released into Catherine Creek, Lookingglass Creek, the Lostine River, and Upper Grande Ronde River, complete brood years 1998-2016. Note: Captive Broodstock program releases into Lookingglass creek reflect reintroduction efforts.

Compensation area returns and smolt-to-adult return rates

Hatchery adult (age 3-5) returns to the Grande Ronde and Imnaha basins rarely meet compensation mitigation goals (Figure 8.4). In the Grande Ronde basin, the mitigation goal of 5,820 adults returning to the Grande Ronde basin has only been achieved three times since the first adults started returning in 2000. The Imnaha basin return goal of 3,210 adults has only been achieved six times in the last 25 years.

The compensation smolt-to-adult return (SAR) goal is 0.65% for both the Grande Ronde and Imnaha river hatchery programs. Each Grande Ronde Basin program has achieved the SAR goal in three or more years, and SAR goals were achieved with both captive and conventional smolt releases (Figure 8.5). Since BY 1982, the Imnaha program has achieve the SAR goal in 14 years. For the captive and conventional programs in the Grande Ronde basin, annual SAR rates for the conventional program were generally higher than the captive program and showed similar annual variation between programs (Figure 8.6). However, BYs 2007-2009 in the Lostine River program indicate that the captive program smolts outperformed the conventional program smolts. For BYs 2007-2004, the Lostine River mean captive SAR rate of 1.59% was 62% greater than the mean conventional SAR rate of 0.97%.

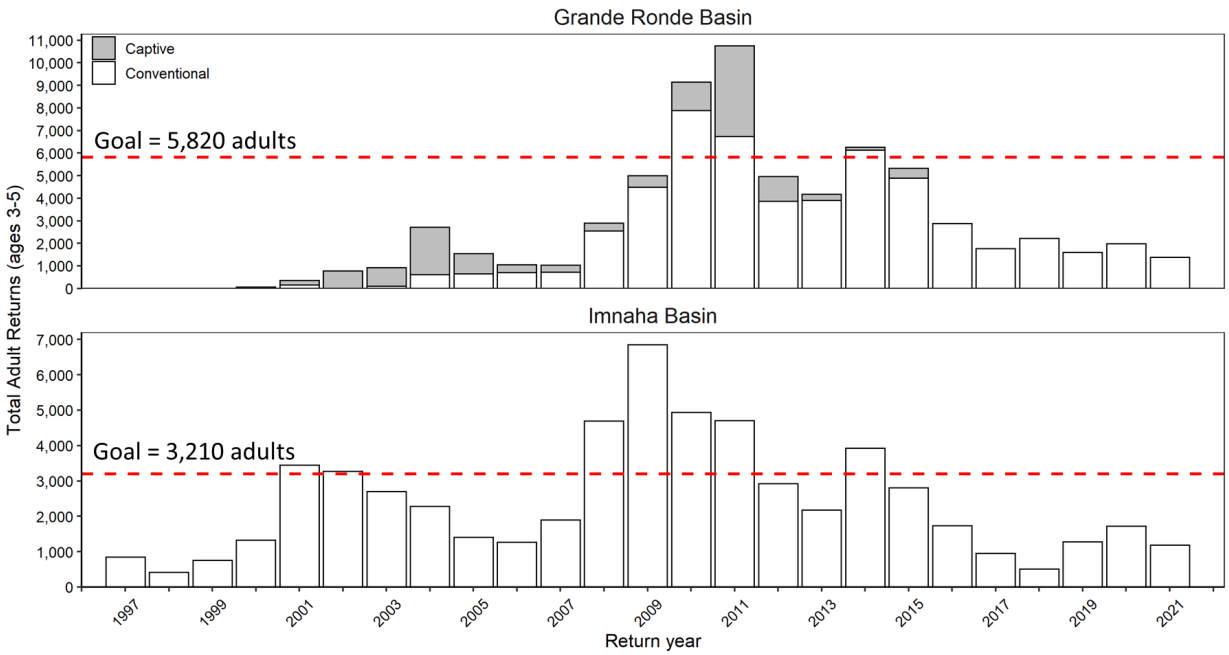

Figure 8.4. Total adult age 3-5) returns to the LSRCP compensation area compared to mitigation goals for endemic hatchery-origin Grande Ronde basin spring Chinooks salmon and Imnaha basin spring-summer Chinook salmon, run year 1997-2021. The red dashed lines represent adult mitigation goals of 5,820 adults to the Grande Ronde Basin and 3,210 adults to the Imnaha basin.

The mean SAR rates for the last 5 complete brood years (BYs 2011-2016) were lower than SAR rates observed in BYs 2007-2011 for all hatchery programs (Figure 8.5). For BYs 2011-2016, the 0.302% SAR rate in the Imnaha program was almost 3 times lower than the SAR rate of 0.932% observed for the previous five BYs 2007-2011. A similar trend in decreasing SARs was observed in the Grande Ronde Basin conventional programs where the SAR rate for complete BYs 2011-2016 was less than 50% of SAR rate determined for BYs 2007-2011. For Grande Ronde Basin conventional programs, the highest average SAR rate for BYs 2011-2016 was 0.316% for the Lostine River and the lowest was 0.142% for the Upper Grande Ronde River. The mean SAR rates for BYs 2011-2016 were 0.167% and 0.249% for Catherine Creek and Lookingglass Creek, respectively. For comparison, the mean BY2007-2011 SAR rates for the conventional programs were 0.555%, 0.820%, 0.957%, and 0.733% for Catherine Creek, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River, respectively.

Within the Grande Ronde Basin, each individual hatchery program has adult return goals that comprise the overall LSRCP compensation goal of 5,820 adults. Goals are for 970 adult returns produced from the Catherine Creek program and 1,617 returns produced from each of the Lookingglass Creek, Lostine River, and the Upper Grande Ronde River programs. Between return years 2010 and 2021, adult return goals have been achieved twice in Catherine Creek; and three times each in the Lookingglass Creek, Lostine River, and Upper Grande Ronde River programs (Figure 8.7). Prior to return year 2010, the only Grande Ronde basin program to achieve the mitigation adult goals was the Lostine River with estimates of 1,639 and 3,014 adult returns in 2008 and 2009, respectively. In the Imnaha River, the adult return goal of 3,210 adults has been achieved six times in the last 25 years (1997-2021) and the largest number of adult returns during this time was

The average number of adult returns to the compensation area for return years 2017-2021 was lower than determined for return years 2012-2016 in both the Grande Ronde and Imnaha River basins (Figure 8.7). For the Imnaha program, the mean number of adult returns for return years 2017-2021 was 1,130 (range 513-1,725), 42% of the mean adult return of 2,714 (range 1,735-3,931) observed between 2012 and 2016. In the Grande Ronde Basin, the 2017-2021 average returns were also 50% or less of the average returns observed during 2012-2016 return years. The mean number of adult returns for return years 2017-2021 was 210 (range 114-266) to Catherine Creek, 541 (range 402-744) to Lookingglass Creek, 786 (range 546-970) to the Lostine River, and 259 (range 117-353) to the Upper Grande Ronde. For comparison, the mean number of adult returns from 2012-2016 was 579 (range 324-824) for Catherine Creek, 1,561 (range 968-2,183) for Lookingglass Creek, 1,528 (range 1,141-2,289) for the Lostine River, and 1,056 (range 456-1,725) for Upper Grande Ronde River programs.

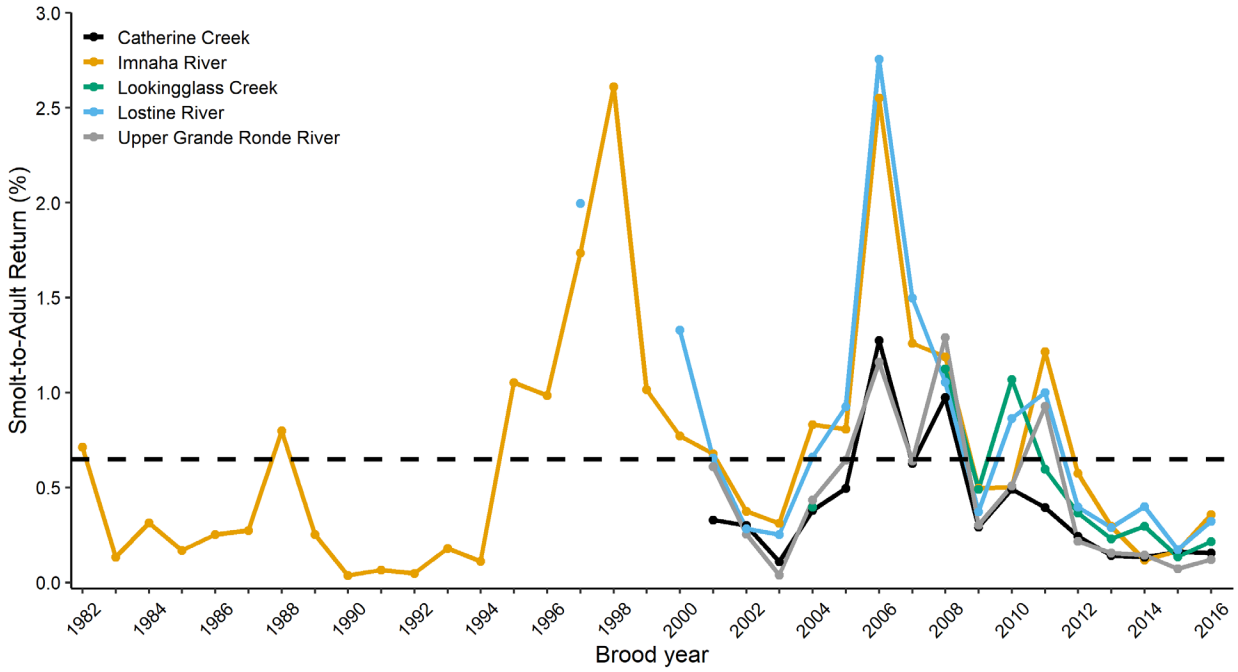

Figure 8.5. Smolt-to-adult return (SAR) rates for conventional hatchery smolt production compared to the LSRCP compensation SAR goal of 0.65% for endemic Catherine Creek, Imnaha River, Lookingglass Creek (note: limited to reintroduction with Catherine Creek stock), Lostine River, and Upper Grande Ronde, and Imnaha River populations.

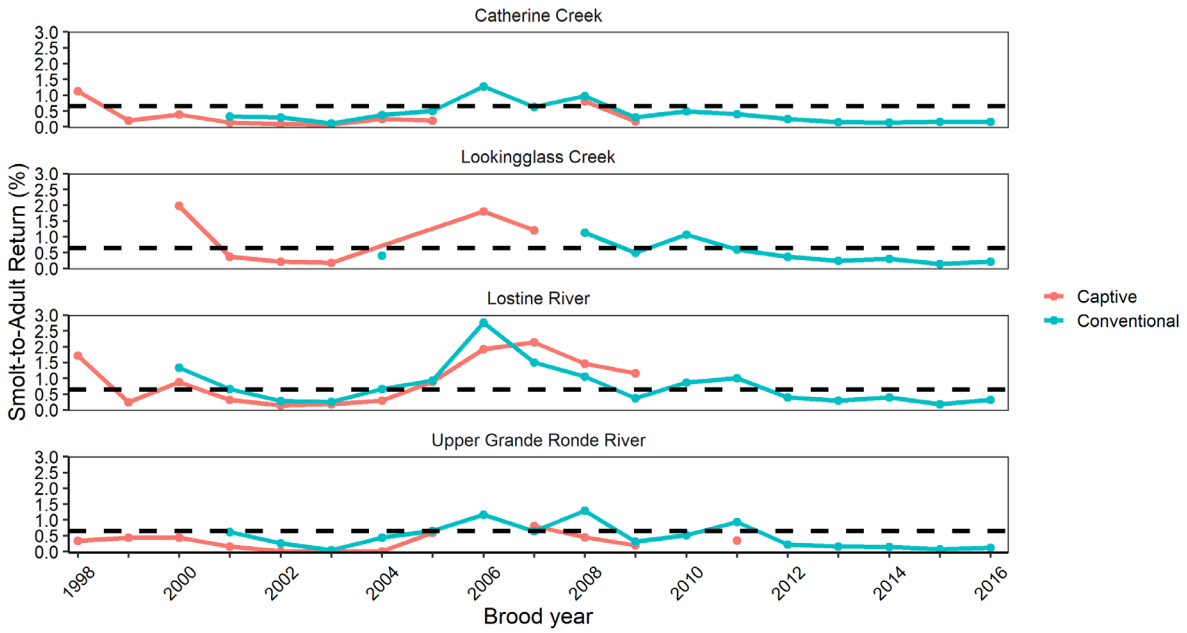

Figure 8.6. Smolt-to-adult (age 3-5) return rates for captive and conventional program smolts released into Catherine Creek, Lookingglass Creek, the Lostine River, and Upper Grande Ronde River, complete brood years 1998-2016. Note: Captive Broodstock program releases into Lookingglass creek represent reintroduction efforts.

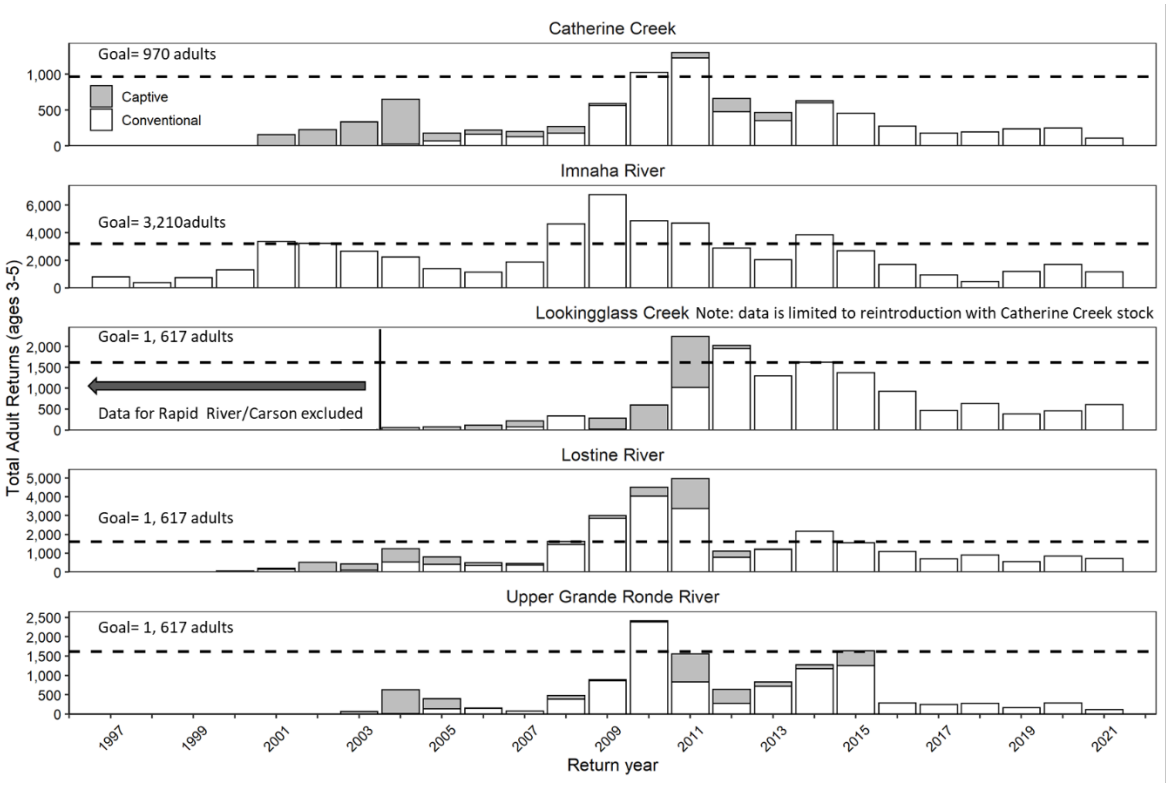

Figure 8.7. Adult returns to the LSRCP compensation area for endemic hatchery-origin spring and summer Chinooks salmon from the Catherine Creek, Imnaha River, Lookingglass Creek (note: limited to reintroduction with Catherine Creek stock), Lostine River, and Upper Grande Ronde Imnaha river populations compared to populations specific mitigation goals (dashed line, run year 1997-2021.

Juvenile survival compared to smolt-to-adult return rates

An increase in the estimated juvenile survival rate to Lower Granite Dam was positively correlated with SAR rates for both the captive and conventional programs (Figure 8.8). This relationship was highly significant for captive smolts released into the Lostine River ($P = 0.004$), marginally significant for captive smolts released into Catherine Creek ($P = 0.084$) and Lookingglass Creek ($P = 0.095$), but not significant for captive smolts release into the Upper Grande Ronde (P = 0.147; Figure 8.8). There was a highly significant relationship between the conventional program juvenile survival to LGD and SAR rates in Catherine Creek ($P = 0.005$), it was marginally significant in the Imnaha River ($P = 0.076$) and Upper Grande Ronde River ($P = 0.078$), but not significant for Lookingglass Creek or the Lostine River ($P > 0.2$; Figure 8.9).

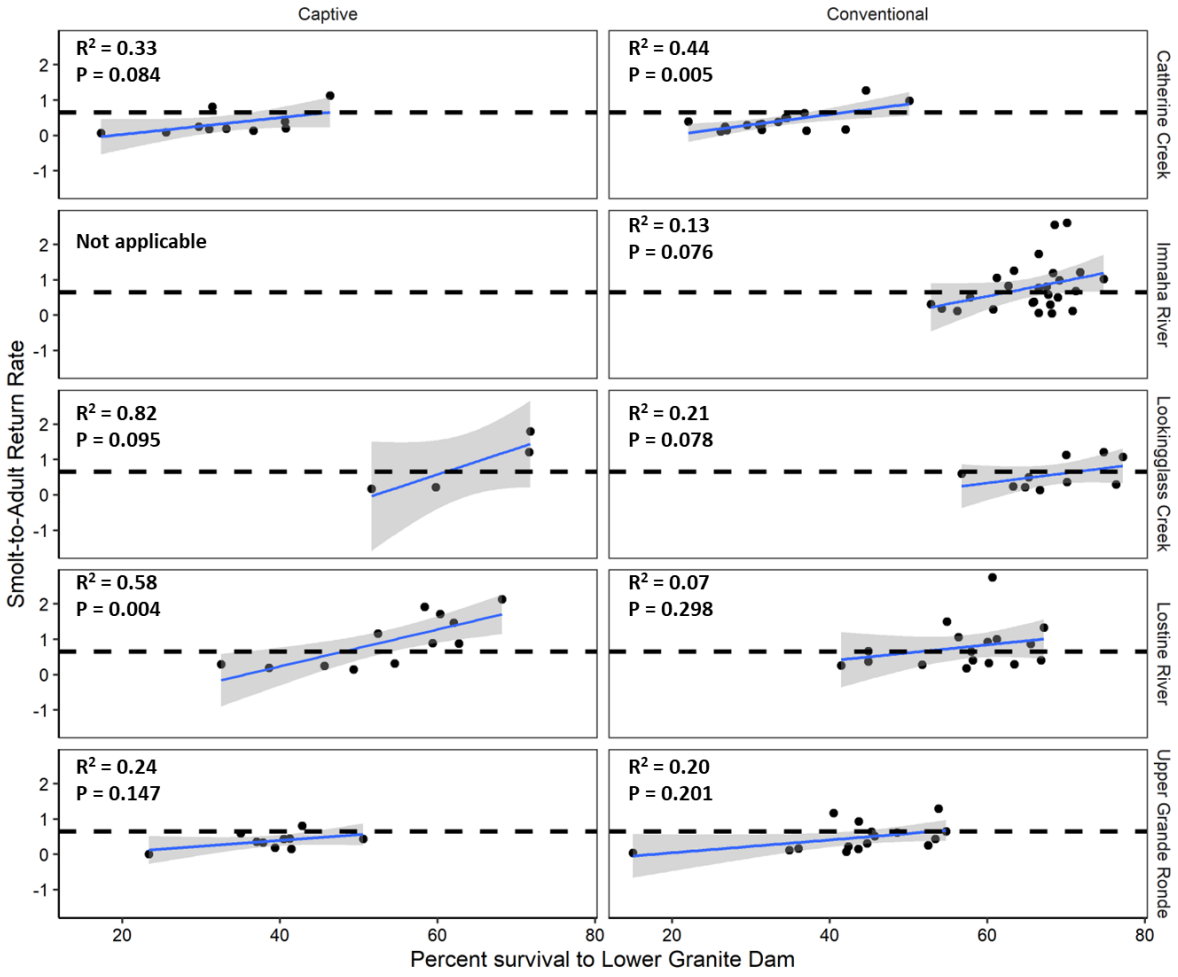

Figure 8.8. Estimated juvenile survival rate to Lower Granite Dam compared to smolt-to-adult return rates for captive program and conventional program smolts. Captive smolts were released into for Catherine Creek (BYs 1998-2005, 2008-2009), Lookingglass Creek (BYs 2002-2003, 2006-2007), Lostine River (BYs 1998-2009), and Upper Grande Ronde (BYs 1998-2002, 2005, 2007-2011). Conventional program smolts were released into Catherine Creek (BYs 2001-2016), Imnaha River (BYs 1991-2016), Lookingglass Creek (BYs 2007-2016), Lostine River (BYs 2000-2016), and Upper Grande Ronde (BYs 2001-2016). The shaded area around the linear regression line is a 95% confidence interval and the dashed lines is the 0.65% SAR goal.

Objective 4. Compare recruits-per-spawner (R/S) for hatchery and natural origin fish.

Recruit per spawner (R/S) ratios are used to compare productivity of fish spawning in nature and at the hatchery and are sometimes referred to as progeny to parent ratios. Ratios >1 represent populations exceeding replacement. We report R/S ratios to StreamNet for naturally spawning populations three different ways: 1) spawner to spawner; 2) return to river: spawner, and 3) smolts: spawner (see Table 11.2 under Data archiving and sharing). The spawner-to-spawner ratios are different from return to river ratios because spawners are first adjusted for population specific annual rates of pre-spawn mortality. Return to river is total escapement of salmon to the population before adjusting for pre-spawn mortality estimates. This distinction is important because the return to river estimates include salmon removed from the population via harvest, broodstock collection, and outplanting or food-banking efforts. The spawner-to-spawner estimates represent what is left in the river available to spawn after adjusting for pre-spawn mortality. Because of the sliding scale management criteria, it is common for hatchery fish that are not kept for broodstock to be removed from the population (e.g., sent to foodbanks, outplanted, killed) to manage the proportion of hatchery fish spawning in nature.

For spring and summer Chinook salmon spawned at Lookingglass Fish Hatchery, the return to river recruits R:S ratios typically exceed 1 and have exceeded 40 in the Imnaha River and Lostine River population (Figure 9.1). All five hatchery programs show synchrony in the annual variation in R:S. The average R:S for complete BYs 2007-2011 was more than twice that observed for complete BYs 2012-2016. The mean R:S ratios for BYS 2007-2011 were 9.2, 14.2, 14.6, 16.4, and 11.5 for the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde conventional hatchery programs, respectively. For BYs 2012-2016, the mean R:S ratios were 2.4, 5.2, 4.0, 5.8, and 2.0. for the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde conventional hatchery programs, respectively.

The return to river R:S ratios for naturally spawning spring Chinook salmon range from nearly zero to 7.5 (Figure 9.2). For the last five complete BYs 2012-2016, the R:S was <1 for all five years in the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, Minam River, and Upper Grande Ronde populations. In the Wenaha River, the R:S ratio was 1.2 for BY2012 and ranged from 0.3 to 0.5 for BYs 2013-2016. For BYs 2012-2016, the two highest mean R:S ratios were 0.6 and 0.5 in the Minam and Wenaha rivers, respectively. For the supplemented populations, the mean R:S ratios for BYs 2012-2016 were 0.3 in Catherine Creek, and 0.2 in each of the Imnaha River, Lookinglass, Creek, Lostine, and Upper Grande Ronde River populations.

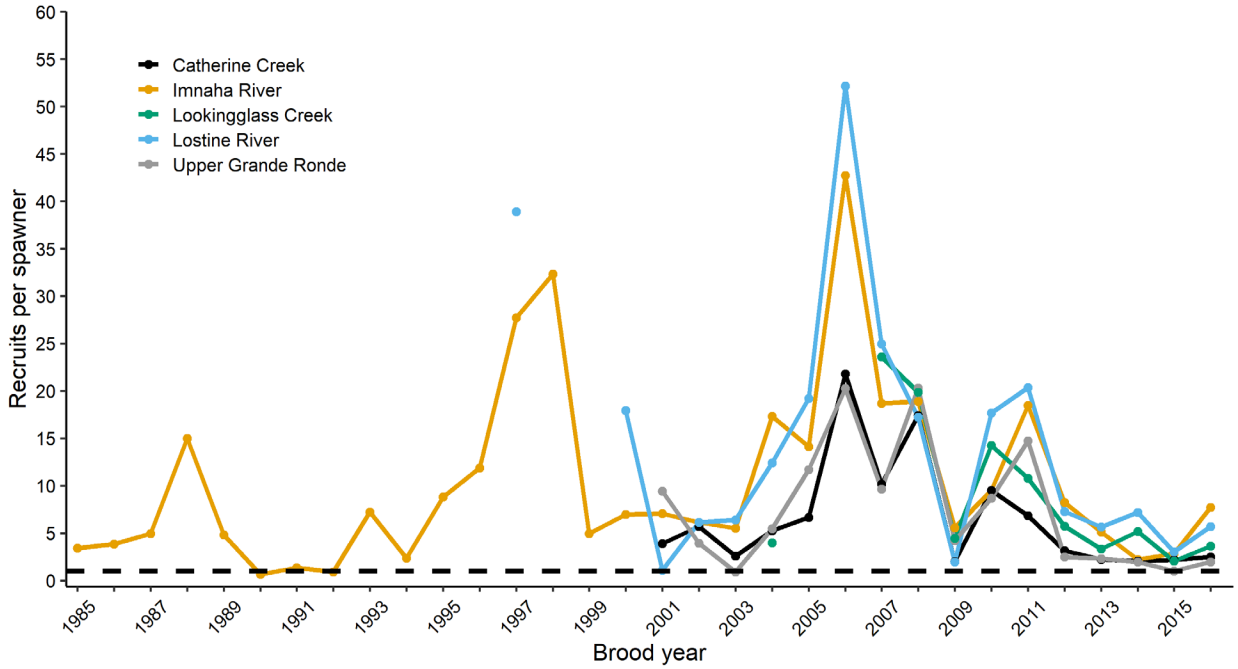

Figure 9.1. Total adult return to river recruits per spawner ratios for conventional production produced from Catherine Creek, Imnaha River, Lookingglass Creek (note: limited to reintroduction with Catherine Creek stock), Lostine River, and Upper Grande Ronde, and Imnaha River populations. The dashed line represents the level necessary for population replacement (1:1).

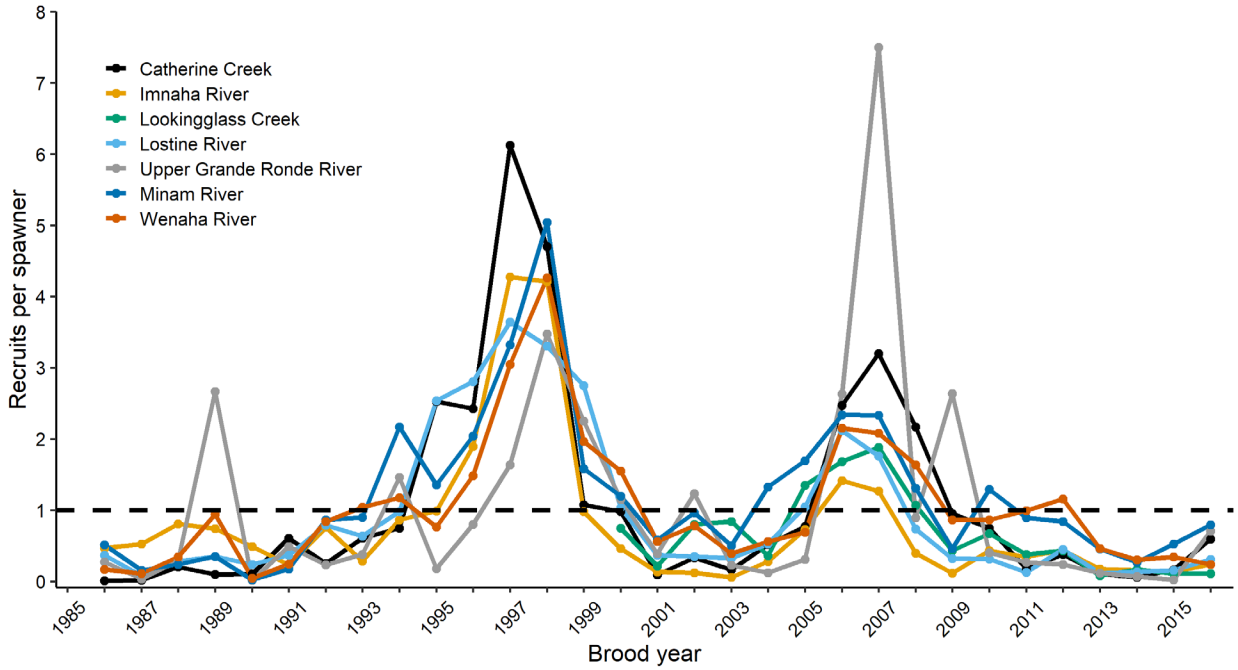

Figure 9.2. Total adult return to river recruits per spawner ratios for naturally produced populations of Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde, Imnaha River, Minam River, and Wenaha River spring and summer Chinook salmon populations. The dashed line represents the level necessary for population replacement (1:1).

Objective 5. Assess response in natural population abundance and productivity (adult R/S, smolts-per-spawner) to supplementation.

Natural adult returns

Adult spring and summer Chinook returns to the supplemented Grande Ronde and Imnaha basin populations have been dominated by hatchery returns since 1997 (Figure 10.1). Even with sliding scale management to limit numbers of hatchery fish spawning in nature, the proportion of adult salmon including jacks (pHOSij) has regularly exceeded 0.5 for all five hatchery supplemented populations (Figure 10.2). One important distinction is that natural and hatchery return to river estimates represent total escapement and pHOSij represents estimates of fish spawning in nature.

The estimated number of natural adult returns to Catherine Creek since 1997 has ranged from 50 adults in 2005 to 677 adults in 2011, and the median proportion of natural adult returns is 0.27. The second highest natural return to Catherine Creek was in 2014 when an estimated 651 natural returns exceeded the hatchery return estimate of 623 adults. For the last 5 return years (2017-2021), the estimated number of natural adult returns has ranged from 53 to 218, and pHOSij has average 0.66 (range 0.43 to 0.75; Figure 10.2).

In Lookingglass Creek, from 2004 to 2021, the estimated number of natural origin adult returns has ranged from 32 (return year 2007) to 432 (return year 2016), and the median proportion of natural adult returns is 0.15. Over the last five return years, annual natural adult returns have ranged from 64 to 79, hatchery adult returns have ranged from 395 to 638, and pHOSij has average 0.77 (range 0.73 to 0.82, Figure 10.2).

From 1997-2021, the estimated total natural adult returns to the Lostine River have ranged from 72 (return year 1999) to 1,198 (return year 2014), and the median proportion of natural adult returns is 0.23. During the last 5 years, natural adult return numbers to the Lostine River have ranged from 120 to 268 and corresponding hatchery returns have ranged from 571 to 910. For the Wallowa-Lostine population, pHOSij for the last 5 years has averaged 0.70 and ranged from 0.6 to 0.78 (Figure 10.2). Returns to the Lostine river account for nearly all the production in the Wallowa-Lostine population.

From 1997 to 2021, the estimated natural adult returns to the Upper Grande Ronde River have ranged from 4 (return years 1999) to 817 (return year 2014), and the median proportion of natural adults is 0.25. Over the last five years, natural adult return numbers have ranged from 25 to 112 (mean = 63), hatchery adult returns have ranged from 167 to 295, and pHOSij has averaged 0.71 (range 0.62 to 0.81; Figure 10.2).

Imnaha river natural adult return estimates from 1997 to 2021 range from 228 (return years 1997 and 2019) to 2,379 (return year 2001), and the median proportion of natural adult returns is 0.22. Over the last 5 return years, the total natural return estimates has ranged from 228 to 368, hatchery return estimates range from 485 to 1,720, and the mean pHOSij is 0.69 (range 0.52 to 0.78, Figure 10.2).

The consistency in pHOS among the supplemented populations and across years indicates that weirs and sliding scale management strategies are being effectively applied. However, this same consistency creates challenges in answering Objective 5. The lack of contrast in pHOS among the supplemented populations in recent years may make it difficult to evaluate effects of supplementation on natural populations. If that remains a priority, experimental manipulations to the sliding scales may be required in some population-year pairs.

The low number of natural adult returns is concerning because we are not meeting NOAA recovery goal (Figure 10.3). In the 2017 Recovery Plan for Northeast Oregon Snake River Spring and Summer Chinook Salmon populations, NOAA set minimum abundance threshold for the Wallowa-Lostine Population, the Upper Grande Ronde, and Imnaha River populations at 1,000 adults, and set the minimum adult abundance for Catherine Creek, the Minam River, and Wenaha River at 750 adults (NOAA 2017 see page 127). Although Lookingglass Creek is considered functionally extinct, the management goal is 500 natural adults. On an individual year basis, the Catherine Creek, Upper Grande Ronde populations have never met the minimum abundance criteria and Lookingglass Creek has never met the management goal. Since 1994, the Imnaha River population has only exceeded the minimum abundance threshold 3 times in spawn years 2001-2003. The Wallowa-Lostine population of natural origin spawners is comprised of natural spawning in the upper Wallowa River, Hurricane Creek, Bear Creek, and the Lostine River. The Wallowa-Lostine population has only exceeded 1,000 adults in 2010-2012 and in 2014. The unsuplemented Minam and Wenaha River populations consistently return more natural adult salmon than Catherine Creek, Lookingglass Creek, and the Upper Grande Ronde populations, but also fail to meet minimum abundance thresholds.

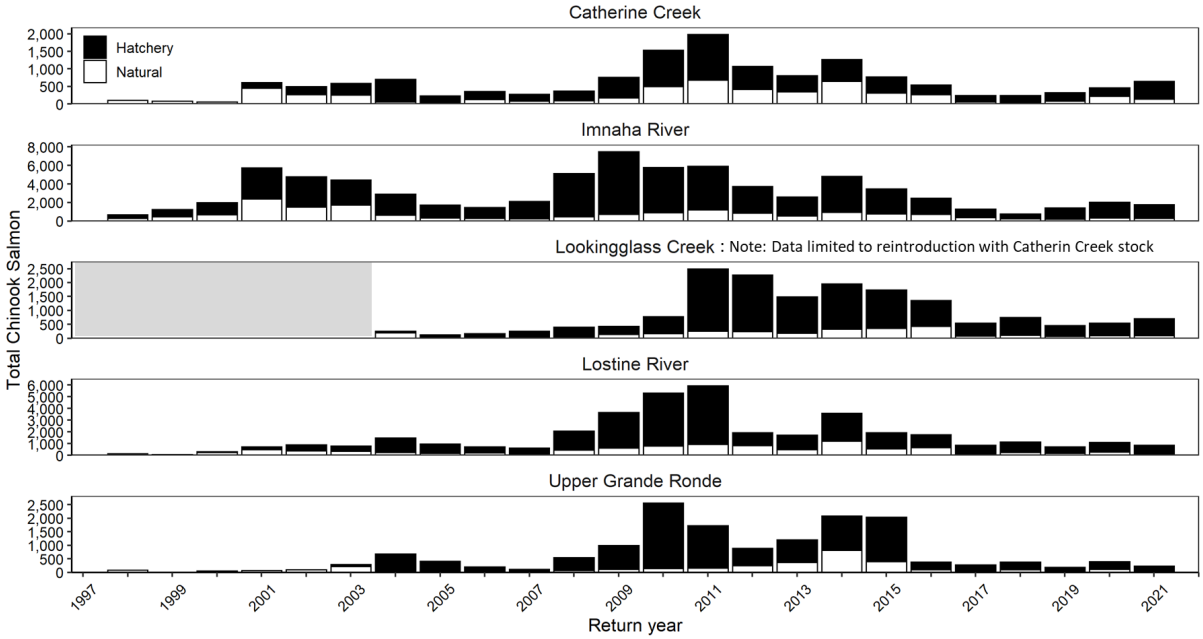

Figure 10.1 Total adult returns of hatchery and natural origin spring and summer Chinook salmon to supplemented populations in Catherine Creek, the Imnaha River, Lookingglass Creek, the Lostine River, and Upper Grande Ronde River. Data for Lookingglass Creek are limited to the period after the Catherine Creek reintroduction.

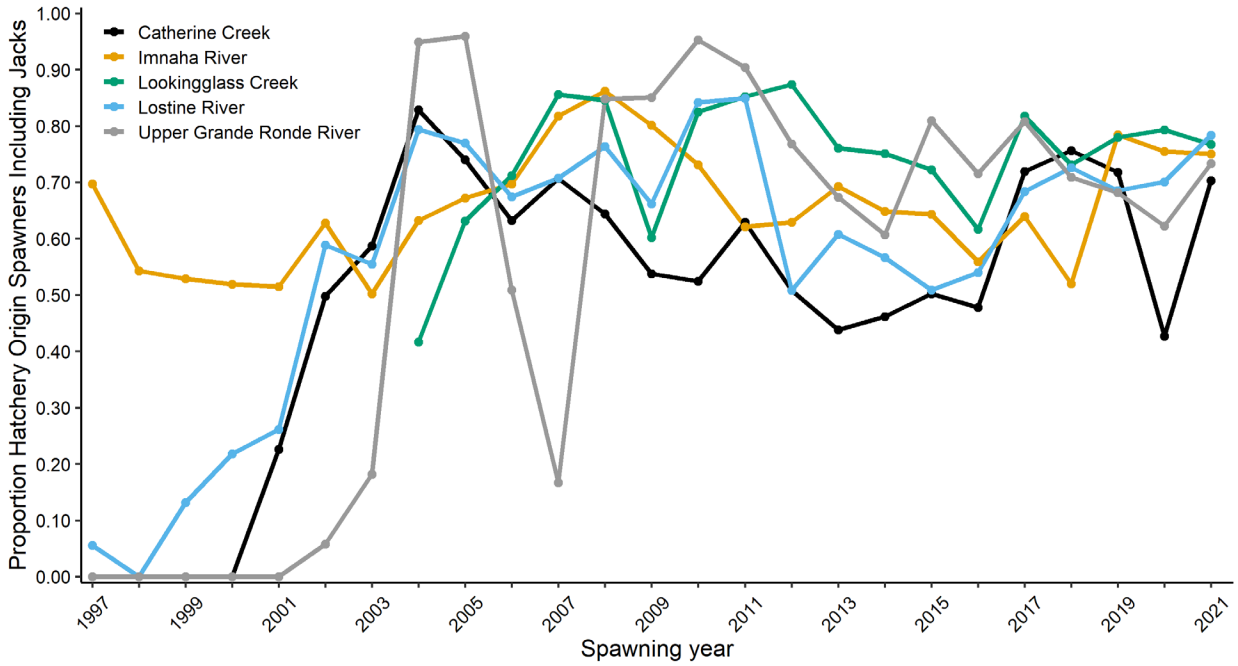

Figure 10.2. Proportion hatchery origin spawners including jacks in the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde River spring Chinook populations, spawning year 1997 to 2021.

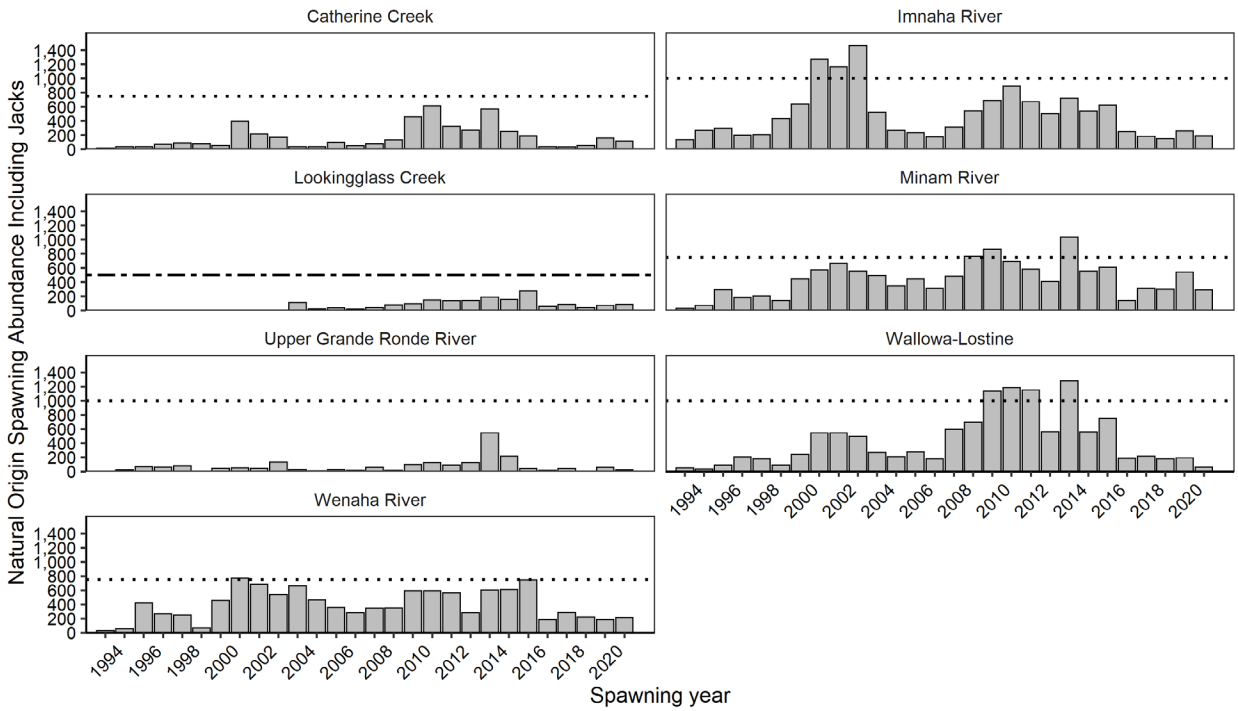

Figure 10.3. Estimated total number of adult natural origin salmon in each of the Independent Populations of Snake River Spring/Summer Chinook salmon identified by the Interior Columbia Basin Technical Recovery Team (ICTRT) compared to NOAA'S 2017 Recovery Plan minimum abundance thresholds (dotted line). Note: returns to Lookingglass Creek are limited to returns after 2003 and the dashed line represents the management goal.

Genetic monitoring

Both CTUIR and NPT are collaborating on Relative Reproductive Success (RRS) studies. Brief summaries for existing projects are summarized.

- Lookingglass Creek: The CTUIR partnered with CRITFC project 2009-009-00 to evaluate the re-introduction of spring Chinook into Lookingglass Creek. This is a multi-year study to test the presumption that natural origin adults derived from natural spawning of hatchery adults descended from the Catherine Creek captive broodstock hatchery program would demonstrate improved productivity, estimated by comparison within brood years of average juvenile recruits-per-spawner of natural origin versus hatchery origin adults spawning naturally. Progress to date for the genetic analysis for this study is detailed in (Nuetzel et al. 2021, Nuetzel et al. 2022).
- Catherine Creek. As part of a multi-year project, CTUIR has partnered with NOAA fisheries. The relative reprodutive success studies spans the entire reintoruction period (i.e, late 1990's to present). Relevant results are presented in Berntson et al. 2013.
- Lostine River. The NPT partnered with NOAA fisheries to evaluate the Lostine River hatchery program. The RRS study had some setbacks from 2001-2008 due to data integrity issues and several years of relatively low weir capture efficiency (Figure 11.3 in Objective 6). Inference from the RRS evaluation is limited because only three complete brood years have sufficient data for analysis (Berntson et al. 2020).

We have been collecting genetics samples for the parentage-based tagging (PBT) baseline (Steele et al. 2019) since 2008 for all Chinook salmon spawned at Lookingglass. Analysis of the PBT data collected from broodstock revealed several key findings.

- PBT data supported our previous findings with CWT recoveries that most in-basin hatchery straying attributed to Catherine Creek, Upper Grande Ronde, and Lostine River hatchery fish straying into Lookingglass Creek (Figure 10.4). In general, <1% of hatchery salmon from Catherine Creek, Upper Grande Ronde, and Lostine River stray to any of the other hatchery supplemented populations.
- While effort was expended to prevent captive broodstock returns from being used in the conventional hatchery program, the PBT data suggested that a small portion of captive broodstock adults were inadvertently spawned (Figure 10.4).
- The largest proportion of non-program hatchery strays (i.e., hatchery fish from stocks not reared at LFH) were detected in the Imnaha River stock (Figure 10.4). A total of 116 hatchery salmon from IDFG hatchery programs were identified in the LFH broodstock programs: nine from Dworshak, one from Pahsimeroi; 103 from Rapid River; and three from Sawtooth Fish Hatchery. For the Imnaha River stock, strays from Idaho comprised between 0.4% and 16.3% of the hatchery salmon broodstock collections at the Imnaha River weir. Furthermore, the PBT data indicated that Idaho hatchery salmon have been present in the Imnaha stock every year from 2012–2018 and comprised 16.3% and 13.9% of the Imnaha River hatchery broodstock in 2014 and 2015, respectively. One Rapid River hatchery Chinook was spawned as part of the Catherine Creek stock in 2014. Finding Rapid River salmon in the Imnaha River hatchery broodstock was unexpected because we did not recover any CWT- marked salmon from Idaho programs in any of our

hatchery broodstock collections at LFH, nor on spawning ground surveys on the Imnaha River.

- For salmon determined to be of natural origin (i.e., intact adipose fin and no CWT) at LFH, PBT results show that from 2012–2018, a portion of these salmon were misclassified and were hatchery origin (Figure 10.5). From 2012–2018, the mean percentages of hatchery salmon that were incorrectly classified as natural origin were 1.3% (range = 0–4.2%) for Catherine Creek, 4.6% (range = 0–10.3%) for the Imnaha River, 7.6% (range = 0–21.7%) for Lookingglass Creek, 5.4% (range = 0–16.7% for the Lostine River, and 12.5% (range = 5.7– 22.2%) for the Upper Grande Ronde River. Overall, Chinook Salmon collected from the Upper Grande Ronde River weir had the largest misclassification rate (i.e., hatchery origin, not natural). Beginning with release year 2004 (BY 2002 smolts), between 50% and 100% of all Upper Grande Ronde River conventional program releases were coded-wire tagged but did not carry an adipose fin clip, or any external mark (i.e., 50% = ADCWT and 50% = CWT only) and were thus more likely to be misidentified as natural-origin adults upon return.
- The PBT data provided the ability to assign a genetic age to every spawned hatchery origin adult starting nearly 100% of the hatchery adults that returned as offspring from adults sampled in the PBT baseline (ODFW, unpublished data). Compared with CWT based ages, this nearly doubled the number of known aged salmon and significantly reduced efforts required to collect and process scales samples for ageing.

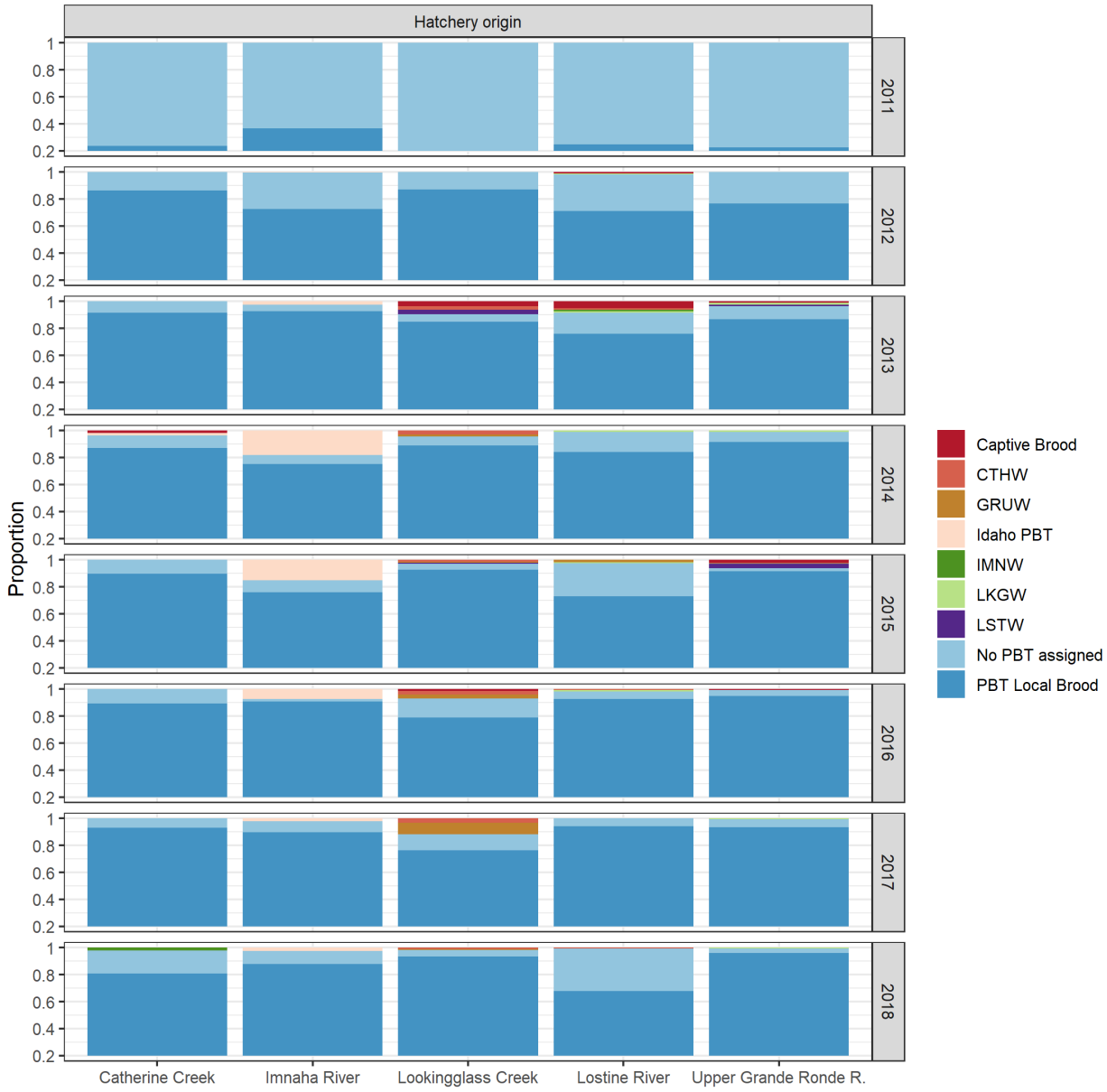

Figure 10.4. Hatchery-origin broodstock and the corresponding parentage-based tagging (PBT) stock assignments, return years 2011–2018. Abbreviations: CTHW = Catherine Creek weir, GRUW = Upper Grande Ronde River weir, IMNW = Imnaha River weir, LKGW = Lookingglass Creek weir, LSTW = Lostine River weir.

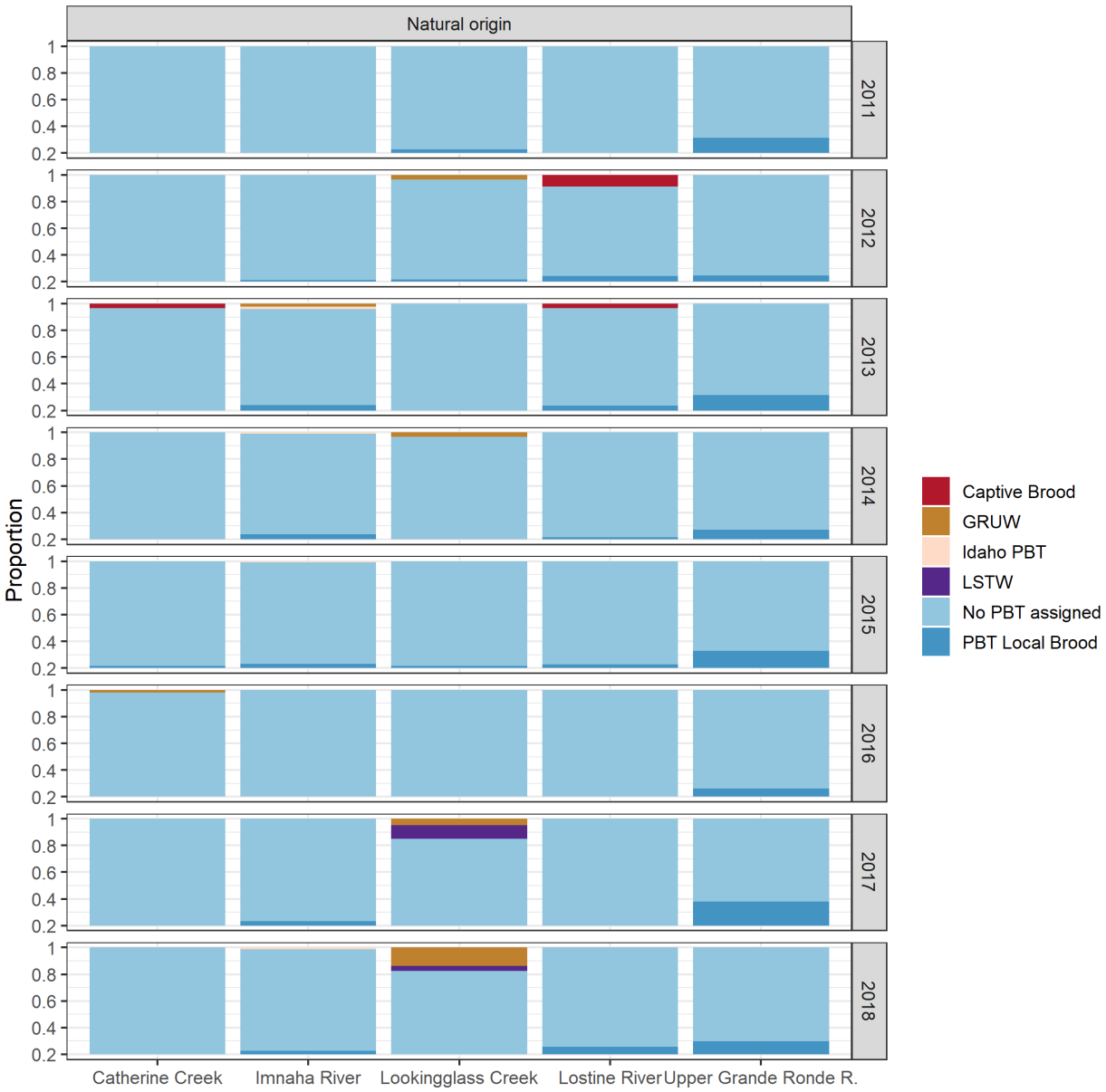

Figure 10.5. Natural-origin broodstock and the corresponding parentage-based tagging (PBT) stock assignments, return years 2011-2018. Abbreviations: CTHW = Catherine Creek weir, GRUW = Upper Grande Ronde River weir, IMNW = Imnaha River weir, LKGW = Lookingglass Creek weir, LSTW = Lostine River weir.

Smolts per spawners

Smolt equivalents are defined as the estimated number of smolts from a population that successfully emigrate from a specified area (Hesse et al. 2006). Combining the survival probability estimates with our migrant abundance estimates, we estimated the number of smolt equivalents produced from spawning upstream of the rotary screw trap in each of our study populations: in this case, "smolt equivalents" describes the estimated number of smolt that leave the mouth of the tributary in late spring on their way out to the ocean after having survived over the winter, including both fish that passed the trap in the fall (early migrants) and those that passed the trap in the spring (late migrants).

Plots of smolts per spawner versus number of spawners for Catherine Creek, the Lostine River, Minam River, and Upper Grande Ronde River show that productivity, measured as smolts per spawner, decreases as spawner density increases, although the wilderness Minam population shows the weakest density-dependence (Figure 10.6). Another trend observed in these natural populations is that 1) as mean smolt length increases, juvenile survival decreases, 2) increased smolt abundance tends to decrease smolt size, and 3) as the number of spawners in nature increases, there appears to be a capacity limit to natural smolt production (Figure 10.7). These trends suggest that habitat or other environmental conditions continue to limit natural production and we are unlikely to see improvements in natural population productivity or abundance from supplementation until the capacity and survival limitations are ameliorated (e.g., Venditti et al. 2018).

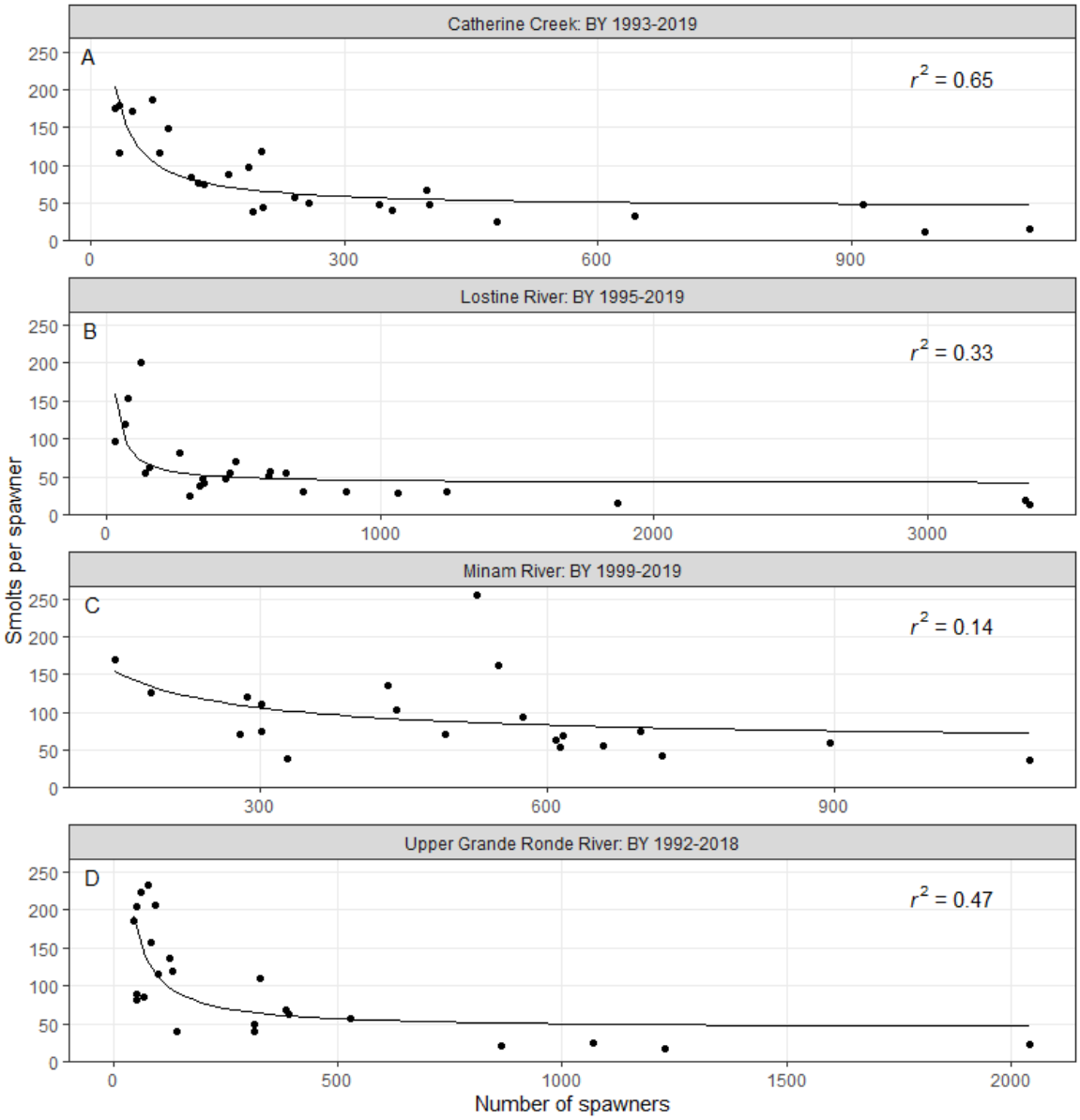

Figure 10.6. Spring Chinook salmon smolt equivalents produced per spawner in Catherine Creek (A), Lostine River (B), Minam River (C), and Upper Grande Ronde River (D). BY = brood year.

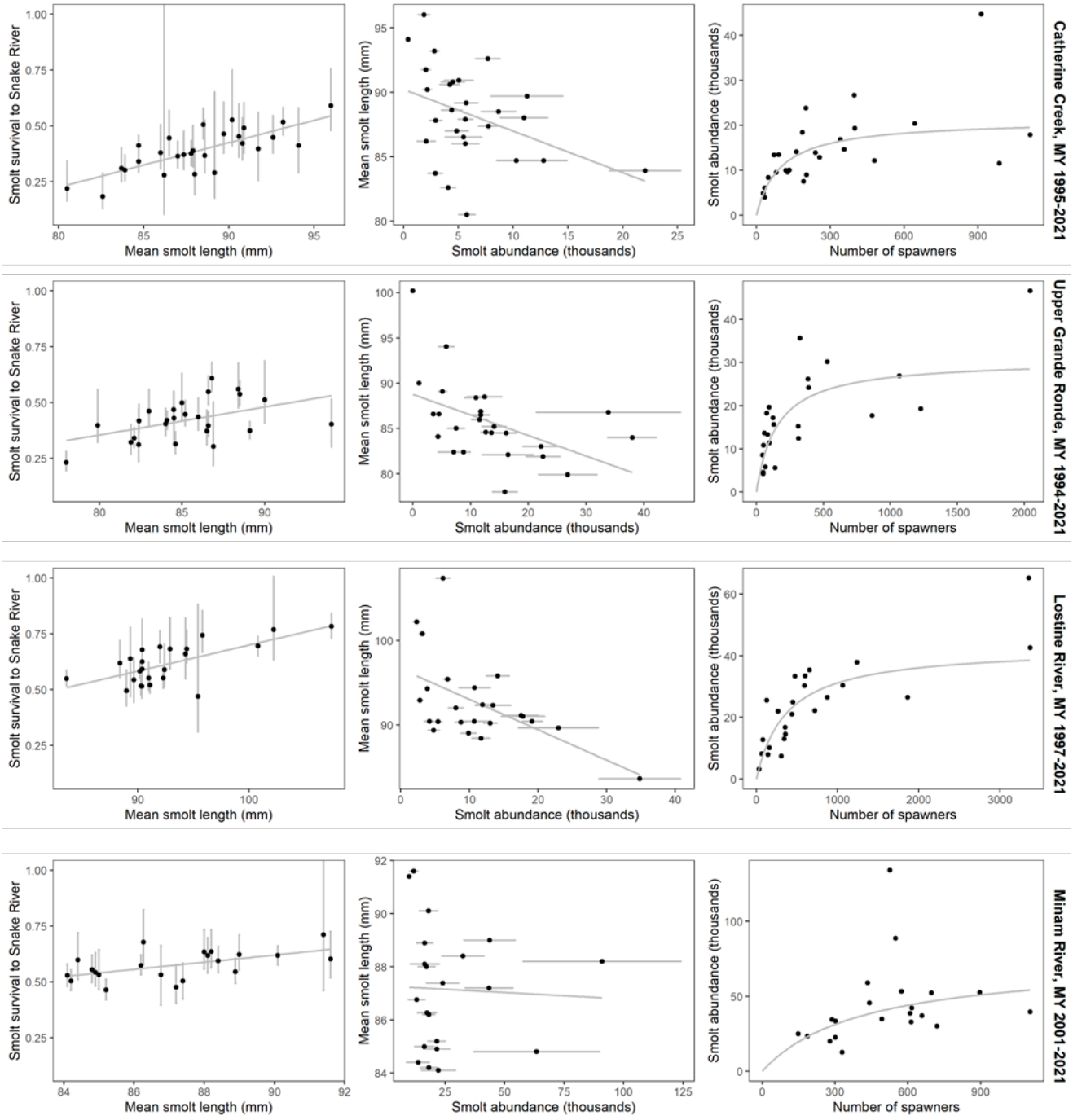

Figure 10.7. Mean smolt length compared to juvenile survival to Lower Granite Dam and smolt abundance, and the number of spawners compared to smolt abundance for naturally spawning spring Chinook in Catherine Creek, the Upper Grande Ronde River, Lostine River, and the Minam River. MY = smolt outmigration year.

Objective 6. Assess and compare life history characteristics (age structure, run timing, sex ratio, smolt migration, fecundity) of hatchery and natural fish.

Hatchery smolt releases vs natural smolt out-migrants

The typical hatchery smolt is approximately 15-20 mm larger than a corresponding natural origin smolt (ODFW, unpublished data). A trend observed across all hatchery releases, is that when compared to natural spring migrants, the arrival time at Lower Granite Dam for hatchery smolts is more truncated than the arrival time of natural emigrants. For example, natural smolts that left the Lostine River in the spring begin to arrive at Lower Granite Dam in early April and continue migrating through the end of May whereas hatchery smolts do not arrive until mid-April and complete emigrating by mid-May (Figure 11.1). In general, release dates for hatchery fish tend to correspond with late naturally produced migrants (Figure 11.2). Both factors could limit the ability of hatchery populations to adapt to climate driven changes in Mainstem, plume and ocean conditions, or limit their ability to capitalize on inter-annual variation in the timing of productive ocean conditions.

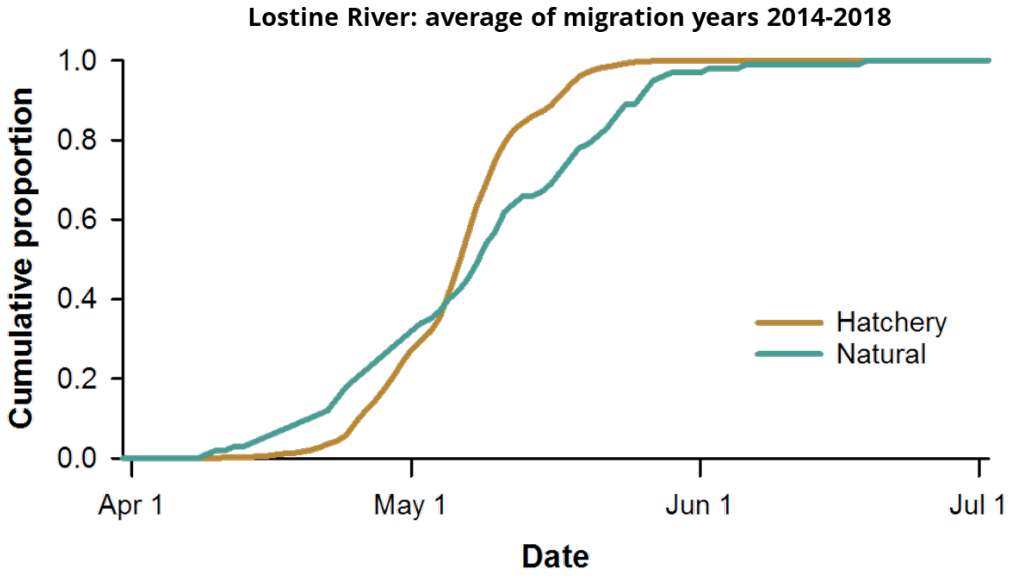

Figure 11.1. Cumulative arrival time at Lower Granite Dam for hatchery and natural spring Chinook salmon smolts emigrating from the Lostine River, average outmigration years 2014-2018.

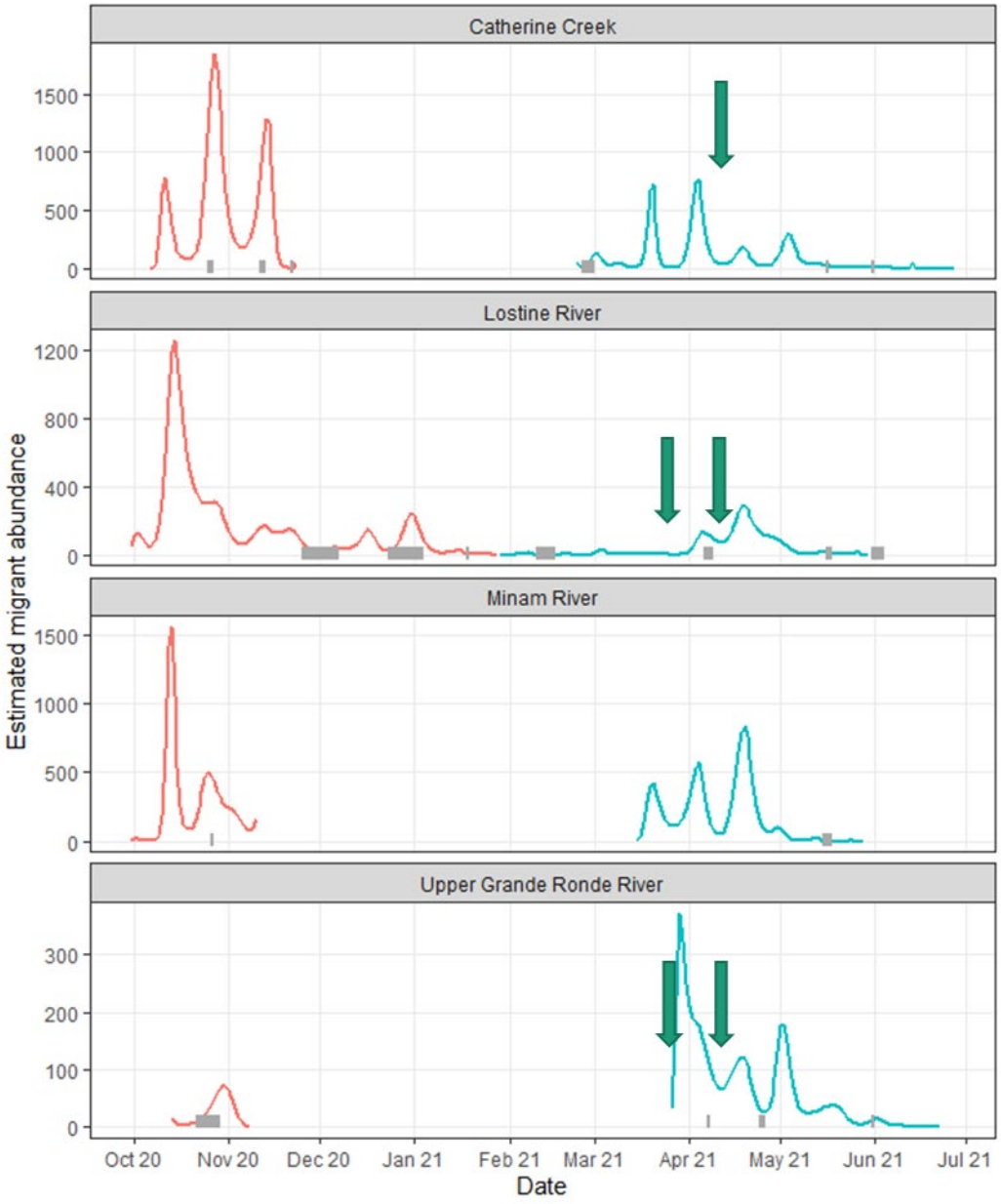

Figure 11.2. Estimated migration timing and abundance for juvenile spring Chinook salmon migrants sampled by rotary screw traps during MY 2021. Red color shows the early migration period, green color is the late migration period. Grey bars indicate periods when the trap was not operating effectively. The green arrows represent the 2021 release dates for hatchery spring Chinook salmon in Catherine Creek (April 23), the Lostine River (April 5 and April 20), and the Upper Grande Ronde (April 6 and April 23).

Weir operations and trap efficiency

Weirs are constructed in streams with hatchery supplementation for the purpose of capturing fish and then distributing the fish according to needs and the sliding scale. Fish are distributed to broodstock, upstream to spawn in nature, downstream to be recycled to the fishery, sacrificed, out-planted, etc. Without weirs, it would be almost impossible to fulfill management objectives and requirements. Additionally, weirs enable us to capture other data on populations, such as run timing, return to river estimates, marking fish for mark recapture analysis above the weir, length and age data, etc. Specifically, weirs enable us to better compare hatchery and natural runs.

There have been several notable changes to weir operations since 2009. For more details and diagrams on the Catherine Creek and Upper Grande Ronde weir operations, see BPA project # 199800703.. For a description of the Lostine weir operations, refer to BPA project # 199800702. Those changes are briefly described below.

- Beginning in 2010, the Upper Grande Ronde weir is removed when the daily maximum water temperature exceeds 68° F (20° C). Because of the temperature requirement, the weir is removed before the run is complete. Therefore, data are missing to accurately represent run timing and there may be potential bias in other metrics if relationships between run timing and adult age observed in the Columbia River mainstem propagate all the way into tributary streams.
- On Lookingglass Creek there is a main ladder and trap that remain open throughout the trapping season. This ladder is located at the Lookingglass weir, which is upstream of the hatchery facility, and is referred to as the "upper trap." There is also another trap further downstream adjacent to Lookingglass Fish hatchery that does not have a weir to encourage fish into the trap. This trap is referred to as the "lower trap" and relies solely on attraction flow to lure fish into the trap. Operations for the lower trap began in 2018 to trap broodstock and manage the number of fish spawning below the weir. The lower trap is typically opened when tribal fishing seasons have concluded. Interestingly, the lower trap captures predominately hatchery fish. One hypothesis is that the adults are attracted to this entrance because it is exact same fish ladder used to release juveniles from the hatchery. Data collected at both weirs by ODFW hatchery staff and CTUIR are now showing more hatchery returns being caught at the lower trap compared to natural origin returns (92% more hatchery origin), and overall the lower trap catches 62% of all returns even though it is only operated a fraction of the time the "upper trap" is operating.
- Lostine River: permanent hydraulic weir installed in 2010.
- A new bridge style weir was installed in the summer of 2015 on the Imnaha River and was operational for the 2016 return.

Effective weir operations are critical to managing the hatchery populations in nature, particularly pHOSij (Figure 10.2 in Objective 5). Since spawning and migration timing (for instance) are heritable, variability in adult capture creates potential risk of divergence from the natural population, if the full breadth of phenological characteristics cannot be consistently incorporated into the hatchery population. Therefore, both the weir location and the efficiency of that weir in capturing upstream moving adults are important variables. The Imnaha program is an example of a weir that has historically struggled to trap adults throughout the entire run because of its location in the watershed and an ineffective design. Prior to the construction of a new bridge style weir on the Imnaha River in 2016, the previously operated picket weir could only be safely installed when river discharge was < 28 m^3/s, and estimated weir efficiency

ranged from 30 to nearly 100% (Figure 11.3). After the new weir was operational in 2016, annual weir efficiency has been ≥ 90%. Finally, a challenge that is still present today is that up to 50% of the spawning can occurs below the weir (ODFW, unpublished data).

From 1997 to 2021, the Upper Grande Ronde River, Catherine Creek, and Lostine Rive weir efficiencies range from around 10% to above 90%. During that same time, the weir located by the Upper Trap on Lookingglass Creek has regularly exceeded capture efficiencies of 90% and is often above 95% (Figure 11.4). The 2011 return years coincided with high water events in the Grande Ronde basin that damaged the Catherine Creek, Upper Grande Ronde, and Lostine Rive weirs resulting in weir efficiencies <20%. This high-water event was a reminder that environmental factors are difficult to control.

The effectiveness of the Upper Grande Ronde weir in trapping salmon and is the requirement that it is pulled if water temperatures ≥ 20 ◦C. This requirement was put in place to prevent mortality event of adults trapped below the weir after around 300 succumbed to thermal stress below the weir in 2009. Ronde weir typically has a lower efficiency because it is pulled early (Figure 11.4). In contrast, the Catherine Creek weir tends to be one of the most efficient weirs at trapping adults, there are generally no adults spawning below the weir (ODFW, unpublished data), and the weir is in place for the length of the run (Figure 11.4).

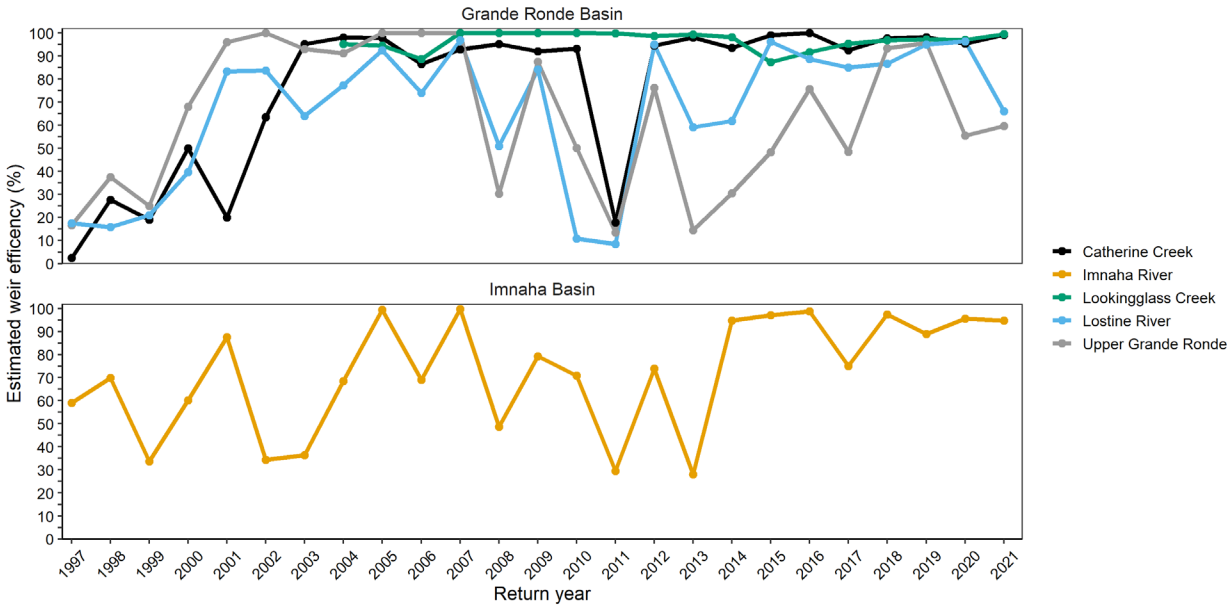

Figure 11.3. Weir efficiency by return year for streams in the Grande Ronde (Catherine Creek, Lookingglass Creek, Lostine River, and Upper Grande Ronde River) and Imnaha basins (Imnaha River).

We used the average return timing from 2018-2022 to look at patterns of hatchery and natural adults arriving at the Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Imnaha River weirs (Figure 11.4). The Imnaha River, Lookingglass Creek, and Lostine River all have bi-modal arrival times. For the Imnaha River and Lookingglass Creek, peaks occur around the middle of August and September. In the Lostine River, one peak occurs near mid-July and another in late August. Arrival time of hatchery and natural fish are nearly identical in Catherine Creek with little evidence to suggest a bi-modal arrival time. Data for the

Imnaha and Lostine suggest an earlier arrival timing of hatchery adults, with a visually larger proportion arriving in the first mode. Further monitoring will elucidate if this potential divergence continues in future years.

In the Upper Grande Ronde, hatchery fish and natural fish appear to have similar arrival time, but because the weir is pulled by the part of July, it is difficult to assess the patterns for the entire run. Low weir efficiency indicates adult salmon are escaping by the weir and we assume that it is these late arriving fish that pass the weir site after the weir is removed.

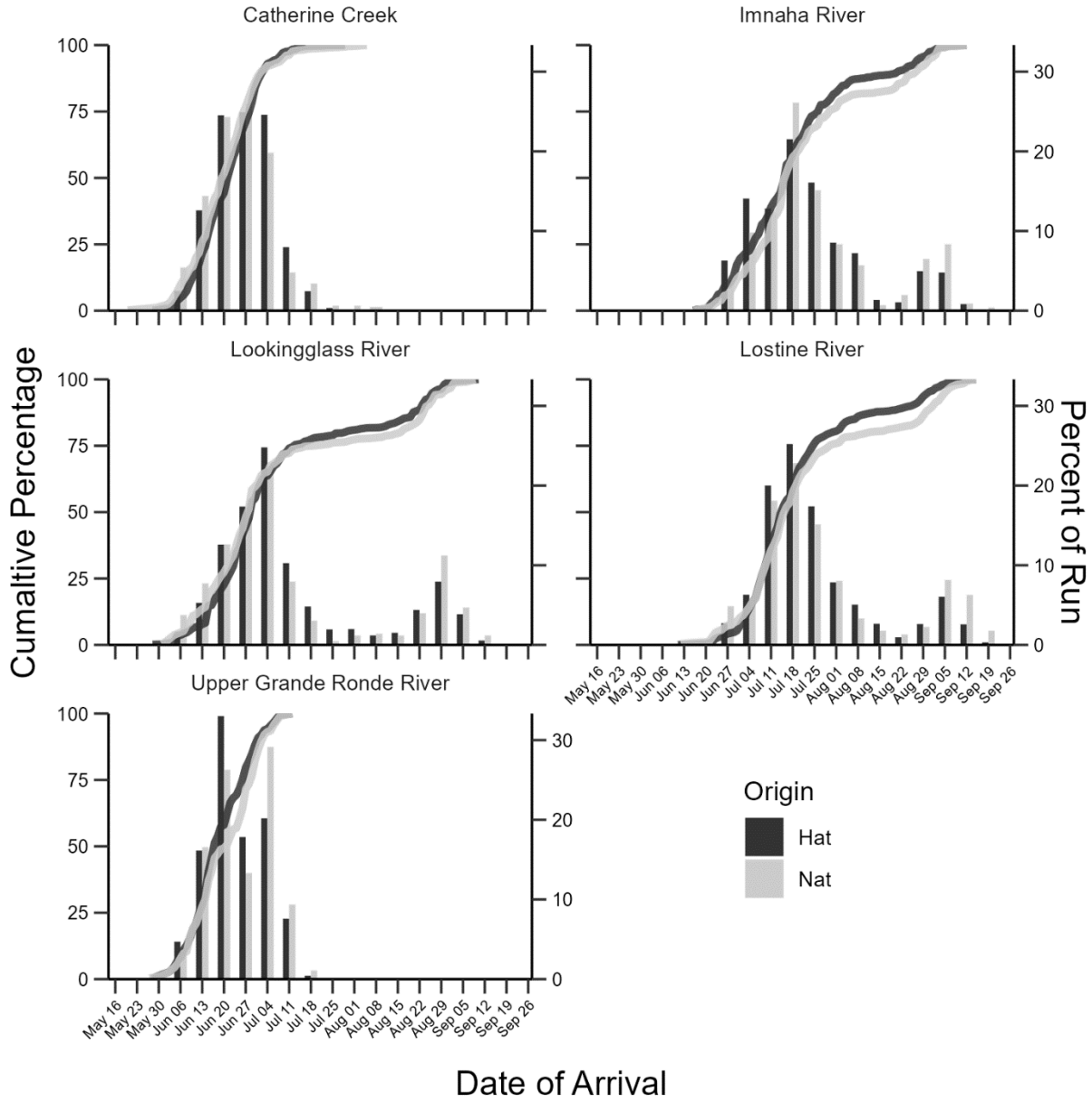

Figure 11.4: Five-year average (2018–2022) cumulative percentage of the run of both hatchery and natural adult Chinook salmon to the weirs on Catherine Creek, Imnaha River, Lookingglass River, Lostine River, and Upper Grande Ronde River by date of arrival. Bars are the five-year average (2018–2022) of the percentage of the run by week of the year for both hatchery and natural adult Chinook Salmon

Two critical functions of weirs are 1) broodstock collection, and 2) managing the number of hatchery fish in nature. Figure 11.5 shows the distribution of Chinook salmon handled at weirs on Catherine Creek, the Imnaha River, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River from 2017-2022. At all weirs, natural origin fish are either kept for broodstock or returned to the river for natural spawning. Of the total hatchery and natural spring Chinook captured at the weirs, over 50% are kept for broodstock or returned to the river for natural spawning. Because many of the fisheries are limited by natural returns, and to help manage the sliding scale, a portion of the hatchery adult returns in the Imnaha River, Catherine Creek, and Lookingglass Creek, and Lostine River weir are donated to either tribal or state foodbanks. In the Imnaha River, hatchery adults can be outplanted as live adults into Big Sheep/Lick Creek or killed and placed into Big Sheep/Lick Creek for nutrient enhancement. Hatchery adults from the Lostine River are outplanted into the Wallowa River or Hurricane Creek, and hatchery adults from Catherine Creek are outpanted for natural spawning in either Indian creek or Lookingglass creek. To support fisheries, another option is to recycle live hatchery adults downstream of active fisheries to allow more fishing opportunity. Recycling fish through fisheries occurs in Lookingglass creek, the Imnaha River, and the Lostine River.

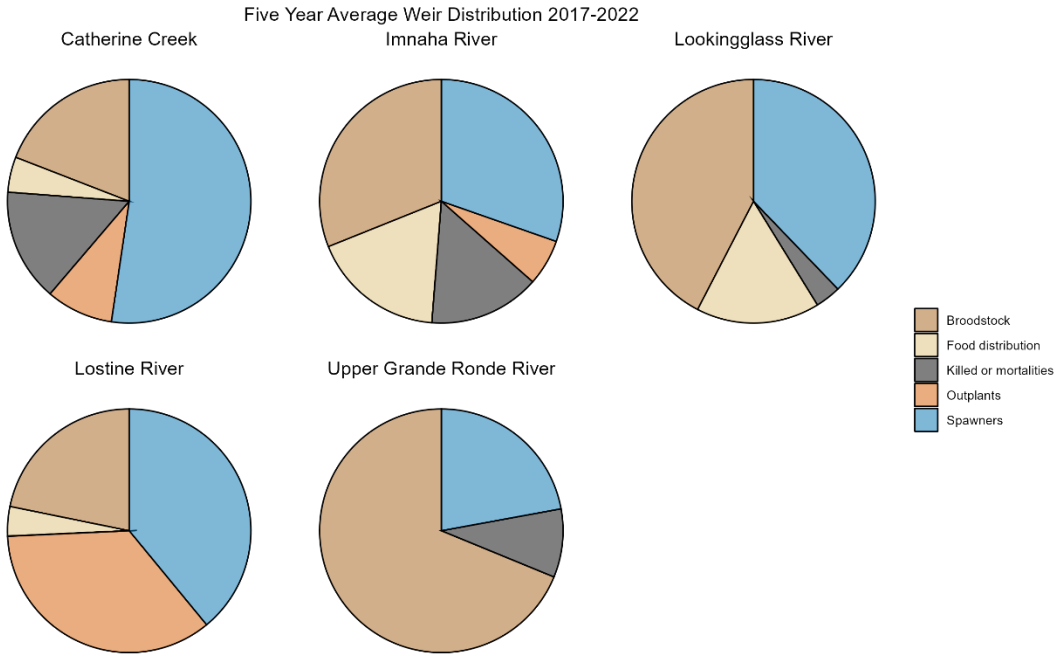

Figure 11.5. Five-year (2017–2022) average weir distribution for Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde River.

Spawning distribution

Female carcasses recovered on spawning ground surveys have been used to represent the spawning distribution of hatchery and natural Chinook salmon within a river system. For example, Hoffnagle et al. 2008 used female carcasses to examine spawning distribution hatchery and natural adult returns to the Imnaha River. This study found that even though hatchery and natural origin salmon were present throughout the Imnaha River spawning grounds, a higher proportion of hatchery fish were found near the Imnaha Juvenile Acclimation and Adult Trapping facility. One explanation for this finding was that hatchery fish were homing to their release site.

For all our supplemented populations, data averaged for returns years 2018-2022 shows that both hatchery and natural females are present throughout the entire extent of the spawning populations (Figure 11.6). Unfortunately, low natural origin returns confounded by the low recovery rate of female carcasses on the spawning grounds over the last 5 years make it difficult to accurately assess changes in spawning distribution of hatchery and natural origin salmon using female carcasses for this time series.

Another way to assess spawning distribution and changes over time is to examine redd counts. As an example, the percentage of redds below the Lookingglass weir were plotted with those observed during the endemic era study (1964 to 1971) for comparison with the current re-introduction period (see Figures 11. 7 and 11.8). These plots showed the disproportional amount of redds being constructed in the lowest section of Lookingglass below the weir compared to the endemic period. In 2018 the cooperative management of Lookingglass Creek allowed for the operation of the “lower Trap” and by 2019, only 14% of the total redds being constructed on LGC were below the weir, in comparison to 52% the previous year. Since this change in operation of the weir the percentage of redds observed below the weir is similar to that recorded in the 1960’s/70’s for the endemic stock (Figure 11.8).

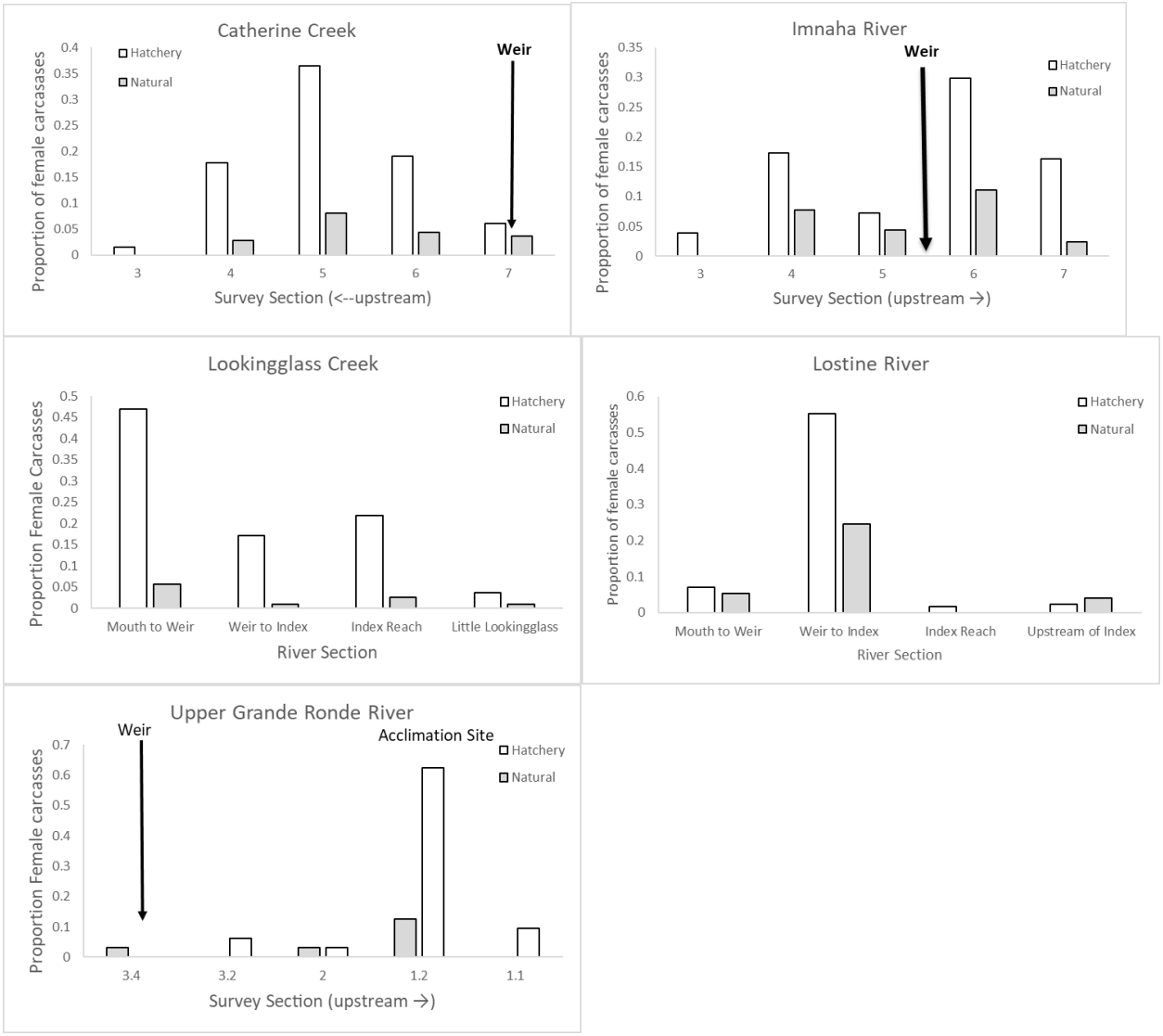

Figure 11.6. Five-year (2018–2022) average proportion of female adult Chinook carcass distribution of hatchery and natural fish across spawning survey sections on Catherine Creek, Imnaha River, Lookingglass Creek, Lostine River, and Upper Grande Ronde River.

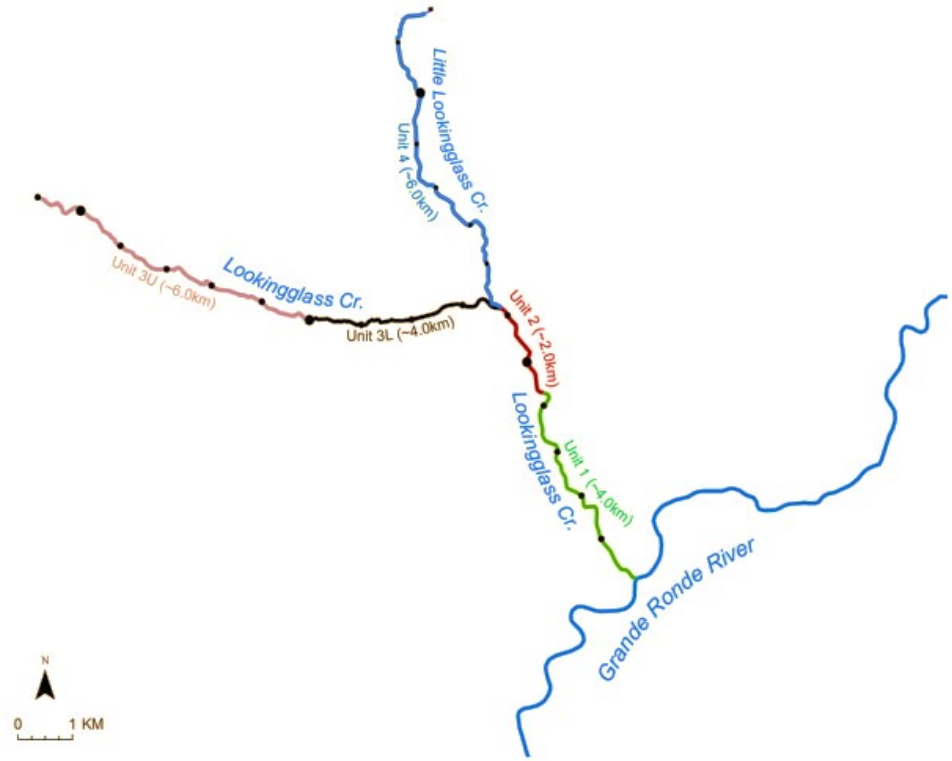

Figure 11.7. Lookingglass Creek section breaks for spawning surveys. Unit 1 is below the weir, while all other units are above.

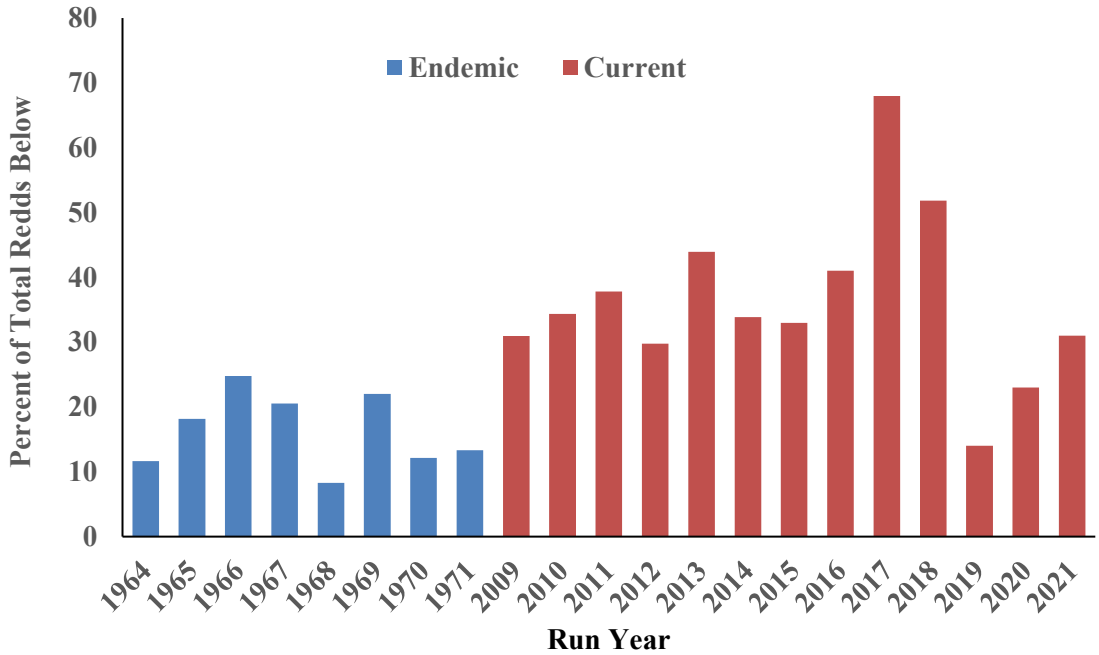

Figure 11.8. Percentage of total Chinook salmon redds on Lookingglass Creek observed below the weir during the endemic era (RY 1964-1971) and the current reintroduction era (RY 2009-2021; see Figure 11.7 for location of hatchery and weir) In 2018 both the upper and lower and traps were in use. Prior to 2018 only the upper trap was in use.

Age structure

Age structure of adult Chinook varies from year to year and varies between hatchery and natural fish. Fish captured at the weirs and spawned at the hatchery, and carcasses found on spawning ground surveys allow us to estimate overall age sturcutre for each hatchery program (Figures 11.9 and 11.10) . For all these programs, hatchery age strucure tends to be composed primarily of age 3 and age 4 returns while natural origin age sturcture is generally represented by greater proportion of age 4 and 5 adults. For all populatons, over time we have observed a decrease in the proportion of age 5 returns. Indeed, ages based on females spawned at Lookingglass Fish Hatchery indicate that age 5 females are missing from the broodstock recent years for the Catherine Creek, Lookingglas Creek, and the Upper Grande Ronde populations (See Figure 6.2 under Objective 6).

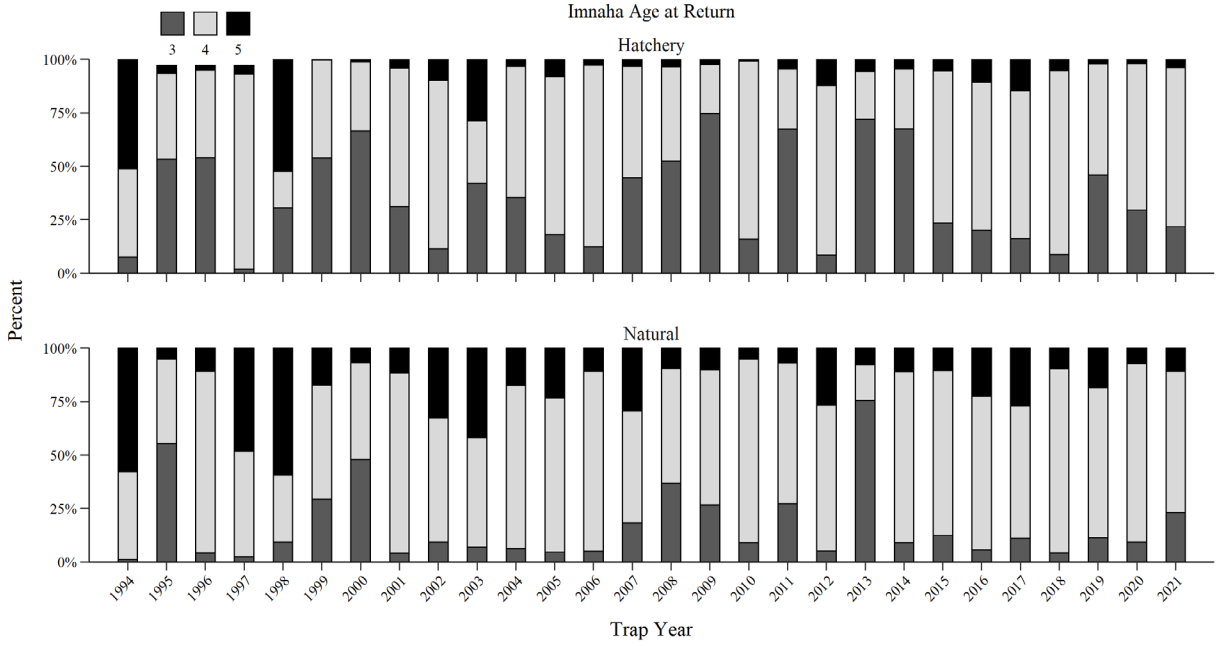

Figure 11.9. Proportion of hatchery and natural age three, four, and five adult Chinook Salmon returning to the Imnaha River by trap year.

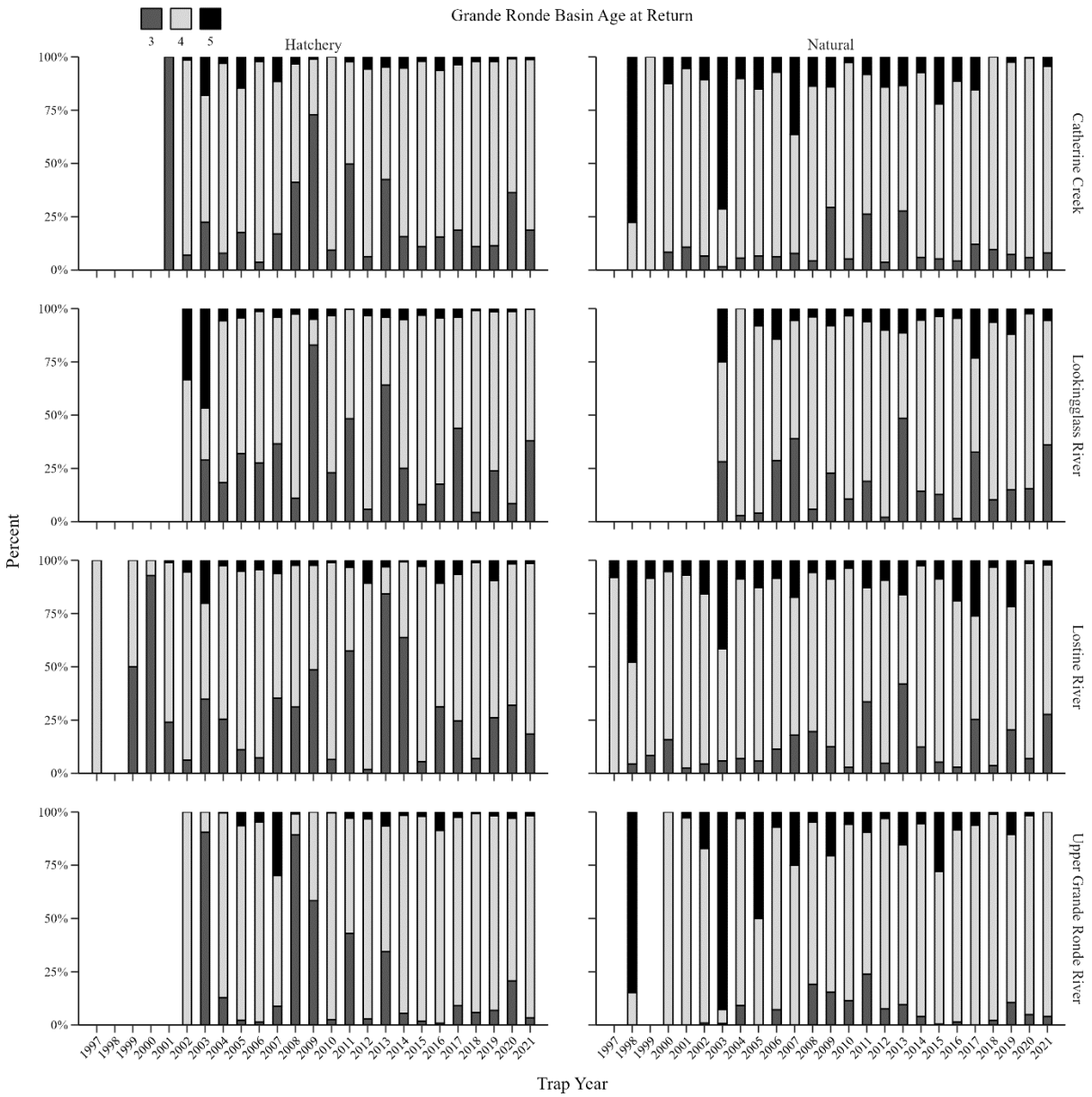

Figure 11.10. Proportion of hatchery and natural age three, four, and five adult Chinook Salmon returning to the Grande Ronde Basin (Catherine Creek, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River) by trap year.

Objective 7. Determine the success of maintaining genetic integrity of endemic wild spring Chinook salmon in the Minam and Wenaha rivers.

The primary way we assess the RM&E objective 7 is by conducting annual spawning ground surveys in the Minam and Wenaha rivers to count redds and recover salmon carcasses. Hatchery origin spring Chinook salmon carcasses recovered from annual spawning ground surveys in the Minam and Wenaha River from 1997-2021 are shown in Table 10.1. This time series was chosen because it represents a period of significant hatchery program changes. As discussed in Program development, endemic hatchery programs were developed for Catherine Creek, the Upper Grande Ronde, and Lostine River in the late 1990's. The BY 2000 (outmigration year 2002) release of Rapid River smolts represented the last non-endemic hatchery releases into the Grande Ronde Basin and they would return as adults in spawn years 2003-2006. The adult (age 3-5) returns from the Catherine creek, Upper Grande Ronde, and Lostine River programs smolt releases from BYs 1997 and 1998 began returning to the Grande Ronde Basin in spawn years 2000-2002.

Under the terms and conditions outlined in the National Marine Fisheries Service (NMFS) Section 10 permits for the Upper Grande Ronde River (permit #18033), Catherine Creek (permit #18034), Lookingglass Creek (permit #18035) and Lostine River (permit #18036) hatchery programs, monitoring for strays into the Minam and Wenaha river is required. As stated in the ESA permits, if any of the individual hatchery programs are responsible for contributing more than 5% of the total spawners to either the Minam or Wenaha rivers, co-managers are required to contact NMFS to discuss if program changes are needed to reduce the hatchery influence on the natural-origin populations. The proportion is calculated based on a 3-year running average starting in 2016 (Figure 12.1)

Proportion Hatchery Origin Spawners in the Minam and Wenaha rivers

From 2007-2021, the proportion of hatchery origin spawners (pHOS) was estimated to range from 0%-33% and 0%-50% in the Minam and Wenaha rivers, respectively (Figure 7.1). We hypothesize that years of 0 pHOS are an artifact of low carcass recovery probability, rather than dramatic inter-annual variation. Substantially more surveys (and more staff to conduct those surveys) of these wilderness streams during July-September would be needed to test this hypothesis.

During 2007-2021, the 35 CWT marked hatchery recoveries in the Minam River were primarily comprised of hatchery fish produced from the Lookingglass Creek (34%) and Lostine River (37%) programs (Table 10.2). No out-of-basin (i.e., hatchery salmon released outside the Grande Ronde and Imnaha River basin) strays have been found in the Minam River since 2007. In the Wenaha River, 62 CWT marked salmon have been recovered and 90% are from the Lookingglass Creek program (Table 10.3). One stray from the Clearwater Basin in Idaho and one stray from the Umatilla River hatchery program have been recovered in the Wenaha River.

Of the Grande Ronde basin programs, releases into Lookingglass are the predominant source of identifiable hatchery strays into the Minam and Wenaha rivers. The CWT recovery data show that the Lookingglass Creek releases are also straying into nearby streams (Table 10.4). Since 2005, the first year of age 3 returns from the CBS smolts released into Lookingglass Creek (BY 2002), Lookingglass program fish have been found in Bear Creek, Catherine Creek, the Lostine River, the Upper Grande Ronde River, Hurricane Creek, and the Wallowa River.

One reason we are unable to pair each hatchery carcass recovery with a hatchery program is because we release a portion of the hatchery smolts without a CWT. The CWT marking rates in Catherine Creek, Lookingglass Creek, and the Lostine River are currently 67%, 48%, and 50%, respectively. To aid in visual identification, the goal is to adipose clip 100% of the smolts released into the Imnaha River, Catherine Creek, Lookingglass Creek, and Lostine River hatchery programs. The goal is to mark 100% of the Upper Grande Ronde smolts with a CWT and to release 50% with an intact adipose fin. Starting about 2010, we established protocols to scan 100% of salmon carcasses recovered in the Minam and Wenaha rivers with a CWT wand and to collect genetic samples on adipose clipped hatchery salmon that lacked a CWT. The genetic sample can be used to identify the hatchery program using the parentage-based PBT baseline (Steele et al. 2019). Partly due to the low quality of genetic material recovered on decomposing carcasses, these efforts have been largely unsuccessful. However, one non-CWT marked hatchery salmon was assigned to the Lookingglass Creek program in 2014.

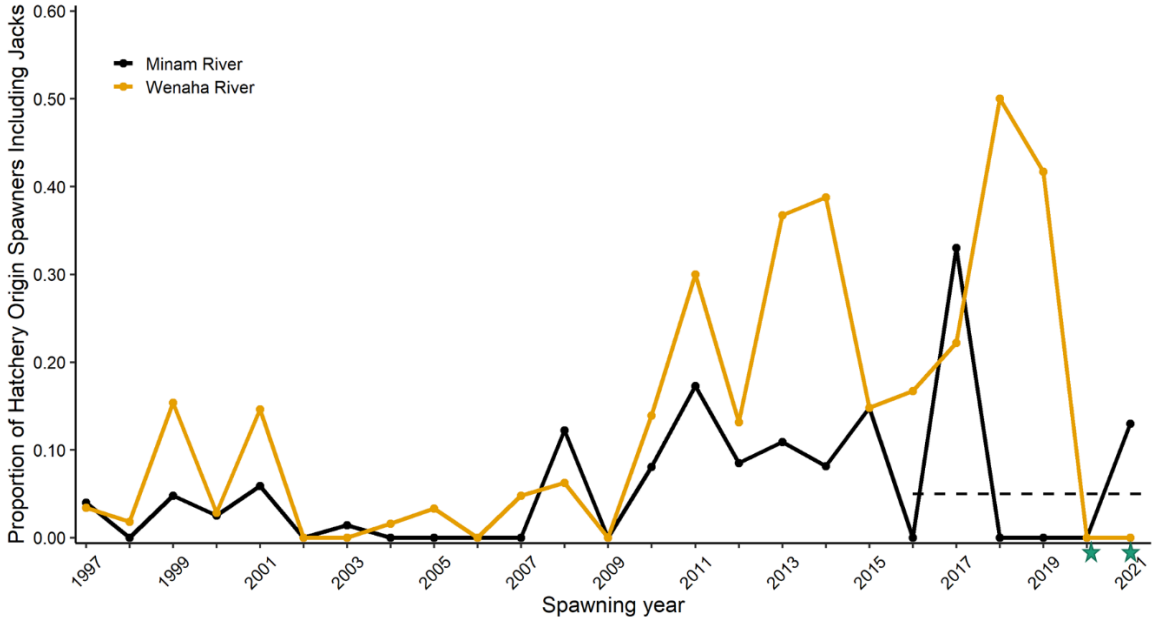

Figure 12.1. Proportion of known-origin carcasses recovered on spawning ground surveys that were of hatchery origin in the Minam and Wenaha rivers, return years 1997 to 2021. Black dashed line represents ESA Section 10 permit requirements to keep hatchery stray rates into these non-target populations ≤ 5% (3-year running average). The stars in 2020 and 2021 represent estimates based on two carcasses in the Wenaha River.

Overall, the number of carcasses we recover in the Minam and Wenaha rivers can be very low, presumably due to abundant scavengers occupying these wilderness streams. For example, in the Wenaha River only two natural origin carcass recoveries were found 2020 and 2021 and we were unable to reliably assess pHOS. These low sample sizes contribute to considerable uncertainty in calculating straying estimates. One key factor that has contributed to low carcass recoveries has been our inability to complete surveys because of wildfires. In 2015, the Grizzly Ridge complex fire burned a majority of the Wenaha driver drainage and destroyed over 80% of

the trail system used to access the river. Similarly, surveys in the upper Minam River were curtailed in 2019 because of the Granite Gulch Fire. Smoke from nearby fires also prevented complete surveys in the Minam and Wenaha rivers from 2020-2021. In 2022 multiple fires in the Eagle Cap Wilderness forced cancellation of over half the planned surveys in the Minam River. Carcass collections in these wilderness streams appear unlikely to provide precise pHOS estimates in the future, and we may need to discontinue this dataset and shift toward observation of holding adults (avoids scavenger issues, and can be conducted prior to fire activities) or other more precise and reliable metrics of pHOS in these two streams. Any new pHOS monitoring strategies are likely to require additional personnel and funding to implement however.

Table 10.1. Number of known hatchery origin carcass recoveries in the Minam and Wenaha rivers and the release hatchery. Lookingglass = hatchery salmon reared at Lookingglass and released into Grande Ronde basin streams or the Imnaha River. Unknown hatchery = no CWT code was recovered to determine hatchery source. Out-of-Basin = coded-wire-tag for hatchery programs outside the Grande Ronde and Imnaha basins.

	Minam River				Wenaha River			
Row Labels	Lookingglass	Unknown hatchery	Out Of Basin	Total	Lookingglass	Unknown hatchery	Out Of Basin	Total
1997	2	0	0	2	2	0	0	2
1998	0	0	0	0	1	0	0	1
1999	1	0	0	1	1	1	0	2
2000	2	0	0	2	0	1	1	2
2001	2	0	1	3	2	9	1	12
2002	1	0	0	1	2	0	0	2
2003	1	0	0	1	0	0	0	0
2004	1	0	0	1	1	0	0	1
2005	0	0	0	0	0	1	0	1
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	1	0	1
2008	5	2	0	7	1	0	0	1
2010	8	2	0	10	5	5	0	10
2011	13	6	0	19	15	0	0	15
2012	2	2	0	4	5	0	0	5
2013	2	4	0	6	10	10	0	20
2014	2	8	0	10	17*	15	1	33
2015	3	1	0	4	1	0	0	1
2016	0	0	0	0	1	7	1	9
2017	0	1	0	1	1	1	0	2
2018	0	0	0	0	5	6	0	11
2019	0	0	0	0	0	5	0	5
2020	0	0	0	0	0	0	0	0
2021	0	1	0	1	0	0	0	0
Total	45	1	27	73	69	4	63	136

* One hatchery carcass recovered in the Wenaha River in 2014 that lacked a CWT was identified using the PBT baseline.

Table 10.2. Hatchery carcasses found in the Minam River with a coded-wire tag and their hatchery program, spawn years 2007-2021

Spawn Year	Catherine Cr.	Upper Grande Ronde	Imnaha R.	Lookingglass Creek	Lostine River	Total
2007	0	0	0	0	0	0
2008	0	0	0	2	3	5
2010	0	2	1	2	3	8
2011	6	0	0	4	3	13
2012	0	0	0	0	2	2
2013	1	0	0	1	0	2
2014	0	0	0	1	1	2
2015	0	0	0	2	1	3
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	0	0	0	0	0
2019	0	0	0	0	0	0
2020	0	0	0	0	0	0
2021	0	0	0	0	0	0
Total	7	2	1	12	13	15

Table 10.3. Hatchery carcasses found in the Wenaha River with a coded-wire tag and their hatchery program, spawn years 2007-2021

Spawn Year	Upper Grande Ronde	Imnaha River	Lookingglass Creek	Lostine River	Out-of-Basin	Total
2007	0	0	0	0	0	0
2008	0	0	1	0	0	1
2010	0	0	5	0	0	5
2011	0	0	15	0	0	15
2012	0	1	3	1	0	5
2013	1	0	8	1	0	10
2014	0	0	16	0	1	17
2015	0	0	1	0	0	1
2016	0	0	1	0	1	2
2017	0	0	1	0	0	1
2018	0	0	5	0	0	5
2019	0	0	0	0	0	0
202.0	0	0	0	0	0	0
2021	0	0	0	0	0	0
Total	1	1	56	2	2	62

Table 10.4. Lookingglass Creek stock hatchery-origin carcasses with a CWT present that have strayed within the Grande Ronde basin, 2004-2021.

Year	Bear	Catherine	Hurricane	Lostine	Minam	UGR	Wallowa	Wenaha	Total
2004	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	2	0	2	1	5
2009	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	2	0	0	5	7
2011	0	0	0	5	4	3	0	15	27
2012	0	0	0	0	0	0	0	3	3
2013	0	1	0	0	1	0	0	8	10
2014	0	0	0	2	1	0	0	17*	20
2015	0	0	1	0	2	0	0	1	4
2016	0	0	0	1	0	0	0	1	2
2017	0	0	0	0	0	0	0	1	1
2018	1	0	0	1	0	0	0	5	7
2019	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0
Total	1	1	1	9	12	3	2	57	86

* One hatchery carcass recovered in the Wenaha River in 2014 that lacked a CWT was identified using the PBT baseline.

Objective 8: Assess success in restoring fisheries.

Managing sport and recreational fisheries in the Grande Ronde and Imnaha basins is a collaborative effort between state and tribal co-managers. The fisheries that target returns to the Imnaha and Grande Ronde hatchery programs are guided by Fishery Management and Evaluation Plans (FMEP), approved by NOAA fisheries under limit 4 of the final 4(d) rule of the Endangered Species Act (ODFW 2011, ODFW and WDFW 2012). In general, planning for fisheries begins with the pre-season run estimates that determine abundance-based sliding scales to set annual fishery impacts. In-season run monitoring of PIT tagged adult returns over Bonneville and Lower Granite dams and subsequent tributary detection at in-stream interrogation sites allows for stock-specific run-updates.

As explained by Bratcher et al. 2016, the Grande Ronde and Imnaha Basin fisheries are prescribed maximum impact rates for both direct and incidental mortality of natural-origin adult salmon in sport and tribal fisheries. Impacts are assessed for each population in relation to critical and minimum abundance thresholds (MAT) as described by the Interior Columbia Technical Recovery Team (ICTRT 2007). Importantly, the abundance-based harvest rate schedule for Imnaha and Grande Ronde Basin fisheries is shared by all fishing entities in the basin. Therefore, co-managers within each basin have a sharing agreement that provides tribal fisheries more of the natural origin impacts to reflect the non-selective nature of traditional fishing techniques. Recreational fisheries are provided a larger portion of the hatchery harvest such that all available impacts (hatchery and natural collectively) are shared equally. Harvest is not considered when hatchery run size does not exceed the number of adults identified for broodstock and supplementation needs as described by sliding scale management plans set for each population's hatchery program. Surplus is generally defined as the adult hatchery run projection less hatchery adults needed for broodstock. This approach limits sport harvest during years when wild fish runs are below MAT. In addition, near the lower end of the harvest rate scale, fisheries are not implemented until the allowable hatchery fish harvest exceeds 20 fish due to potential to over harvest within a single week.

Over the last 21 years, terminal harvest has been inconsistent (Figure 13.1). In Catherine Creek, the single sport fishery opened in 2012 resulted in an estimated harvest of 24 spring Chinook salmon hatchery adults and estimated incidental impact of 7 natural adults. Tribal harvest in Catherine Creek has been severely limited with a total of 1 spring Chinook salmon harvested in 2010, 9 in 2012, and 3 in 2021. In the Upper Grande Ronde, over the last 21 years, there have been no sport fishing opportunities. Upper Grande Ronde tribal harvest opportunities have been limited to only a few years with a total harvest in the last 21 years of 78 fish, all of which occurred from 2010 to 2016. Peak harvest numbers in the Imnaha River exceeded 2,000 adults in 2011. In the Lostine River and Lookingglass Creek, peak harvest numbers were 413 in 2010 and 983 in 2012, respectively. Between 2017 and 2021, harvest number in the Imnaha River, Lookingglass Creek, and Lostine River reduced dramatically compared to the previous 5 years (Figure 13.1). Estimated harvest from 2017 to 2021 ranged from 1 to 254 salmon in the Imnaha River, 15 to 282 in Lookingglass Creek, and 4 to 106 in the Lostine River.

Figure 13.1. Number of fish by origin and age class (jacks/adults) harvested in the terminal fisheries in Catherine Creek, the Imnaha River, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde. Harvest includes tribal harvest (BPA Project# 200206000), CTUIR tribal, and the ODFW sport fishery.

Objective 9: Coordinate project activities and disseminate results

Project coordination and timeline

As discussed in the section on Partnerships, the Grande Ronde and Imnaha River hatchery programs are complex and require significant collaboration both within the co-management structure and across agencies (Table 4, Figure 5). These partnerships and regular meetings with transparent data sharing are critical to meeting Objective 9. The timeline in Table 11.1 provides a rough overview of annual project activities and coordination.

Table 11.1. Timeline of key production, research and collaboration activities for a normal calendar year.

Project Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Production												
Catherine Creek: Chinook trapping					■	■	■					
Upper Grande Ronde: Chinook trapping					■	■	■					
Lookingglass Creek: Chinook trapping					■	■	■	■	■			
Lostine River: Chinook trapping					■	■	■	■	■			
Imnaha River: Chinook trapping						■	■	■	■			
Hatchery								■	■			
Fin clipping and CWT marking								■				
Egg shocking										■		
Egg hatching	■										■	■
Acclimate and release juvenile Chinook			■	■								
Research												
Trapping QA-QC with co-managers										■	■	
Chinook spawning ground surveys								■	■			
Adult radio tracking					■	■	■	■	■			
Hatchery juvenile PIT tagging										■		
Pre-release hatchery juvenile sampling		■	■									
Fin clip and CWT retention checks		■	■							■		
PIT array operations and maintenance	■	■	■	■	■	■	■	■	■	■	■	■
Pre-season run projections											■	■
In-season run monitoring				■	■	■	■					
Upload PIT tag data to PTAGIS	■	■	■	■	■	■	■	■	■	■	■	■
Submit annual report to the LSRCP office	■										■	■
Submit statement of work to LSRCP office						■	■					
Joint												
Annual Operating Plan development										■	■	■
Local and regional coordination	■	■	■	■	■	■	■	■	■	■	■	■
Data sharing among co-managers	■	■	■	■	■	■	■	■	■	■	■	■
ESA reporting to NOAA & USFWS	■										■	■
Reporting to Coordinated Assessments									■			

Data sharing

The ODFW, CTUIR, and NPT M&E projects rely on a combination of online databases, in-house access databases, and annual reports provided to BPA and the LSRCP office to archive and report findings. Successful project coordination, data management, and reporting of results

to fisheries managers occurs regularly at various scales and levels of complexity. A list of key data collection and reporting metrics are summarized in Table 11.2.

Table 11.2. Key data collection and reporting metrics and where data is stored and reported by the Oregon Department of Fish and Wildlife (ODFW), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Nez Per Tribe (NPT). CDMS = Central Data

Key data collection or reporting metric	Where data is stored or reported
Chinook trapping and broodstock collection	a) CTUIR stores data for the Catherine Creek, Upper Grande Ronde, and Lookingglass Creek in CTUIR's CDMS system. b) NPT stores Lostine River Chinook trapping data in 1) NPT's CDMS system, and 2) and FINS. c) ODFW stores Imnaha and Lookingglass trapping data in FINS d) Chinook trapping data for all traps is also reported to the ODFW Hatchery Management System. e) ODFW annual reports submitted to LSRCP f) Individual reports by NPT and CTUIR to BPA
Egg Collection Numbers	a) ODFW Hatchery Management System b) ODFW in-house access database c) ODFW annual reports submitted to LSRCP
Hatchery broodstock spawning records	a) ODFW Hatchery Management System b) ODFW in-house access database c) ODFW annual reports submitted to LSRCP d) CTUIR CDMS system for Lookingglass Creek, Upper Grande Ronde, Catherine Creek
Chinook spawning ground surveys	a) ODFW in-house access database b) portions of the data are uploaded to NPT and CTUIR CDMS systems c) Redd counts and carcass data StreamNet (www.streamnet.org)
Genetic samples	a) Starting in 2008, genetic samples for the parentage-based tagging baseline (BPA # 201003100; Steele et al. 2019) have been collected from all Chinook salmon spawned at Lookingglass Fish Hatchery for all five hatchery programs. b) relative reproductive success evaluations on Catherine Creek and Lookingglass Creek (BPA # 198909600) c) relative reproductive success study in Lookingglass Creek (BPA #200900900)
Juvenile release numbers, number of CWT marked releases, release locations	a) ODFW Hatchery Management System b) ODFW annual reports submitted to LSRCP c) Individual reports by NPT and CTUIR to BPA. d) Pacific States Reginal Mark Processing Center (rmpc.org)
Coded-wire-tagged fish recoveries	a) ODFW Hatchery Management System b) ODFW annual reports submitted to LSRCP c) Pacific States Reginal Mark Processing Center (rmpc.org)
PIT tagged hatchery releases	a) ODFW annual reports submitted to LSRCP b) PTAGIS.org
PIT tag detections (in-stream or adult ladders and traps).	Both ODFW, NPT, and CTUIR collaborate to operate and maintain PIT tag equipment to monitor streams and fish ladders, and to scan individual adults at Chinook traps in the Grande Ronde and Imnaha basin. All data is submitted to PTAGIS. Efforts support BPA Project #201005700.
Harvest Monitoring	a) In-season harvest sport and tribal harvest information is shared during weekly meetings with co-managers. b) For sport fisheries, data is provided in ODFW annual reports submitted to LSRCP.

	c) CTUIR and NPT complete independent harvest monitoring efforts. Harvest data is shared via e-mail and in annual reports.
Smolt-to-Adult-Survival (SAS) and Smolt-to-Adult Return (SAR) rates	a) Hatchery SAR/SAS rates are in ODFW annual reports submitted to LSRCP for all five hatchery programs. b) Hatchery SAR rates: NPT and CTUIR provide in reports to BPA. c) Natural SAR estimates. ODFW reports Catherine Cr, Upper Grande Ronde, Lostine R, Minam R to https://cax.streamnet.org. CTUIR reports natural SAS and SAR to LSRCP and data is stored on the CTUIR CDMS system.
Outmigration juvenile survival rates	a) ODFW annual reports submitted to LSRCP b) Individual reports by NPT and CTUIR to BPA and LSRCP. c) Natural origin Chinook outmigrant estimates: StreamNet Coordinated Assessments https://cax.streamnet.org
Stray-rates (in-basin and out of basin)	a) ODFW annual reports submitted to LSRCP
Recruit:Spawner ratios 1. Spawner:Spawner 2. Return to river: spawner 3. Smolts:spawner	a) ODFW and CTUIR annual reports submitted to LSRCP b) StreamNet Coordinated Assessments https://cax.streamnet.org
Proportion of natural influence (PNI)	a) ODFW annual reports submitted to LSRCP
Percent Hatchery Origin Spawners (PHOS)	a) For Grande Ronde and Imnaha basin populations, including Minam and Wenaha rivers: StreamNet Coordinated Assessments https://cax.streamnet.org
Natural Origin Spawner Abundance (NOSA)	a) For Grande Ronde and Imnaha basin populations, including Minam and Wenaha rivers: StreamNet Coordinated Assessments https://cax.streamnet.org

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