LOWER SNAKE RIVER COMPENSATION PLAN:
Oregon Spring Chinook Salmon Evaluation Studies
2015 Annual Progress Report

Oregon Department of Fish and Wildlife
Northeast-Central Oregon Research and Monitoring

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LOWER SNAKE RIVER
COMPENSATION PLAN

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Photo cover: ODFW Spring Chinook Salmon spawning ground surveyors on the Imnaha River: Photo by Joseph Feldhaus.

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Preface

This annual progress report provides summary information for Lower Snake River Compensation Plan (LSRCP) spring Chinook Salmon programs operated by the Oregon Department of Fish and Wildlife (ODFW) in the Imnaha and Grande Ronde river basins during 2015. Also included in this report are summaries of data collected at Chinook Salmon broodstock collection facilities operated by our co-managers, the Nez Perce Tribe (Lostine River) and the Confederated Tribes of the Umatilla Indian Reservation (Catherine Creek and Upper Grande Ronde River), and funded by the Bonneville Power Administration. These ongoing monitoring and evaluation programs provide technical, logistical, and biological information to managers charged with maintaining viable natural Chinook Salmon populations, and managing hatchery programs and recreational and tribal fisheries in northeast Oregon.

The data in this report serve as the basis for assessing the success of meeting our management objectives and were derived from hatchery inventories, standard databases (e.g., PSMFC, coded-wire tag), through standard sampling techniques, or provided by other agencies. As such, specific protocols are usually not described. When possible, data obtained from different sources were cross-referenced and verified. In cases where expansions of data or unique methodologies were used, we describe protocols in more detail. Additional descriptions of protocols can be found in the 2015 work statement (Carmichael et al. 2015).

We used coded-wire tag (CWT) data collected from 2013-2015 returns to evaluate smolt-to-adult survival rates, harvest, straying, escapement, and specific information on experimental results. In addition, much of the data that we discuss in this report will be used in separate and specific evaluations of ongoing supplementation and research programs for Chinook Salmon in the Imnaha and Grande Ronde river basins. We began salmon culture evaluations in 1983 and have improved many practices. Progress for work completed in previous years is presented in annual progress reports (Carmichael and Wagner 1983; Carmichael and Messmer 1985; Carmichael et al. 1986a; 1987; 1988; 1999; 2004; Messmer et al. 1989; 1990; 1991; 1992; 1993; Hoffnagle et al. 2005; Monzyk et al. 2006a; b; c; d; e; 2007; 2008a; b; Feldhaus et al. 2010; 2011; 2012a;b; 2014a;b; 2016; 2017a) and United States v Oregon production report (Carmichael et al. 1986b).

In this report, data are organized into salmon culture monitoring for juvenile and mature salmon (ages 3-5), CWT recoveries, compensation goals, hatchery and natural escapement monitoring, and bacterial kidney disease monitoring. During the period covered in this report, juveniles from brood year (BY) 2013 were hatched, ponded and tagged, Chinook Salmon smolts from BY 2013 were released, Chinook Salmon from BYs 2010-2012 returned to spawn in 2015, and some of those mature Chinook Salmon were used to create BY 2015.

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EXECUTIVE SUMMARY

For 2013 brood year (BY) Imnaha River Chinook Salmon smolts released in 2015, the green egg-to-smolt survival rate was 85.0% and we released 331,702 smolts. We estimated that 99.9% of these smolts were visually marked with an adipose fin clip (AD clip) or internally tagged with a coded-wire tag (CWT). The AD clip and CWT tag facilitate identification of returning adults as hatchery origin. In addition, we released BY 2013 smolts from the Grande Ronde Basin Spring Chinook Salmon Conventional Hatchery Program (CHP) into four Grande Ronde Basin streams. Green egg-to-smolt survival rate of BY 2013 Catherine Creek CHP smolts released into Catherine Creek was 78.6%. We released 146,310 CHP smolts into Catherine Creek and estimate that 99.9% were identifiable as hatchery origin. The green egg-to-smolt survival rate of Upper Grande Ronde River CHP smolts was 89.4%. We released 224,443 CHP smolts into the Upper Grande Ronde River and 97.8% were identifiable as hatchery origin. The green egg-to-smolt survival rate of Lookingglass Creek CHP smolts released into Lookingglass Creek was 72.0%, we released 176,440 smolts, and 100% were identifiable as hatchery smolts. The green egg-to-smolt survival rate of the 249,369 CHP smolts released into the Lostine River was 84.6%, and 100% were identifiably as hatchery origin.

Mean survival rate of Imnaha River smolts from the release site to Lower Granite Dam was 68%. In the Grande Ronde Basin, the lowest mean smolt survival rate from the release site to Lower Granite Dam was 27% from Catherine Creek CHP smolts released at the Catherine Creek Acclimation site. The highest mean survival rate was 64% for Lostine River CHP smolts released from the Lostine River Acclimation site.

We estimated that 4,727 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River in 2015, 29.5% of the total mitigation goal of 16,050 mature hatchery salmon. We also estimated that 2,725 mature Imnaha River hatchery Chinook Salmon returned to the Lower Snake River Compensation Plan area above Lower Granite Dam in 2015, achieving 84.9% of the hatchery compensation goal (3,210) for the Imnaha River Basin. In addition, we estimated that 768 mature natural origin Chinook Salmon returned to the Imnaha River. An estimated 435 mature hatchery Chinook Salmon were harvested in sport (ODFW) and tribal (CTUIR and NPT) fisheries in the Imnaha River and an estimated 1,945 mature Chinook Salmon were harvested in fisheries below Lower Granite Dam, 15.2% of the downstream harvest mitigation goal (12,840)

We estimated that 6,826 Grande Ronde Basin hatchery Chinook Salmon returned to the Columbia River in 2015, 23.3% of the total mitigation goal of 29,300 mature hatchery Chinook Salmon. Below Lower Granite Dam, we estimated 1,420 Grande Ronde Basin hatchery Chinook Salmon were harvested in fisheries, 6.1% of the downstream harvest mitigation goal (23,440). We estimated that 5,398 mature hatchery salmon (503 Catherine Creek, 1,723 Grande Ronde River, 1,418 Lookingglass Creek, and 1,754 Lostine River) returned to the compensation area, achieving 92.1% of the compensation goal (5,860) for the Grande Ronde Basin. In 2015, we estimated that 459 hatchery and 314 natural salmon returned to Catherine Creek, 1,642 hatchery and 401 natural salmon returned to the Upper Grande Ronde River, 1,376 hatchery and 357 natural salmon returned to Lookingglass Creek, and 1,620 hatchery and 573 natural salmon returned to the Lostine River. In Lookingglass Creek, CTUIR and NPT reported that tribal fishers harvested a total of 329 mature hatchery salmon and ODFW estimated that sport fishers harvested 171 mature hatchery salmon. There were no sport or tribal fisheries in Catherine Creek or the Upper Grande Ronde River. Tribal fishers reported a harvest of 572 mature

hatchery salmon in the Lostine River and the ODFW estimated sport fishers harvested 138 mature hatchery salmon in the Wallowa River. Additionally, ODFW estimated that zero mature hatchery salmon were harvested in the Lower Grande Ronde River Pilot fishery near Troy, OR (Bratcher et al. 2015).

After accounting for the estimated number of unmarked mature hatchery returns, the Oregon Department of Fish and Wildlife trapped 1,661 hatchery and 456 natural Chinook Salmon at the Imnaha River weir and 788 hatchery and 273 natural Chinook Salmon in Lookingglass Creek. In the Grande Ronde Basin, the Confederated Tribes of the Umatilla Indian Reservation captured 441 hatchery and 304 natural Chinook Salmon in Catherine Creek and 780 hatchery and 200 natural Chinook Salmon in the Upper Grande Ronde River. The Nez Perce Tribe captured 595 hatchery and 416 natural Chinook Salmon in the Lostine River.

During the 2015 spawn year at Lookingglass Fish Hatchery, we spawned 100 hatchery and 35 natural females from the Imnaha River and collected 615,672 green eggs. From Catherine Creek, we spawned 33 hatchery and 20 natural females and collected 233,109 green eggs. In the Upper Grande Ronde River, we spawned 62 hatchery and 23 natural females, and collected 356,924 green eggs. In Lookingglass Creek, we spawned 48 hatchery females and 27 natural females and collected 262,782 green eggs. In the Lostine River, we spawned 46 hatchery females and 26 natural females and collected 318,550 green eggs. A greater number of eggs were collected from age 4 (88.8%) than age 5 (11.2%) females and the mean egg weight of age 5 females (0.26 g) was greater than that of age 4 females (0.22 g).

In the Imnaha River, the BY 2010 recruits-per-spawner (R:S) ratio was 9.5 for the hatchery program and 0.4 for naturally spawning salmon. In the Grande Ronde Basin, BY 2010 R:S for the CHP component was 9.4 in Catherine Creek, 8.7 in the Upper Grande Ronde River, 14.3 in Lookingglass Creek, and 17.7 in the Lostine River. The natural component R:S for BY 2010 was 0.7 in Catherine Creek, 0.4 in the Upper Grande Ronde River, 0.7 in Lookingglass Creek, and 0.3 in the Lostine River.

In 2015, we observed 619 redds and recovered 340 carcasses during spawning ground surveys in the Imnaha River Basin. Hatchery salmon comprised 66.0% of known origin carcass recoveries. In the Grande Ronde Basin, we observed 1,279 redds and recovered 769 carcasses. We recovered 27 hatchery salmon outside of the stream into which they were released as smolts (i.e., strays). The percentage of known hatchery salmon recovered on spawning ground surveys was 65.2% in Catherine Creek, 88.4% in the Upper Grande Ronde River, 83.1% in Lookingglass Creek, 54.8% in the Lostine River, 14.8% in the Minam River, and 11.1% in the Wenaha River.

To estimate pre-spawn mortality rates, we examined female carcasses for egg retention. For streams with ≥20 female carcass recoveries, pre-spawn mortality rates ranged from 0.0% in Hurricane Creek to 37.8% in the Upper Grande Ronde River. We recovered 12 female carcasses in the Minam River and eight in the Wenaha River, and none of these females were pre-spawn mortalities. Estimated pre-spawn mortality rates for the Imnaha River, Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River were 15.0%, 2.1%, 37.8%, 24.6%, 22.8%, respectively.

To monitor bacterial kidney disease (BKD), we collected 220 Chinook Salmon kidney samples from Imnaha River Basin streams and 538 kidney samples from Grande Ronde Basin streams in 2015. The enzyme-linked immunosorbent assay optical density values remain very low in samples collected in both hatchery and natural-origin salmon. We found no evidence that hatchery salmon releases are causing an increase in BKD prevalence in the monitored streams.

INTRODUCTION

This annual progress report summarizes spring-summer Chinook Salmon monitoring data collected by ODFW for the Lower Snake River Compensation Plan (LSRCP) facilities in 2015. Also summarized are the associated broodstock monitoring data collected at weirs in the Grande Ronde Basin that are operated by our co-managers, the Nez Perce Tribe (NPT; Lostine River) and Confederated Tribes of the Umatilla Indian Reservation (CTUIR; Catherine Creek and Upper Grande Ronde River). The main objectives of this report are to document and evaluate spring-sumer Chinook Salmon culture performance for hatchery programs and achievement of management objectives in the Imnaha and Grande Ronde river basins (CTUIR and NPT have specific program goals for Chinook returns to Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River that are discussed and evaluated in separate reports prepared by each co-management agency). Overall, these data are used to adaptively manage salmon culture practices in order to optimize egg-to-smolt survival rate, smolt quality, smolt-to-adult survival rate, the recruits-per-spawner (R:S) ratio, and to monitor spawning in nature by hatchery-reared salmon.

This report provides information on rearing and release operations for brood year (BY) 2013 of juvenile Chinook Salmon smolts, the collection of eggs for BY 2015, numbers and characteristics (e.g., age composition) of mature Chinook Salmon in the 2015 return year, the 2015 spawning year at Lookingglass Fish Hatchery and in nature, BKD monitoring, and survival information (e.g., SAR, R:S) for BY 2010. These metrics document the success of these programs in meeting the LSRCP objectives for mature salmon returning to the mitigation area above Lower Granite Dam (LGD) and for harvest below LGD. In order to avoid confusion around whether jacks (age 3) are included with adult metrics, we will use the convention that "adults" include only ages 4 and 5 and "total" or "mature salmon" include all sexually mature salmon ages 3–5.

LSRCP Chinook Salmon Program Objectives

There were seven program objectives originally outlined by Carmichael and Wagner (1983).

1. Establish for each designated stock an annual supply of brood fish that can provide an egg source capable of meeting compensation goals for spring Chinook Salmon and summer steelhead in the Grande Ronde and Imnaha systems.
2. Restore and maintain natural spawning populations of spring Chinook Salmon and summer steelhead in the Grande Ronde and Imnaha River systems.
3. Re-establish sport fisheries for spring Chinook Salmon and summer steelhead in the mainstem Snake River and tributaries.
4. Minimize the effects of hatchery releases on stocks of resident game fish.
5. Determine total survival (catch and escapement) for compensated stocks of salmon and steelhead.
6. Determine if the total return of adult spring Chinook Salmon resulting from LSRCP activities in Oregon meets the compensation goals for Oregon.

7. Continue the technical oversight of the program to make recommendations that will ensure consistency of operation with inter-agency agreements on principles, procedures, and goals for LSRCP hatchery operations.

These program objectives were updated following the 1990 and 1998 symposium reviews (Carmichael et al. 1990, Carmichael et al. 1998). At the request of LSRCP (S. Yundt, personal communication, 2014), definitions for Oregon compensation goals were clarified in Feldhaus et al. (2014a), based on Corps of Engineers (1975) and Herrig (1990). Our compensation goals are now stated as follows:

1. Establish adequate broodstock to meet annual production goals.
2. Establish a consistent total return of Chinook Salmon that meets the LSRCP mitigation goal of 3,210 mature (ages 3–5) hatchery salmon in the Imnaha River Basin and 5,860 mature hatchery salmon in the Grande Ronde Basin with a 4:1 catch to escapement ratio (commercial catch 3:1 and sport catch 1:1) in the Pacific Ocean and the Columbia River System downstream from the Lower Snake River Project Area (Corps of Engineers 1975). The total production goal is 16,050 mature hatchery Chinook Salmon from the Imnaha hatchery program (12,840 mature salmon below LGD and 3,210 mature salmon above LGD) and 29,300 mature hatchery salmon from the Grande Ronde Basin hatchery programs (23,440 mature salmon below LGD and 5,860 mature salmon above LGD; Herrig 1990).
3. Re-establish historic tribal and recreational fisheries.
4. Minimize impacts of hatchery programs on resident stocks of game fish.
5. Prevent extinction of Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde River Chinook Salmon populations and ensure a high probability of population persistence well into the future, once causes of basin-wide declines have been addressed
6. Operate the hatchery program so that the genetic and life history characteristics of hatchery salmon mimic those of wild salmon, while achieving mitigation goals.
7. Maintain genetic and life-history characteristics of natural Chinook Salmon populations in the Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde River.
8. Maintain the genetic and life-history characteristics of the endemic wild populations of Chinook Salmon in the Minam and Wenaha rivers.
9. Provide a future basis to reverse the decline in abundance of endemic Chinook Salmon populations in the Imnaha and Grande Ronde river basins.

Research Monitoring and Evaluation Objectives

1. Document Chinook Salmon rearing and release activities at all LSRCP facilities.
2. Determine optimum rearing and release strategies that will produce maximum survival to adulthood for hatchery-produced Chinook Salmon smolts.
3. Document Chinook Salmon returns of mature salmon to broodstock collection facilities in the Imnaha River, Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River.
4. Estimate annual returns of mature hatchery salmon to the LSRCP compensation area and total hatchery salmon production, and determine success in meeting mitigation goals.

5. Estimate annual commercial, sport and tribal harvest of Imnaha River and Grande Ronde Basin hatchery Chinook Salmon and determine success in meeting mitigation goals.
6. Estimate annual smolt survival to Lower Granite Dam (LGD) for production and experimental groups.
7. Conduct index, extensive, and supplemental Chinook Salmon spawning ground surveys for all populations in northeast Oregon to assess spawn timing and spawning distribution, and estimate natural spawner escapement.
8. Determine the proportion of naturally spawning spring Chinook Salmon that are of hatchery origin in the Imnaha and Grande Ronde basin Chinook Salmon populations.
9. Determine annual escapement and spawner numbers to estimate and compare productivity (recruits-per-spawner) and survival rates for natural- and hatchery-produced Chinook Salmon in the Imnaha and Grande Ronde basins.
10. Compare life history characteristics (age structure, run timing, sex ratio, egg size, and fecundity) of hatchery and natural origin salmon.
11. Coordinate Chinook Salmon broodstock marking programs for Lookingglass Fish Hatchery.
12. Participate in planning activities associated with anadromous salmon production and management in the Imnaha and Grande Ronde river basins and participate in ESA permitting, consultation, and recovery planning.

METHODS, RESULTS, AND DISCUSSION

During 2015, spring Chinook Salmon from BY 2013 produced from the Conventional Hatchery Program (CHP) were released into the Imnaha River, Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River. The final Captive Broodstock Program (CBS) smolts were released into the Lostine River in 2013 (BY 2011) and comprised a portion of the age 4 hatchery returns to the Lostine River. Mature Chinook Salmon from BYs 2010–2012 returned to spawn and some of these returns were collected from each population to use as broodstock to create offspring for the BY 2015 CHP production. All of these salmon were reared at Lookingglass Fish Hatchery. Coded-wire-tag (CWT) recoveries from mature hatchery salmon were used to assess the success of achieving mitigation goals and management objectives. In addition, much of the data discussed in this report will be used in separate and specific evaluations of ongoing supplementation programs for Chinook Salmon in the Imnaha and Grande Ronde river basins.

2013 Brood Year Juvenile Rearing and Release

2013 Brood Year Egg to Smolt Survival

Green egg-to-smolt survival rate for BY 2013 Imnaha River Chinook Salmon released in 2015 was 85.0% (92.0% green egg-to-eyed egg; 92.4% eyed egg-to-smolt; Table 1). Green egg-to-smolt survival rate for Catherine Creek CHP salmon was 78.6% (83.6% green egg-to-eyed egg; 94.0% eyed egg-to-smolt). For the Upper Grande Ronde River, the green egg-to-smolt survival rate was 89.4% (91.7% green egg-to-eyed egg; 97.5% eyed egg-to-smolt) for CHP offspring. For Lookingglass Creek CHP salmon, the green egg-to-smolt survival rate was 72.0% (80.8% green egg-to-eyed egg; 89.5% eyed egg-to-smolt). For Lostine River CHP salmon, the

green egg-to-smolt survival rate was 84.6% (89.3% green egg-to-eyed egg; 94.7% eyed egg-to-smolt).

In an effort to reduce the incidence of BKD in Chinook Salmon offspring, the ODFW Fish Health recommends that eggs from female Chinook Salmon from the CHP program with enzyme-linked immunosorbent assay (ELISA) optical density values ≥ 0.2 should be culled. We only culled eggs from one Lookingglass Creek hatchery female in 2013(ELISA 0.213).

2013 Brood Year Production and Tagging

The release of 331,702 Imnaha River BY 2013 smolts in 2015 was below both the long-term juvenile production goal of 490,000 and the specific annual production goal of 360,000[*] (Table 1). The long-term juvenile production goals for the Grande Ronde Basin were set 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. We released 146,310 CHP smolts from the BY 2013 CHP production into Catherine Creek in 2015, achieving 97.5% of the juvenile production goal. The Upper Grande Ronde River BY 2013 production released 224,443 CHP smolts in 2015, 89.8% of the juvenile production goal. In Lookingglass Creek, we released 176,440 smolts from the Lookingglass Creek CHP, achieving 70.6% of the juvenile production goal. In the Lostine River, we released 249,369 CHP smolts, 99.7% of the juvenile production goal. Consistent challenges that have sometimes limited smolt production include low returns of mature salmon, low capture rates at weirs, and space limitations at Lookingglass Fish Hatchery.

Hatchery origin smolts are identified by either an adipose (Ad) fin clip, a coded-wire-tag (CWT), or an Ad clip and a CWT (Ad CWT). Target numbers of parr to be tagged and marked differed among stocks. We evaluated BY 2013 smolts released in 2015 for CWT and mark application success by checking least 500 juvenile Chinook Salmon from each raceway at Lookingglass Fish Hatchery (Table 2). Smolts were sampled on either 1 October 2015 or from 9-10 February 2015. We sampled smolts during two different time periods because the ponding plan at Lookingglass Fish Hatchery resulted in smolts marked with only an Ad fin clip being mixed with Ad CWT marked smolts. To accurately represent the proportion of smolts marked with an Ad CWT, sampling had to occur before the Ad marked salmon were mixed with the Ad CWT marked salmon. The intention was for raceways with CWTs to receive a unique code, but as a result of ponding logistics to reduce smolt densities, some raceways received multiple CWT codes. We are working with the hatchery to modify ponding plans to prevent the mixing of CWT codes.

For Imnaha River smolts, a unique CWT code was used in four of the five raceways (Table 2). The 68,278 smolts in Raceway 7 only received an Ad clip (100%). Some smolts that were only marked with an Ad clip were placed into the four raceways with the unique CWT codes. We estimate that 1,240 Ad clipped smolts were placed into Raceway 5, 2,461 were placed into Raceway 6, 3,622 were placed into Raceway 8, and 2,347 were placed into Raceway 9. For the portion of smolts receiving both an Ad clip and a CWT, we estimated that 99.2% were successfully marked with both marks, 0.8% received an Ad clip but no CWT, 0.1% had a CWT but no Ad clip, and 0% were released unmarked. The fin clip application success was estimated at 99.6% for the portion receiving just Ad clips. For smolts released from all five raceways combined, we estimated that 99.9% of the smolts were identifiable as hatchery origin.

[*] Due to space limitations at Lookingglass Fish Hatchery, the annual production goal was less than the LSRCP mitigation goal.

For smolts released into Catherine Creek, four unique CWT codes were placed into two raceways (Table 2). Additionally, smolts marked with only an Ad clip were placed into the two raceways with smolts marked with both an Ad clip and a CWT. For the portion of smolts receiving both Ad clips and CWTs, we estimated that 99.6% of the smolts received both an Ad clip and a CWT, 0.2% received an Ad clip but no CWT, 0.2% had a CWT but no Ad clip, and 0% were released unmarked. Fin clip application success was estimated at 100% for the portion that received just Ad clips. For all smolts released into Catherine Creek, we estimated that 100% of the smolts were identifiable as hatchery origin.

For Upper Grande Ronde River smolts, we attempted to mark 100% the smolts in two raceways with both an adipose fin clip and a CWT and the two remaining raceways were only marked with CWTs (Table 2). For the raceways receiving both adipose fin clips and CWTs, we estimated that 97.9% were successfully marked with both marks, 1.3% were only marked with an Ad clip, 0.8% were only marked with a CWT, and 0% were released unmarked. For the two raceways marked with only a CWT, 95.9% were successfully tagged and 4.1% were released untagged. For smolts released from all four raceways combined, we estimated that 97.9% of the smolts were identifiable as hatchery origin.

We reared three raceways of Lookingglass Creek CHP smolts and four unique CWT codes were placed into these three raceways (Table 2). Additionally, 77,748 smolts that were only marked with an Ad clip were placed into the same three raceways. For the portion of smolts that received both Ad clips and CWTs, we estimated that 99.0% of the smolts received both marks, 1.0% were only marked with an Ad clip, 0% had a CWT but no Ad clip, and 0% were released unmarked. For the portion that only received an Ad clip, we estimated that 100% were successfully marked and 0% were released unmarked. For smolts released from all three raceways combined, we estimated that 100% of the smolts were identifiable as hatchery origin.

We reared four raceways of Lostine River CHP smolts and placed 5 unique CWT codes into these same raceways (Table 2). For the portion of smolts that received both Ad clips and CWTs, we estimated that 88.9% of the smolts received both marks, 11.1% were only marked with an Ad clip, 0% had a CWT but no Ad clip, and 0% were released unmarked. For the estimated 103,950 smolts that only received an Ad clip, we estimated that 100% were successfully marked and 0% were released unmarked. Overall, we estimated that 100% of the Lostine River smolts were identifiable as hatchery origin.

2013 Brood Year Downstream Survival

We monitored smolt migration success based on survival to Lower Granite Dam (LGD) for all stocks. We compiled release-recapture information for PIT-tagged smolts from each raceway to calculate Cormack-Jolly-Seber survival probabilities (rates) to LGD with a single release recapture model using the PIT Pro 4 Program (Westhagen and Skalski 2009). Mean stock survival was calculated as the mean of the raceways for each stock.

Three raceways containing BY 2013 Imnaha River Chinook Salmon smolts were transported to the Imnaha River Acclimation and Trapping Facility on 26 March 2015 (Table 3). Two raceways were released directly into the Imnaha River at the Imnaha River Acclimation Facility, one raceway on 14 April 2015 and the second on 15 April 2015. Volitional release of the acclimated smolts began on 1 April 2015. All remaining smolts in the acclimated group were forced out on 8 April 2015. Mean survival rate to LGD for smolts directly released into the

Imnaha River at the acclimation facility was 73% and 65% for those that were acclimated. The overall mean survival rate to LGD for Imnaha River smolts released in 2015 was 68% (Figure 1).

Two raceways of Catherine Creek CHP smolts were transferred to the Catherine Creek Acclimation Facility on 17 March 2015 (Table 3). Volitional release began on 19 March 2015 and smolts were forced out on 15 April 2015. Mean survival rate to LGD for CHP smolts released into Catherine Creek was 27%. Smolts released into Catherine Creek had the lowest mean survival rate for BY 2013 smolts released in the Grande Ronde Basin (Figure 1).

Two of the four raceways of smolts produced from the Upper Grande Ronde River CHP were transferred to the Upper Grande Ronde River Acclimation Facility on 16 March 2015 and the remaining two raceways were transferred on 31 March 2015 (Table 3). Volitional release of CHP smolts from the first transfer began on 18 March 2015, with force-out occurring on 30 March 2015. Volitional release of CHP smolts from the second transfer began on 1 April 2015, with force-out occurring on 15 April 2015. The mean survival rate to LGD for smolts released from the Upper Grande Ronde River Acclimation facility was 38% for the early release, 35% for the late release, and the overall survival rate was 36% (Figure 1).

Smolts produced from the Lookingglass Creek CHP were volitionally released into Lookingglass Creek directly from their rearing ponds at Lookingglass Fish Hatchery starting on 23 March 2015, with force-out occurring on 30 March 2015 (Table 3). Mean survival rate to LGD for CHP smolts released into Lookingglass Creek was 63%, the second highest mean survival rate for smolts released in the Grande Ronde Basin (Figure 1).

Two raceways of Lostine River CHP smolts were transported to the Lostine River Acclimation Facility on 9 March 2015 (Table 3). This group was volitionally released beginning on 9 March 2015, with force-out occurring on 31 March 2015. The two remaining raceways of Lostine River CHP smolts were transferred to the acclimation facility on 31 March 2015. Volitional release of the second group started on 31 March 2015 and smolts were forced out on 22 April 2015. The mean survival rate to LGD for CHP smolts released into the Lostine River was 52% for the early release, 75% for the late release, and the overall survival was 64%, the highest overall survival rate for BY 2013 smolts released in the Grande Ronde Basin (Figure 1).

2014 Brood Year Parr at Lookingglass Fish Hatchery

From 18–27 August 2015, brood year 2014 parr from the Imnaha River, Catherine Creek, Upper Grande Ronde River, and the Lostine River were marked and/or tagged at Lookingglass Fish Hatchery with either an Ad clip, a CWT, or an Ad clip and CWT.

Marking and tagging rates varied among stocks and were based on management and monitoring requirements. We estimated from tagging records that 66% of Imnaha River parr were marked with both an Ad clip and CWT and 34% were only marked with an Ad clip (Table 4). Approximately 69% of the Catherine Creek parr were marked with an Ad clip and CWT and 31% were only marked with an Ad clip. About 50% of the parr from the Upper Grande Ronde River were marked with both an Ad clip and a CWT and 50% were marked with only a CWT. Of the Lookingglass Creek parr, 47% received an adipose fin clip and CWT and 53% received only an Ad clip. We estimate 54% of the Lostine River parr were marked with an Ad clip and CWT and 46% were only marked with an Ad clip. Mark and tag retention checks will be conducted in October and February 2016, after which we will calculate the numbers of parr that were successfully marked/tagged.

Parr at Lookingglass Fish Hatchery were implanted with a PIT tag in October 2015. We estimated that 20,950 Imnaha River, 20,947 Catherine Creek, 1,997 Upper Grande Ronde River, 4,999 Lookingglasss Creek, and 2,403 Lostine River parr were successfully PIT-tagged (Table 4). The PIT tags were distributed approximately evenly across all raceways for each population.

2015 Return Year Chinook Salmon Collections

Returning mature (ages 3–5) salmon are captured at weirs for collection of broodstock and management of hatchery salmon spawning in nature. All salmon captured at weirs are classified by origin (based on tags and marks) and have their fork length measured to estimate age. However, there are known sources of error in these data for which we must compensate.

The first limitation to using weir data to characterize the age and sex composition of returning salmon is that sex determination is based entirely on a visual assessment of external characteristics of a live salmon and it is particularly difficult to determine the sex of early arriving salmon because external morphological characteristics (e.g., male kype) are not well developed. These errors in sex determination result in data discrepancies between the numbers of males and females recorded as being collected at the weir and those recorded as spawned at the hatchery (where sex is accurately determined).

Another limitation of weir data is age determination. Since length-at-age distributions overlap, using a fixed length cutoff is arbitrary (e.g., classifies small age 4 salmon as age 3 and large age 3 salmon as age 4) and may bias the estimated age structure of salmon handled at the weir. In this report, we attempt to correct for size overlap by using known age salmon (i.e., using a CWT, PIT tag, or scale to determine age) to create yearly length-at-age categories (see Appendix A for detailed methods). We could decrease our error by reducing the number of salmon without a known age by releasing more CWT-marked hatchery salmon, collecting scales on all salmon passed above the weirs, or increase the number of snouts collected on CWT-marked salmon that are killed or sent to foodbanks.

Lastly, some hatchery salmon are unidentifiable due to a combination of poor marking and tag loss. Therefore, it is also sometimes necessary to account for these unidentifiable hatchery returns, which are recorded as natural salmon, by adjusting the hatchery:natural ratios for each age class (i.e., brood year). This adjustment is made by first assigning a final age to each salmon based on known ages (CWTs, PIT tags, or scale ages) or an estimated age based on length if tags or scales are unavailable (see Appendix A for a detailed methods). We then use the percentage of hatchery juveniles from each BY that were released unmarked and tagged (i.e., no CWT and no adipose fin clip) to account for unidentifiable hatchery salmon that are thought to be natural salmon. This reduces the number of natural Chinook Salmon in our estimate and increases the number of hatchery Chinook Salmon from an equivalent age.

Imnaha River

The Imnaha River weir was operated by ODFW Lookingglass Fish Hatchery personnel from 18 May to 11 September 2015 (Table 5). After adjusting for unclipped returns, we estimated that 1,661 hatchery and 456 natural-origin mature salmon were captured (Table 6). We retained 219 hatchery-and 84 natural mature salmon for broodstock and there were one hatchery and three natural origin trap mortalities. To limit the number of hatchery salmon on spawning grounds, 382 hatchery salmon were outplanted to Big Sheep Creek, 392 were

distributed to Oregon or Nez Perce Tribal food banks, and 152 were killed and their carcasses disposed of either below the weir or in Big Sheep Creek and Lick Creek (i.e., stream enrichment). To provide additional harvest opportunities, 200 hatchery salmon were returned to the river below the weir. The remaining salmon collected at the weir were released above the weir to spawn naturally (315 hatchery, 369 natural). Of the hatchery salmon captured at the weir, 22.7% were age 3, 72.3% were age 4, and 5.0% were age 5. Natural origin returns captured at the weir were comprised of 12.7% age 3, 76.6% age 4, and 10.7% age 5.

Catherine Creek

The Catherine Creek weir was operated by CTUIR from 2 March to 29 July 2015 (Table 5). The first Chinook was captured on 11 May 2015 and the last new (i.e., not a recapture) salmon was captured on 30 June 2015. After adjusting for unmarked hatchery returns, we estimated that a total of 441 hatchery-and 304 naturally-produced salmon were captured (Table 6). CTUIR retained 57 hatchery and 51 natural origin salmon for broodstock. There were four hatchery and three natural origin trap mortalities. To reduce the number of hatchery salmon on the spawning grounds, 106 hatchery salmon were outplanted to Indian Creek, two hatchery salmon were outplanted to Lookingglass Creek, and 28 hatchery salmon were killed for tribal foodbanks. The remaining 244 hatchery and 250 natural mature salmon, were passed above the weir to spawn naturally. Age structure of hatchery salmon captured at the weir was 10.8% age 3, 87.1% age 4, and 2.1% age 5. Natural origin returns were comprised of 4.9% age 3, 73.0% age 4, and 22.1% age 5.

This the 10th complete BY of mature returns to Catherine Creek from the CHP production (BYs 2001-2010). All of the 2015 Chinook Salmon returns were from CHP production. The last mature salmon that returned to Catherine Creek from the Catherine Creek CBS program returned in 2014.

Upper Grande Ronde River

The Upper Grande Ronde River weir was operated by CTUIR from 2 March to 7 June 2015 (Table 5). The weir was pulled on 7 June because the water temperatures reached 18˚C. The first Chinook was captured on 9 May 2015 and the last new (i.e., not a recapture) salmon was captured on 7 June 2015. After adjusting for unmarked hatchery returns, we estimated that 780 hatchery and 200 naturally-produced salmon were captured (Table 6). From the Upper Grande Ronde River weir, CTUIR retained 138 hatchery and 49 natural salmon for broodstock, zero hatchery salmon were killed at the weir, there was one hatchery salmon trap mortality, and 642 hatchery and 151 natural mature Chinook Salmon were released above the weir to spawn naturally. Age structure of hatchery salmon captured at the weir was 1.4% age 3 (100% CHP), 96.7% age 4 (38.5% CBS and 61.5% CHP), and 1.9% age 5 (100% CHP). Natural origin salmon were comprised of 0.5% age 3, 71.5% age 4, and 28.0% age 5.

This is the 12th year of complete brood year returns of mature Upper Grande Ronde River hatchery salmon from the CBS program (BYs 1998 – 2005, 2009, 2011) and the 10th for CHP production (BYs 2001 – 2010). The CBS smolts released into Upper Grande Ronde River from BY 2011 (age 4) were all marked with either an adipose fin clip (53.8%) or an adipose fin clip and a CWT (46.2%). The BY 2011 CHP smolts were only marked with a CWT. There were no releases of CBS smolts into the Upper Grande Ronde River from BY 2012 (age 3 returns) or BY 2010 (age 5 returns).

Lookingglass Creek

The Lookingglass Creek weir was operated by Lookingglass Fish Hatchery (ODFW) personnel from 1 March to 18 September 2015 and had unique captures of 788 hatchery and 273 natural mature salmon (Tables 5 and 6). The trap total includes 21 assumed strays from the Upper Grande Ronde River CHP program based the absence of an adipose fin clip and the presence of a CWT. Of the assumed Upper Grande Ronde River strays, three jacks and thirteen adults were kept for the Grande Ronde River CHP broodstock program, and five jacks were killed.

Totals of 551 hatchery and 218 natural origin Chinook were passed above the weir to spawn naturally; 49 hatchery salmon were released below the weir, 37 hatchery salmon were killed (foodbank or landfill), there was one hatchery origin salmon trap mort, and 145 hatchery and 55 natural mature salmon were kept for the Lookingglass Creek CHP broodstock program. Hatchery salmon captured at the weir (includes strays) were comprised of 13.2% age 3, 84.4% age 4, and 2.4% age 5. Natural origin returns captured at the weir were comprised of 12.8% age 3, 84.6% age 4, and 2.6% age 5.

Lostine River

The Lostine River weir was operated by the NPT from 15 February to 23 September 2015 (Table 5). There were unique captures of 595 hatchery-and 416 natural mature salmon at the weir, of which 111 hatchery and 66 natural origin mature salmon were retained for broodstock (Table 6). To reduce the number of hatchery salmon on the spawning grounds, 194 hatchery salmon were released at the confluence of the Wallowa and Minam Rivers to provide additional harvest opportunities for anglers. Additionally, 11 hatchery jack salmon and 49 hatchery adults were released into the Wallowa River at Wade Gulch (decimal degrees, WGS84: N45.475166 E -117.387606) for natural spawning. One hatchery salmon was kept by the Nez Perce Tribe for ceremonial purposes. All remaining salmon were passed above the weir to spawn naturally (229 hatchery, 350 natural). Age structure of hatchery salmon captured at the weir was 5.4% age 3, 91.7% age 4, and 2.9% age 5. Age structure of the natural origin salmon captured at the weir was 5.3% age 3, 86.2% age 4, and 8.5% age 5.

This is the 12th year we had a complete BY return of mature Lostine River hatchery salmon from the CHP production (BYs 1997, 2000-2010). All 2015 returns were from CHP production. The Lostine River CBS program released smolts into the Lostine River in BYs 1998–2009. The last mature salmon that returned to the Lostine River from these CBS smolts returned in 2014.

Mature Chinook Salmon Accounting Problems

In recent years, accounting for individual salmon at the Imnaha River, Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River weirs has become increasingly difficult. With increased numbers of hatchery returns and low numbers of natural returns, managers have limited the numbers of hatchery salmon passed above the weirs in order to meet sliding scale management agreements for reducing the impact of hatchery salmon on natural populations. Surplus hatchery salmon have been outplanted to other tributary streams (e.g., Bear Creek, Big Sheep Creek, Lick Creek, Indian Creek, and Wallowa River) and distributed to local and tribal foodbanks. Chinook Salmon that are distributed to local and tribal food banks are either distributed directly from the weir or sent to Wallowa Hatchery for distribution. In some years, both the Imnaha River and Lostine River stocks are sent to Wallowa

Fish Hatchery at the same time so there is potential for these stocks to be accidently mixed in the holding ponds prior to distribution, leading to discrepancies in the number of salmon from each population transferred into and out of this facility. Excess trapped hatchery salmon may also be held temporarily at Lookingglass Fish Hatchery before they are distributed to food banks or released back into nature. Because these Chinook Salmon are not uniquely marked and some die prior to food distribution or release, it is difficult to reconcile the trapping records with the number of salmon sent to foodbanks or returned to nature.

One unique challenge with counting returns to Lookingglass Creek occurs in years where surplus hatchery Chinook Salmon captured at the Catherine Creek weir are released into Lookingglass Creek below the weir. Although these salmon were are marked with an OP punch, this mark can sometimes be lost or missed during later handling (e.g., punch can heal and not be obvious). This misidentification can result in an overestimate of the number of stray Catherine Creek salmon recovered in Lookingglass Creek. Also, there is no reliable way of estimating the number of outplanted salmon that were harvested because no biological information is collected from any salmon harvested in tribal fisheries, and the OP mark may not be consistently recorded by the ODFW sport creeler. In years when Chinook Salmon are collected at the Catherine Creek weir and outplanted into Lookingglass Creek, identifying and recording the presence or absence and type of OP mark on all harvested salmon would reduce the chances that outplanted salmon were incorrectly identified as strays. This would also provide data that could be used to determine the proportion of outplanted salmon that were harvested and document or these outplants to the fishery.

Additionally, the number of salmon that enter and leave each facility is documented, but there are usually discrepancies between weir records and hatchery records concerning the numbers of males and females kept, spawned, and distributed to foodbanks. The most common factors that contribute to discrepancies between weir and hatchery records are incorrect sex identification at time of capture, error in classifying salmon into "jack" and "adult" age categories, and incorrectly identifying an adipose fin clip or the presence of a CWT in unclipped hatchery returns. Determining the sex of salmon from external characteristics is difficult early in the season. Age is assigned by length at the weir, but confirmed by tags or scales at a later date, and length distributions overlap between adjacent ages, so these discrepancies are impossible to eliminate. At a minimum, marking all hatchery releases with an adipose fin clip and CWT would help reduce errors associated with differentiating hatchery and natural returns.

2015 Brood Year Hatchery Spawning

Imnaha River

We spawned 100 hatchery and 35 natural females with 88 unique hatchery and 41 unique natural male parents (Table 7). Six jacks were pooled and used as one male and some adult males were spawned multiple times. Counting six jacks as one male is unique to Imnaha River production. Six natural origin males were live-spawned at Lookingglass Fish Hatchery and returned to the Imnaha River on 15 September 2015. We collected 615,672 green eggs which were incubated at Lookingglass Fish Hatchery where mortality rate to shocking was 6.7%, resulting in 574,606 eyed eggs.

Catherine Creek

Mature salmon used as broodstock to create the Catherine Creek 2015 BY were from both natural and hatchery origin (CHP progeny). We spawned 33 hatchery and 20 natural females with 22 unique hatchery and 30 unique natural male parents (Table 7). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 233,109 green eggs and mortality rate to shocking was 11.1%, resulting in 207,199 eyed eggs.

Upper Grande Ronde River

Mature salmon used as broodstock to create the Upper Grande Ronde River 2015 BY were from both natural and CHP origin (returning CBS progeny were allowed to spawn naturally or were removed but were not collected for CHP broodstock due to domestication concerns). We spawned 62 hatchery and 23 natural females with 71 unique hatchery and 19 unique natural male parents (Table 7). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 356,924 green eggs and mortality rate to shocking was 9.9%, resulting in 321,634 eyed eggs.

Lookingglass Creek

We spawned 48 hatchery and 27 natural females with 61 unique hatchery and 22 unique natural origin male parents (Table 7). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 262,782 green eggs and morality rate to shocking was 5.7%, resulting in 247,928 eyed eggs.

Lostine River

We spawned 46 hatchery and 26 natural females with 51 unique hatchery and 30 unique natural male parents (Table 7). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 318,550 green eggs and morality rate to shocking was 11.5%, resulting in 281.954 eyed eggs.

Egg Weight

For all stocks, a greater number of eggs were collected from age 4 than age 5 salmon (Table 8). Mean egg weight for all stocks was greater for age 5 than age 4 females ($P < 0.001$). Mean egg weights for hatchery and natural salmon were similar for Catherine Creek, Lookingglass Creek, and Lostine River stocks ($P \geq 0.280$). Eggs from natural origin females collected from the Imnaha River and the Upper Grande Ronde River were significantly larger than those from hatchery females ($P \leq 0.005$). The largest mean egg weight (0.258 g) was from Imnaha River natural females and the smallest mean egg weight (0.210 g) was from Upper Grande Ronde River hatchery females. Overall, a greater number of eggs were collected from age 4 (88.8%) than age 5 (11.2%) females and the mean egg weight of age 5 females (0.26 g) was greater than that of age 4 females (0.22 g).

Compensation Goals

Coded-wire tag recovery methods

Hatchery salmon from most production raceways were marked with a coded-wire tag to provide basic information on survival, harvest, escapement, and straying, as well as specific information on experimental groups, if any. Recovery information for each CWT code group

was obtained from the Regional Mark Information System (RMIS) CWT recovery database maintained by the Pacific States Marine Fisheries Commission. The RMIS data for this report was updated through 3 May 2017.

We compiled observed and estimated numbers of hatchery salmon from each CWT code group recovered in ocean and Columbia River fisheries, as well as strays collected in and out of the Snake River Basin. Estimated CWT recoveries in the RMIS database were expanded from observed recoveries based on sampling efficiencies at some recovery locations, but not for recoveries observed in the Imnaha and Grande Ronde river basins. Therefore, we estimated total CWT-marked hatchery salmon from each code group (observed from weir collections and spawning ground recoveries) returning to the Imnaha River, Upper Grande Ronde River, Lookingglass Creek, Catherine Creek, and Lostine River based on total escapement to each stream, sampling rate, and the proportion of each cohort marked with CWTs. For some stocks, excess hatchery Chinook Salmon were outplanted to nearby streams. CWTs from these stocks that were recovered in outplant streams were not considered strays and were included in escapement calculations for the stream to which they returned. The methodology for estimating hatchery and natural escapement to the Imnaha River and Grande Ronde Basin streams is described in Appendix B.

We expanded CWT recoveries for CBS and CHP hatchery returns separately because CWTs from the CBS and CHP programs were recovered at different sampling efficiencies. Recovery rates for CHP progeny are usually higher because CWTs are recovered from CHP progeny retained for broodstock, as well as from spawning grounds surveys, whereas CBS recoveries are typically recovered only on spawning ground surveys, since none are retained for broodstock.

In both the Imnaha and Grande Ronde basins, the exception to the CWT expansion method is when there were no CWT recoveries for a particular brood year, but weir data indicated mature salmon from that brood year had returned. In these cases, we estimated the total number of returning salmon by age class. If the returning salmon from the brood year were potentially comprised of more than one tag group, we partitioned the estimated CWT returns into individual code groups based on the relative proportion of tag group recoveries from the previous year's return.

Calculating returns to the Compensation Area

To asses LSRCP success at achieving mitigation goals and management objectives, we estimated the total numbers of hatchery salmon for each stock that were caught in fisheries, escaped to the stream of release (method described in Appendix B), or strayed within or outside the Snake River Basin. To determine the return to the LSRCP Compensation Area, defined as the Snake River Basin above LGD for programs within the State of Oregon, we summed all estimated escapement (harvest, removed at the weir, strays, and all salmon remaining in nature) above LGD for the 2015 return year.

Imnaha River

Coded-wire tag recoveries

We recovered 615 hatchery-reared Imnaha River Chinook Salmon with a CWT from BYs 2010–2012: 177 CWT from BY 2012 (age 3), 434 from BY 2011 (age 4), and four from BY 2010 (age 5; Table 9). From these CWT recoveries, we estimate that 27 Imnaha River salmon were harvested in ocean fisheries and 1,927 were harvested in the Columbia River, where an

estimated 1,300 salmon were harvested in treaty net fisheries, 266 in non-tribal net fisheries, and 361 in sport fisheries. We estimated that 17 Imnaha River salmon were harvested in Snake River sport fisheries, and zero were harvested in Snake River tribal fisheries. Below LGD, 20 stray CWT-marked salmon were recovered in the Deschutes River, one stray was recovered at Bonneville Fish Hatchery, and one stray was recovered in the Tucannon River. We estimated that these CWT recoveries below Lower Granite Dam represented 48 stray Imnaha River Chinook Salmon. Zero stray Imnaha River Chinook Salmon were recovered above Lower Granite Dam.

Within the Imnaha River Basin, we recovered 389 CWT-marked salmon (Table 9). ODFW estimated that 112 Chinook Salmon were caught in the Imnaha River sport fishery (Bratcher et al. 2015) and ten CWTs were recovered. No CWTs were collected from tribal fishers, but NPT and CTUIR reported a total harvest of 323 hatchery salmon (Joe Oatman, NPT, personal communication, 6 November 2015; Preston Bronson, CTUIR, personal communication, 23 November 2015). A total of 1,146 mature salmon were collected at the Imnaha River trapping facility, and we estimate that 1,127 mature hatchery salmon remained in nature, 743 below and 384 above the weir.

Return to Compensation Area

The annual total production goal for mature (ages 3–5) Imnaha River hatchery Chinook Salmon to the mouth of the Columbia River is 16,050 (Corps of Engineers 1974). There is a catch to escapement ratio goal of 4:1, resulting in a harvest mitigation goal of 12,840 mature hatchery Chinook Salmon below LGD and 3,210 mature hatchery salmon to the LSRCP compensation area (above Lower Granite Dam).

For the 2015 return year, we estimated that 4,727 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River, 29.5% of the total mitigation goal of 16,050 mature hatchery salmon. We also estimated that 2,725 mature hatchery salmon returned to the LSRCP compensation area, 84.9% of the hatchery compensation goal (3,210) for the Imnaha River stock (Table 9). Of the total escapement above Lower Granite Dam, we estimated that 435 mature hatchery salmon were harvested in fisheries, 13.6% of the compensation area mitigation goal. We estimated 1,954 mature Imnaha River hatchery Chinook Salmon were harvested in fisheries below Lower Granite Dam, 15.2% of the downstream harvest mitigation goal.

Return to the River

We estimated that 2,707 hatchery and 768 natural origin salmon returned to the Imnaha River in 2015. The estimated total return to the river of hatchery salmon was comprised of 619 age 3, 1,952 age 4, and 136 age 5 returns. For natural salmon, we estimated that 133 age 3, 549 age 4, and 86 age 5 returned.

Estimated total return to the river includes 39 hatchery jacks and 73 hatchery adults harvested by sport anglers (Bratcher et al. 2015). The estimated incidental mortality of hooked and released Chinook (estimated at 10% mortality) was one natural origin adult. The area open to recreational anglers on the Imnaha River extended from the mouth of the Imnaha River upstream to Summit Creek Bridge, and the fishery was open from 6 June–13 July 2015. Additionally, NPT reported that two hatchery jacks, 300 hatchery adults, zero natural jacks, and 29 natural adults were harvested (Joe Oatman, NPT, personal communication, 6 November 2015). CTUIR reported harvest of zero hatchery jacks, 21 hatchery adults, zero natural jacks,

and one natural adult (Preston Bronson, CTUIR, personal communication, 23 November 2015). The combined sport and tribal harvest of 435 hatchery Chinook Salmon represents 16.1% of the estimated total return of mature hatchery salmon to the Imnaha River.

Recruits:Spawner (R:S) and Smolt-to-Adult Return Rates (SAR)

Recruits-per-spawner (R:S) ratios reported here include jacks. The R:S ratio for the hatchery component was calculated by dividing the total return by the number of parents (ages 3-5) spawned at Lookingglass Fish Hatchery to produce those recruits. The R:S ratio for salmon that spawned in nature was calculated by dividing the total return of mature (ages 3-5) salmon that returned to the mouth of the Imnaha River by the estimated number of mature hatchery and natural origin salmon that spawned naturally in the river. Estimates of salmon spawning in nature were adjusted for pre-spawn mortality of the parents. The R:S ratio for BY 2010 was 9.5 for those spawned in the hatchery (any origin) and 0.4 for those spawned in nature (Figure 2). The BY 2010 smolt-to-adult return rate (SAR) for hatchery salmon that returned to the mouth of the Imnaha River was 0.497% (Table 10). Natural smolt numbers were not available to estimate SAR for BY 2010.

Grande Ronde Basin

Catherine Creek coded-wire tag recoveries

We recovered 114 hatchery-reared Catherine Creek Chinook Salmon with a CWT from BYs 2010–2012: 26 from BY 2012 (age 3), 86 from BY 2011 (age 4), and two from BY 2010 (age 5; Table 11). From these recoveries we estimated that zero Catherine Creek Chinook Salmon were recovered in ocean fisheries. We estimated that 54 salmon were harvested in the Columbia River: 17 in tribal net fisheries, 11 in non-tribal net fisheries, and 26 in sport fisheries. In the Snake River, we estimated that six Catherine Creek salmon were harvested in sport fisheries, and zero in tribal fisheries. No CWT-marked Catherine Creek salmon were recovered as strays below LGD. Above LGD, one CWT-marked salmon was recovered outside the Grande Ronde Basin at the Rapid River Fish Hatchery in Idaho.

Within the Grande Ronde Basin, we recovered eight stray Catherine Creek salmon that we estimated to represent 32 mature salmon. Seven stray CWT-marked Catherine Creek salmon were recovered in Lookingglass Creek (four on the spawning ground and three from the weir), and one stray was recovered from spawning ground surveys on the Lostine River (Table 11). Within Catherine Creek, 93 CWT-marked salmon were recovered. A total of 197 mature hatchery salmon were removed from the river at the Catherine Creek weir, and we estimated that 252 were on the spawning grounds above the weir, and 10 were below the weir.

Upper Grande Ronde River coded-wire tag recoveries

We recovered 273 hatchery-reared Upper Grande Ronde River Chinook Salmon with a CWT from BYs 2010–2012: 26 from BY 2012 (age 3), 243 from BY 2011 (age 4), and four from BY 2010 (age 5; Table 12). From these recoveries, we estimated that zero were caught in ocean fisheries, 158 were caught in the Columbia River, and zero were caught in the Snake River. Below Lower Granite Dam, one stray CWT-marked salmon was recovered at Pelton Dam on the Deschutes River. Above LGD, and outside the Grande Ronde basin, three CWT-marked salmon were recovered in Idaho: two from the South Fork Salmon River and one from the Johnson Creek fish trap.

Within the Grande Ronde Basin, 31 CWT-marked salmon were recovered as in-basin strays that were estimated to represent 58 strays. We recovered all 31 of the CWT-marked in-basin stray salmon in Lookingglass Creek (seven from the spawning grounds and 24 from the salmon trap. A total of 139 mature hatchery salmon were removed from the river at the Upper Grande Ronde River salmon weir. We estimated that 1,490 were on the spawning grounds above the weir, and zero were below the weir.

The limited number of CWT recoveries outside the Upper Grande Ronde River is probably because only 48.6% of the BY 2012, 49.2% of the BY 2011, and 46.2% of the BY 2010 smolts were marked with both a CWT and an adipose fin clip. The remainder, approximately 50%, were marked with only a CWT and no adipose fin clip. Therefore, unless a snout was collected for salmon with an intact adipose fin or a CWT wand was used to check for the presence or absence of a CWT for all salmon handled, it is likely that Upper Grande Ronde River hatchery Chinook Salmon were mistakenly identified as natural returns. Furthermore, most sport fisheries prohibit harvesting Chinook Salmon with an intact adipose fin and tribal fishers rarely check non-adipose clipped salmon for tags, further diminishing the chances of recovering a CWT from Upper Grande Ronde River hatchery salmon. This decreases the total survival (SAS) and stray rates for the Upper Grande Ronde River hatchery salmon and inflates the natural return numbers from streams into which they strayed.

Lookingglass Creek coded-wire tag recoveries

We recovered 204 hatchery-reared Chinook Salmon released into Lookingglass Creek with a CWT from BYs 2010–2012: 26 from BY 2012 (age 3), 173 from BY 2011 (age 4), and five from BY 2010 (age 5; Table 13). We estimated that zero Lookingglass Creek salmon were caught in ocean fisheries. In the Columbia River, we estimated that 398 mature salmon were recovered: 89 in treaty net fisheries, 59 in non-tribal net fisheries, and 250 in sport fisheries. We estimated that zero mature hatchery salmon were harvested in Snake River sport and tribal fisheries. Below LGD, one CWT-marked salmon, which expanded to two salmon, was recovered at Pelton Dam on the Deschutes River. Above Lower Granite Dam and outside the Grande Ronde Basin, one stray CWT-marked salmon from Lookingglass Creek was recovered at the South Fork Salmon River trap in Idaho.

Above LGD and within the Grande Ronde Basin, two CWT-marked salmon were recovered in the Minam River, one in Hurricane Creek, and one in the Wenaha River (Table 13). These four in-basin CWT stray recoveries expanded to 41 salmon. Within Lookingglass Creek, 148 CWT-marked salmon were recovered. We recovered five CWTs from Lookingglass Creek hatchery salmon in the Lookingglass Creek sport fishery which was open from 23 May–30 June, and the ODFW estimated that 47 hatchery jacks and 124 hatchery adult salmon were harvested (Bratcher et al. 2015). No CWTs were collected from the tribal fishers, but NPT and CTUIR reported a total harvest of 329 hatchery salmon (Joe Oatman, NPT, personal communication, 6 November 2015; Preston Bronson, CTUIR, personal communication, 23 November 2015). A total of 165 mature Lookingglass Creek CHP hatchery salmon were removed from the river at the Lookingglass Creek salmon trap. We estimated that 563 were on the spawning grounds above the weir and 148 were below the weir.

Lostine River coded-wire tag recoveries

We recovered 288 hatchery-reared Chinook Salmon released into the Lostine River with a CWT from BYs 2010–2012: 11 CWTs from BY 2012 (age 3), 272 from BY 2011 (age 4), and

five from BY 2010 (age 5; Table 14). We estimated that 11 mature Lostine River Chinook Salmon were caught in ocean fisheries. In the Columbia River we estimated that 495 were recovered in tribal net fisheries, 97 in non-tribal net fisheries, and 208 in sport fisheries. Below LGD, one CWT-marked salmon was recovered at Bonneville Fish Hatchery, and three were recovered in the Deschutes River for an estimate of four stray salmon. Within the Snake River above LGD, zero CWT-marked salmon were recovered in sport or tribal fisheries. Five CWT-marked Lostine River salmon were recovered in Johnson Creek, a tributary to the South Fork Salmon River for an estimate of five out-of-basin stray salmon.

Within the Grande Ronde Basin, six CWT-marked Lostine River salmon were recovered in Hurricane Creek, two in the Wallowa River, one in the Minam River, and two on the Lookingglass Creek spawning grounds (Table 14). These 11 CWT recoveries were expanded to represent 129 in-basin stray salmon. Within the Lostine River, 109 CWT-marked salmon were recovered. A total of 366 mature hatchery salmon were removed from the river at the Lostine River salmon trap, and we estimated that 270 were on the spawning grounds above the weir, and 275 were below the weir.

Return to Compensation Area

The annual total production goal of mature hatchery Chinook Salmon for the Grande Ronde Basin is 29,300 (Corps of Engineers 1975). We estimated that total production in 2015 was 6,826, 23.3% of the total adult production goal (Tables 11-14). For the Columbia River Basin below Lower Granite Dam there is a catch to escapement ratio goal of 4:1, resulting in a harvest mitigation goal of 23,440 hatchery Chinook Salmon. We estimated 1,421 Grande Ronde Basin hatchery salmon were harvested in fisheries below Lower Granite Dam, 6.1% of the downstream mitigation goal (Tables 11-14). Harvest below Lower Granite Dam was comprised of an estimated 54 Catherine Creek, 158 Upper Grande Ronde River, 398 Lookingglass Creek, and 811 Lostine River hatchery Chinook Salmon.

In the Grande Ronde Basin, the annual compensation goal for all stocks combined was set at 5,860 mature hatchery salmon (Herrig 1990). We estimated that 503 Catherine Creek, 1,723 Upper Grande Ronde River, 1,418 Lookingglass Creek, and 1,754 Lostine River mature hatchery Chinook Salmon returned to the compensation area, a combined return of 5,402 hatchery salmon, 92.1% of the compensation goal (Tables 11-14).

Of the total escapement above Lower Granite Dam, we estimated that 1,227 hatchery salmon were harvested in sport and tribal fisheries, 20.9% of the compensation area return. The lower Grande Ronde River pilot fishery was open from 6 June – 19 July 2015. A sport fishery was opened on the Wallowa River from 6 June – 13 July 2015. The area open to anglers extended from the Minam State Park upstream to the mouth of the Lostine River (Bratcher et al. 2015). No sport fisheries were open on Catherine Creek or the Upper Grande Ronde River. The ODFW estimated that sport fishers harvested zero hatchery Chinook Salmon in the Lower Grande Ronde River pilot fishery, 137 in the Wallowa River, and 171 in Lookingglass Creek (Bratcher et al. 2015). The remaining 919 hatchery salmon were harvested by tribal fishers in the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River.

Returns of Grande Ronde Basin hatchery Chinook Salmon in 2015 did not meet the compensation area mitigation goal (92.1%) or the total adult production goal (23.3%). Harvest of hatchery salmon in the Grande Ronde Basin is hindered by the paucity of natural salmon and the threat of incidental hooking mortality, lack of fishing access in some streams, and seasonally poor river conditions (high discharge and turbid water) for angling. Factors that have previously

contributed to low hatchery returns of Grande Ronde Basin hatchery salmon included low numbers of CHP broodstock collections, limited rearing space at Lookingglass Fish Hatchery, and a CBS program that was beleaguered with low broodstock survival due to BKD and low fecundity due to slow broodstock growth rates (Hoffnagle et al. 2003; Carmichael et al. 2007). Consistently poor smolt migration survival (<50%) from Catherine Creek and Upper Grande Ronde River hatchery smolts from the acclimation sites to LGD is another factor that has also been identified as contributing to reduced hatchery returns (Monzyk et al. 2009).

Return to the River

We estimated that 55 age 3, 395 age 4, and nine age 5 hatchery salmon and 16 age 3, 229 age 4, and 69 age 5 natural salmon returned to Catherine Creek in 2015 (Table 11). There was no sport fishery in Catherine Creek and tribal fishers reported zero catch in Catherine Creek.

We estimated that 121 age 3, 1,489 age 4, and 32 age 5 hatchery salmon and eight age 3, 282 age 4, and 111 age 5 natural salmon returned to the Upper Grande Ronde River in 2015 (Table 12). There were no sport fisheries in the Upper Grande Ronde River. Tribal fishers reported harvest of 13 hatchery and two natural adults (Preston Bronson, CTUIR, personal communication, 23 November 2015).

We estimated that 142 age 3, 1,197 age 4, and 37 age 5 hatchery salmon released as smolts into Lookingglass Creek and 50 age 3, 299 age 4, and eight age 5 natural salmon returned to Lookingglass Creek in 2015 (Table 13). CTUIR tribal harvest estimates were zero hatchery jacks, 61 hatchery adults, zero natural origin jacks, and 13 natural origin adult (Preston Bronson, CTUIR, personal communication, 23 November 2015). NPT tribal harvest estimates were three hatchery jacks, 265 hatchery adults, six natural jacks, and 42 natural adults (Joe Oatman, NPT, personal communication, 6 November 2015). The sport fishery was open from 23 May – 30 June 2015 and extended 3.2 kilometers upstream from the confluence of Lookingglass Creek and the Grande Ronde River to the confluence of Jarboe Creek (Bratcher et al. 2015). Sport fishery harvest estimates were 47 hatchery jacks and 124 hatchery adults. Additionally, ODFW estimated that zero natural origin jacks and 30 natural origin adults were released by sport anglers.

We estimated that 66 age 3, 1,507 age 4, and 47 age 5 hatchery and 16 age 3, 508 age 4, and 49 age 5 natural salmon returned to the Lostine River in 2015 (Table 14). CTUIR tribal harvest estimates were 0 hatchery jacks, 32 hatchery adults, zero natural origin jacks, and seven natural origin adults (Preston Bronson, CTUIR, personal communication, 23 November 2015). NPT tribal harvest estimates were 10 hatchery jacks, 530 hatchery adults, zero natural jacks, and 50 natural adults (Joe Oatman, NPT, personal communication, 6 November 2015). The Wallowa River sport fishery harvest estimates of Lostine River Chinook Salmon were three hatchery jacks and 134 hatchery adults. It was estimated that 28 natural origin jacks and nine natural origin adults were released.

Recruits:Spawner (R:S) and Smolt-to-Adult Return (SAR) Rates

We calculated R:S ratios for both the hatchery and natural components using estimates of recruits returning to the confluence of the terminal tributary (mouth) within the Grande Ronde River Basin. The R:S ratio for the hatchery component was calculated by dividing the number of mature offspring (ages 3-5) that return to the tributary mouth into which they were released by the number of parents (ages 3-5) spawned at Lookingglass Fish Hatchery to produce those recruits. The R:S ratio for salmon that spawned in nature was calculated by dividing the number

of mature salmon returns to the tributary mouth (ages 3-5) by the estimated number of mature hatchery and natural origin salmon that spawned naturally in the river, adjusted for pre-spawn mortality of the parents.

In Catherine Creek, the R:S ratio for BY 2010 was 9.4 for the CHP hatchery component and 0.7 for the natural component. The BY 2010 SAR rate to the mouth of Catherine Creek for the CHP program was 0.490% (Table 15).

In the Upper Grande Ronde River, the R:S ratios for the CHP hatchery and natural components from the 2010 brood year were 8.7 and 0.4, respectively. The BY 2010 SAR rate for hatchery salmon that returned to the Upper Grande Ronde River was 0.471% (Table 16).

In Lookingglass Creek, the R:S ratios for the hatchery and natural components from BY 2010 were 14.3 and 0.7, respectively. The SAR rate to the mouth of Lookingglass Creek for BY 2010 returns of CHP smolts released into Lookingglass Creek was 0.971% (Table 17).

In the Lostine River, the R:S ratios for BY 2010 were 17.7 and 0.3 for CHP hatchery and natural returns, respectively. The SAR rates to the mouth of the Lostine River for BY 2010 CHP production smolts released into the Lostine River was 0.855% (Table 18).

Escapement Monitoring

We conducted spawning ground surveys on three streams in the Imnaha Basin and 13 in the Grande Ronde Basin. Stream surveys to count Chinook Salmon redds and sample salmon carcasses were conducted as in previous years (see Monzyk et al. 2006a).

In 2015, we counted 619 redds and recovered 340 carcasses in the Imnaha Basin (Table 19). The number of redds/river kilometer (rkm) in 2015 (7.8 redds/rkm) was lower than 2014 when 9.1 redds/rkm were observed (Figure 3). With an estimated 758 natural salmon returning to the Imnaha River Basin, 2015 is the 17th year since the first year of hatchery returns (1985) with >500 mature natural origin salmon returning to the Imnaha River (Figure 4). Hatchery salmon comprised 66.0% of known origin carcasses recovered on spawning ground surveys in the Imnaha River Basin (Figure 5; Table 19). Adult (age 4-5) hatchery salmon returns to the Imnaha River have exceeded natural adult returns for the last 19 consecutive years and 23 of the 31 years that hatchery salmon have returned to the Imnaha River. On two tributary streams to the Imnaha River, two unknown origin carcasses were recovered in Big Sheep Creek and zero carcasses were recovered in Lick Creek. We did not recovery any out-of-basin hatchery strays in the Imnaha River basin (Table 20).

In the Grande Ronde Basin, we counted 1,279 redds and recovered 769 carcasses. The number of redds/rkm in 2015 (6.5 redds/km) was lower than 2014 when 10.5 redds/rkm were observed (Figure 3). Hatchery salmon comprised the majority (64.1%) of known origin carcasses recovered on spawning ground surveys in the Grande Ronde Basin (Table 19). A total of 111 mature salmon from the Upper Grande Ronde River Safety Net Program (SNP) were transferred to Sheep Creek, a tributary to the Upper Grande Ronde River on 12 August 2015. We observed one redd in Sheep Creek, and based on the size of one redd (<1 m^2), we assumed that this redd was constructed by a SNP female Chinook Salmon. Hatchery Chinook Salmon have comprised the majority of returns in 12 of the last 15 return years in Catherine Creek, 11 of the last 14 return years in the Upper Grande Ronde River, 12 of the last 15 return years in the Lostine River, and 11 of the last 12 years in Lookingglass Creek.

In the Grande Ronde Basin, we recovered 27 in-basin strays: one Lookingglass Creek and six Lostine River salmon in Hurricane Creek; four Catherine Creek, seven Upper Grande Ronde River, and two Lostine River salmon in Lookingglass Creek; one Catherine Creek salmon in the Lostine River; two Lookingglass Creek and one Lostine River salmon in the Minam River; two Lostine River salmon in the Wallowa River, and one Lookingglass Creek salmon in the Wenaha River (Table 20). In addition, we recovered one out-of-basin hatchery stray salmon in the Lostine River that had been reared at the Cle Elum Fish Hatchery (Cle Elum, WA) and released from Easton Pond.

In 2015, 268 hatchery salmon (14 jacks and 254 adults) were released into the Wallowa River. All outplants were marked with either one or two opercle (OP) punches in the right opercle plate (i.e., 1ROP or 2ROP). We recovered sixteen hatchery Chinook Salmon in Hurricane Creek and five were marked with an OP punch. Three of the nine hatchery salmon recovered in the Wallowa River were marked with an OP punch. From the Catherine Creek weir, CTUIR also outplanted 108 hatchery salmon: 6 hatchery jack salmon and 100 hatchery adults were released into Indian Creek and two hatchery females were released into Lookingglass Creek.

In Grande Ronde Basin streams with hatchery supplementation, estimates of Chinook Salmon spawning in nature have been largely and consistently comprised of hatchery salmon (Figure 6). The percentage of hatchery salmon recovered on the spawning grounds in 2015 was 65.2%, 88.4% , 83.1%, and 54.8%, for Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River, respectively (Table 19, Figures 7–9).

Pre-spawn Mortalities

We visually examined female Chinook Salmon carcasses sampled on the spawning grounds for egg retention. We classified females as a pre-spawn mortality (PSM) if ≥ 50% of the eggs were retained and spawned if < 50% of the eggs were retained. If we could not determine egg retention for a female carcass, it was not included in the calculation of PSM. We do not estimate spawning success for male carcasses and assume that the PSM rate for males is the same as that of females. The PSM rate is calculated by dividing the number of PSM females by the total number of identifiably spawned and unspawned females. We require a minimum of 20 useable female carcass recoveries for the PSM rate calculation. For streams with weirs (i.e., hatchery supplementation programs), our preference is to estimate PSM rates above and below weirs separately. If we recover <20 females above or below a weir, we combine above and below weir recoveries to calculate a single PSM rate estimate for the stream. For the Wallowa-Lostine populations (i.e., the Lostine River, Bear Creek, Hurricane Creek, and Wallowa River), we calculated a combined annual PSM rate estimate. In the Minam and Wenaha rivers, we seldom recover 20 female carcasses, and when we do recover ≥ 20 females, the estimated mortality rates are <10%, so for those two streams we conservatively assume a PSM rate of 10%. We are currently reviewing methods for estimating PSM rates (e.g., Bowerman et al. 2016) and have a goal of revising our standards for monitoring and applying PSM data in our program.

For streams where egg retention could be determined on at least 20 female carcasses in 2015, the estimated PSM rate ranged from 0.0% to 37.8% (Table 21). In the Imnaha River, the estimated PSM rate was 15.0%. Because of safety concerns over forest fires, we only completed

two of the three scheduled surveys in the Minam River and recovered 12 female carcasses (0% PSM). In the Wenaha River, we completed one partial survey because access was restricted by the Grizzly-Ridge complex fire, and we recovered eight females (0% PSM). For streams with hatchery supplementation programs in the Grande Ronde Basin, PSM rates were 2.1%, 37.8%, 24.6%, and 22.8%, for Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River, respectively. These PSM rates should be considered minimums because the data were mostly collected from carcasses sampled during active spawning and any females that may have died well before the first survey would not be recovered.

Bacterial Kidney Disease Monitoring

We collected 220 kidney samples from Imnaha River Chinook Salmon in 2015 (Table 22). Of those, 149 came from hatchery-reared salmon and 71 from natural salmon; 140 samples were collected at Lookingglass Fish Hatchery and 80 from carcasses recovered on spawning ground surveys. The enzyme-linked immunosorbent assay (ELISA) OD levels were <0.2 for 97.9% of hatchery salmon and 95.0% of natural origin salmon.

We collected 538 kidney samples from Grande Ronde Basin salmon in 2015: 349 from hatchery-reared salmon and 189 from natural salmon; 406 from salmon spawned at Lookingglass Fish Hatchery and 132 recovered during spawning ground surveys (Table 21). The kidney samples collected during Chinook spawning ground surveys in Lookingglass Creek were lost prior to analysis. ELISA OD levels were <0.2 for 95.4% of hatchery salmon and 97.4% of natural origin salmon.

The highest ELISA OD level (2.9) was measured from a hatchery origin male pre-spawn mortality sampled at Lookingglass Fish Hatchery (Table 22). The two natural origin salmon sampled from the Minam River had low ELISA OD levels and zero hatchery salmon were sampled. From the other wilderness stream, the Wenaha River, we were unable to collect kidney samples from any of the carcasses.

Both natural and CHP females returning to Grande Ronde Basin streams tend to have low ELISA OD levels and the eggs of those with ELISA OD levels >0.2 are culled if they are spawned at Lookingglass Fish Hatchery. Therefore, smolts released from the CHP are from females with ELISA OD levels <0.2. We continue to find no evidence that the release of hatchery salmon is causing an increase in BKD prevalence in the monitored streams.

Acknowledgments

Andrew Gibbs, Lookingglass Fish Hatchery Manager, Diane Deal, Assistant Hatchery Manager, and many other hatchery personnel exhibited great dedication and provided essential assistance. Numerous personnel from ODFW, U.S. Fish and Wildlife Service, U.S. Forest Service, Nez Perce Tribe (NPT), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and Grande Ronde Model Watershed were supportive during spawning ground surveys and spawning at Lookingglass Fish Hatchery. The NPT provided Lostine River weir data and CTUIR provided weir data from Catherine Creek and the Upper Grande Ronde River, as well as spawning ground survey data summarized from Lookingglass Creek. This project was funded by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan, contract number F14AC00042-Mod 1, a cooperative agreement with ODFW.

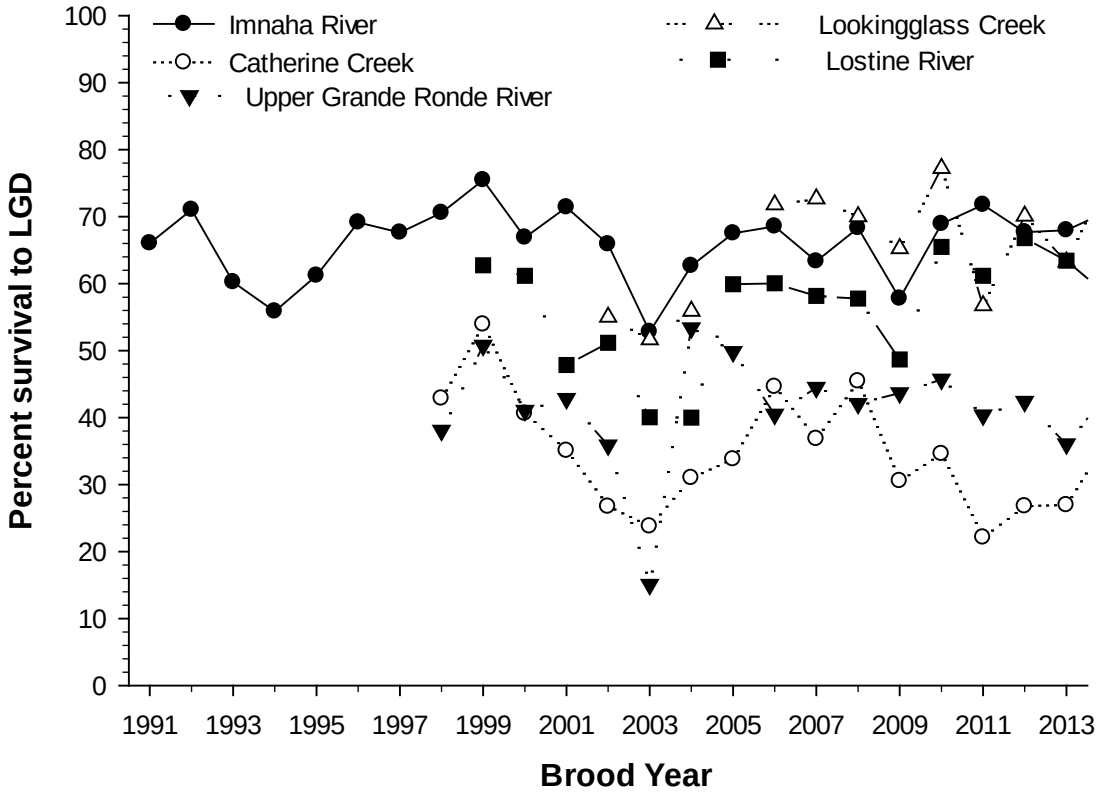

Figure 1. Mean survival rates to Lower Granite Dam (LGD) of PIT-tagged Chinook Salmon smolts released into the Imnaha River, Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River, BYs 1991-2013.

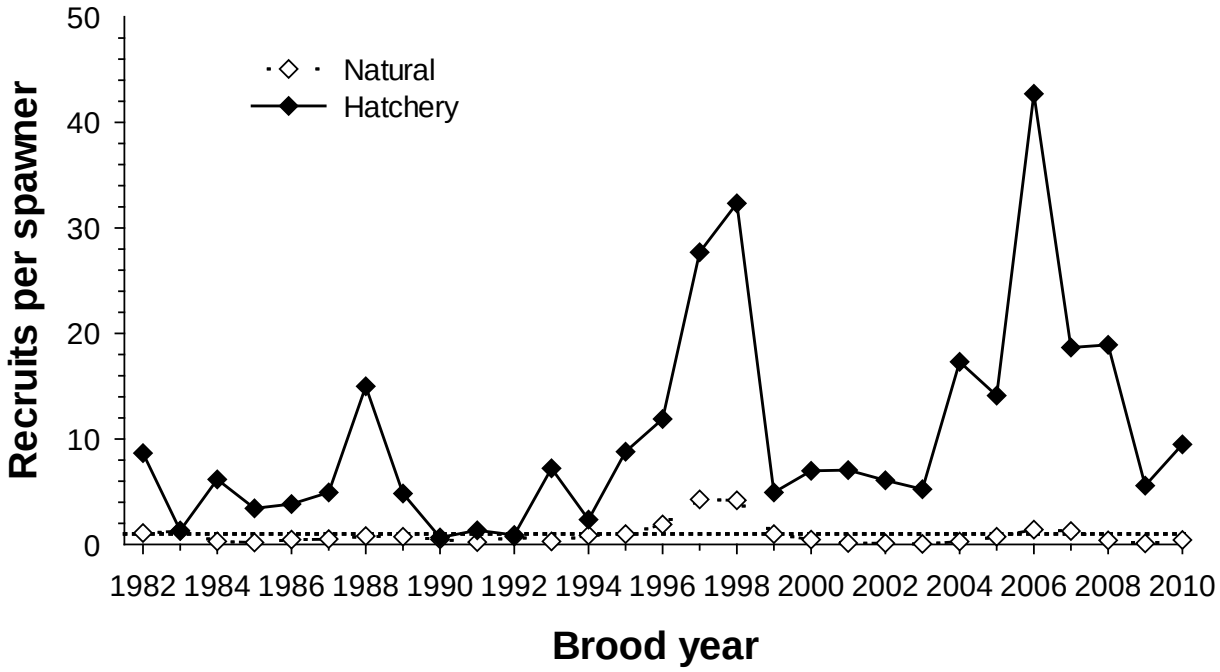

Figure 2. Total (including jacks) recruits-per-spawner ratios for completed brood years of Imnaha River Chinook Salmon, BYs 1982–2010. Note: dotted line indicates recruits-per-spawner ratio=1.

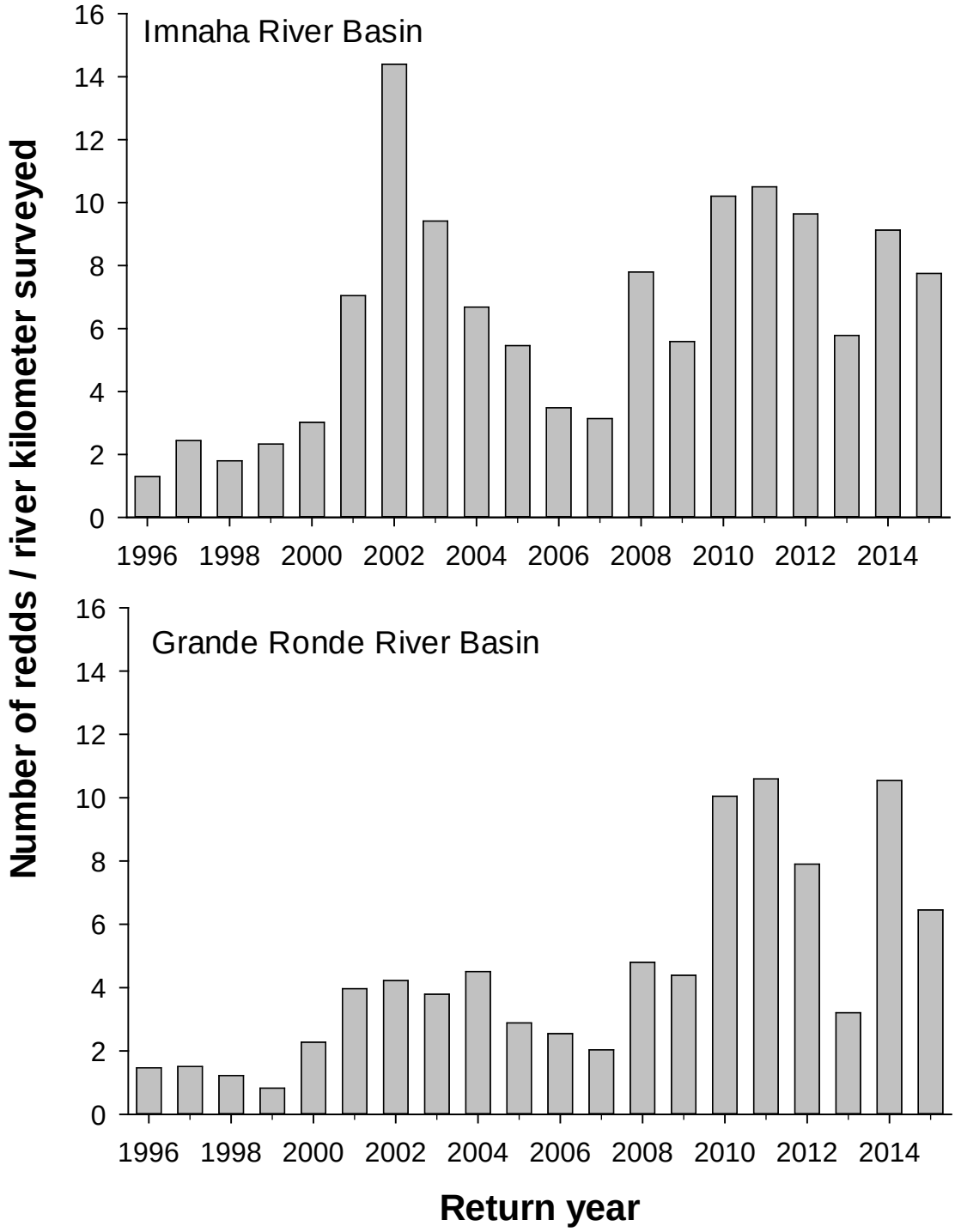

Figure 3. Total redds/river kilometer surveyed in the Imnaha and Grande Ronde river basins, 1996-2015.

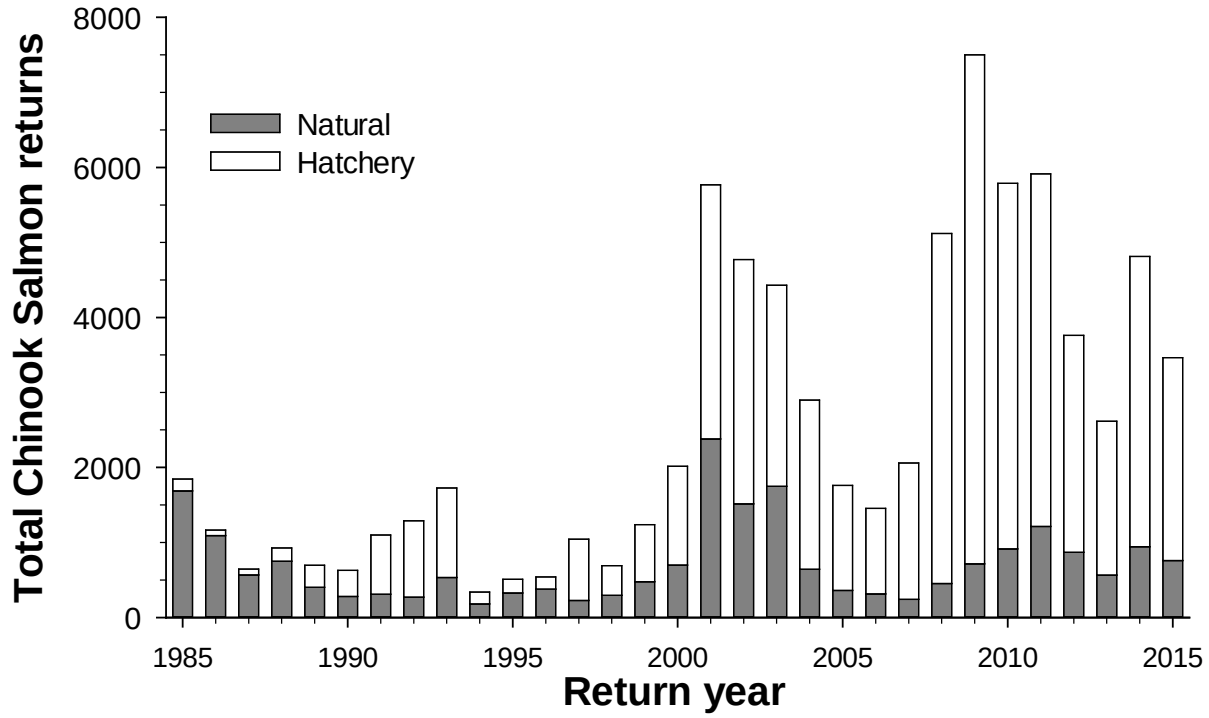

Figure 4. Estimated numbers of mature (ages 3-4) natural- and hatchery-origin Chinook Salmon that returned to the Imnaha River, 1985-2015.

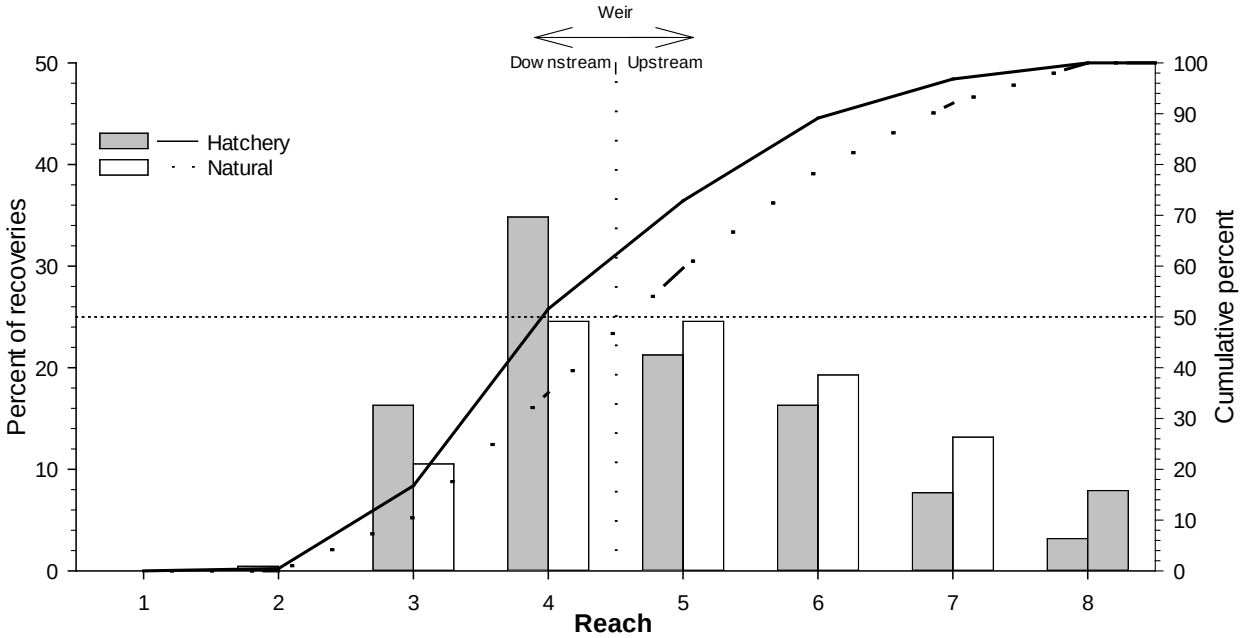

Figure 5. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on the Imnaha River, 2015. Reach 1- Gorge to Freezeout Creek, Reach 2-Grouse Creek to the Gorge, Reach 3-Crazyman Creek to Grouse Creek, Reach 4-Weir to Crazyman Creek, Reach 5-Macs Mine to the weir, Reach 6-Log to Macs Mine, Reach 7-Indian Crossing to Log, Reach 8-Blue Hole to Indian Crossing.

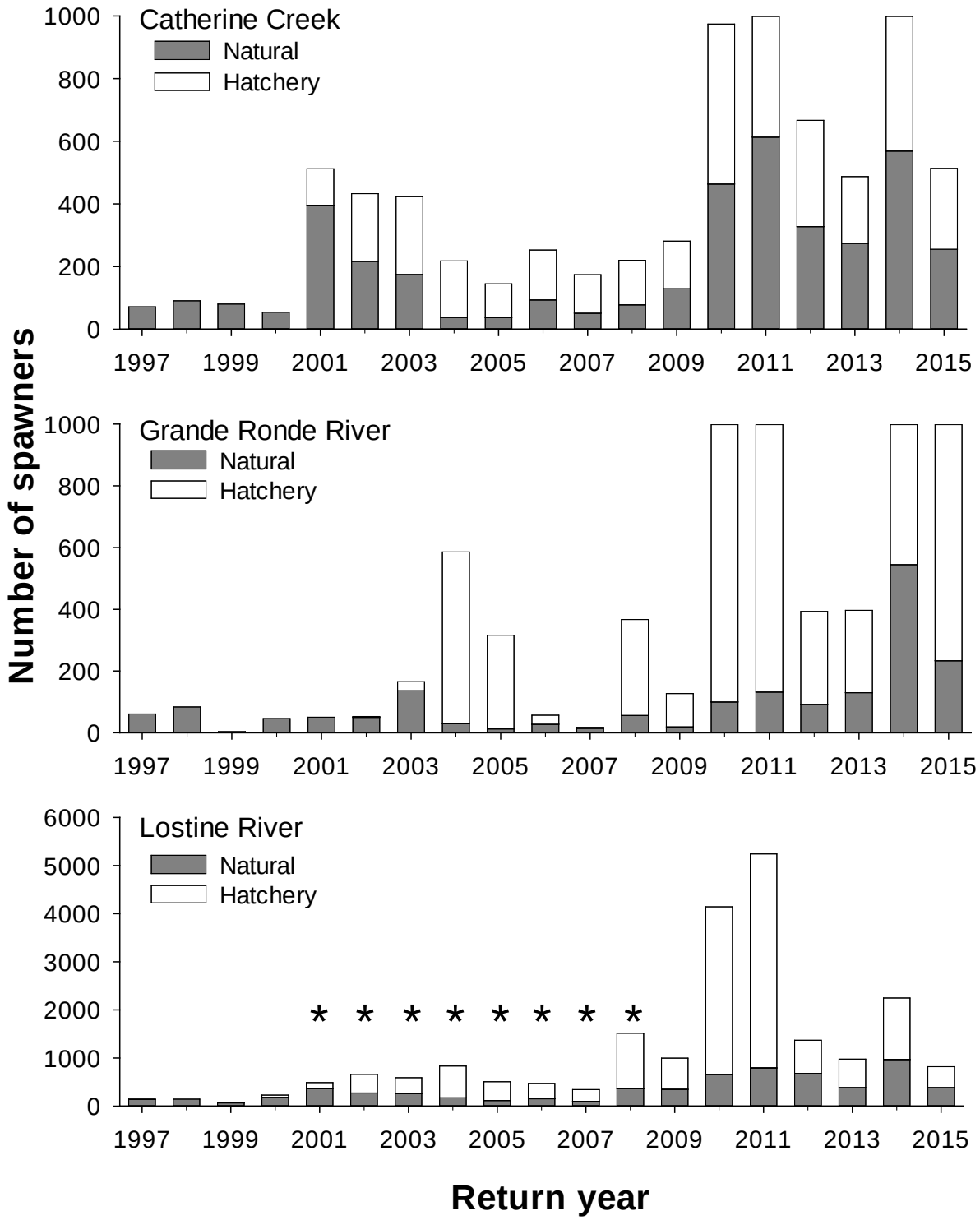

Figure 6. Estimated numbers of mature (ages 3-5) natural- and hatchery-origin Chinook Salmon that spawned naturally in Catherine Creek, Upper Grande Ronde River, and Lostine River, 1997-2015. *Lostine River data from 2001–2008 are not reliable because the Nez Perce Tribe reported that some members of the hatchery production staff falsified weir data.

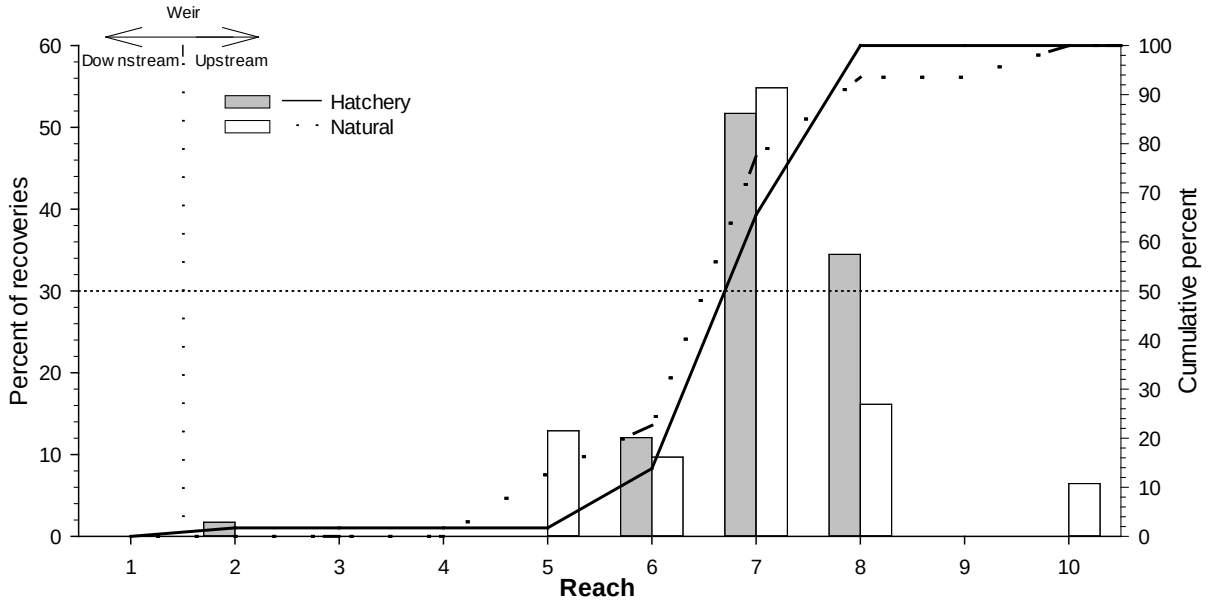

Figure 7. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on Catherine Creek, 2015. Reach 1-Weir to 2nd Union Bridge, Reach 2-Bottom of Southern Cross Ranch to the Weir, Reach 3-Mile Post 5 to top of Southern Cross Ranch, Reach 4-Badger Flat to Mile Post 5, Reach 5- Highway Bridge to Badger Flat, Reach 6-7735 Bridge to Highway Bridge, Reach 7-Forks to 7735 Bridge, Reach 8-South Fork Catherine Creek, Reach 9-North Fork Catherine Creek.

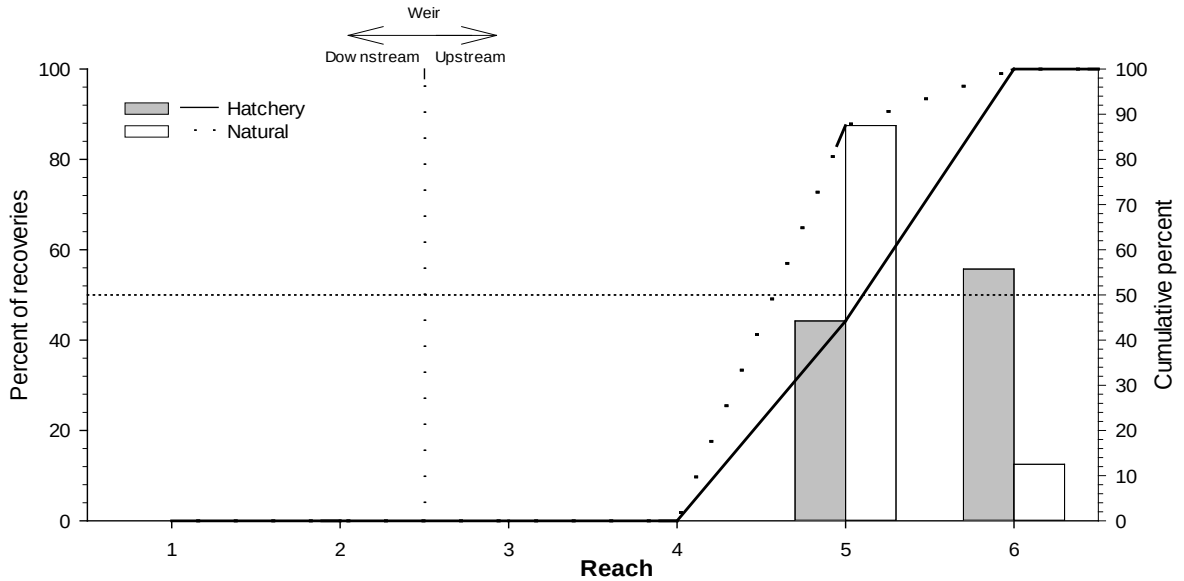

Figure 8. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on the Upper Grande Ronde River, 2015. Reach 1-Weir to Starkey Store, Reach 2-Spoolcart Campground to the Weir, Reach 3-Time and a Half Campground to Spoolcart Campground, Reach 4-Forest Service Boundary below Vey Meadows to Time and a Half Campground, Reach 5-Carson Campground Bridge to Forest Service Boundary below acclimation facility, Reach 6- Three Penny Claim to Carson Campground Bridge.

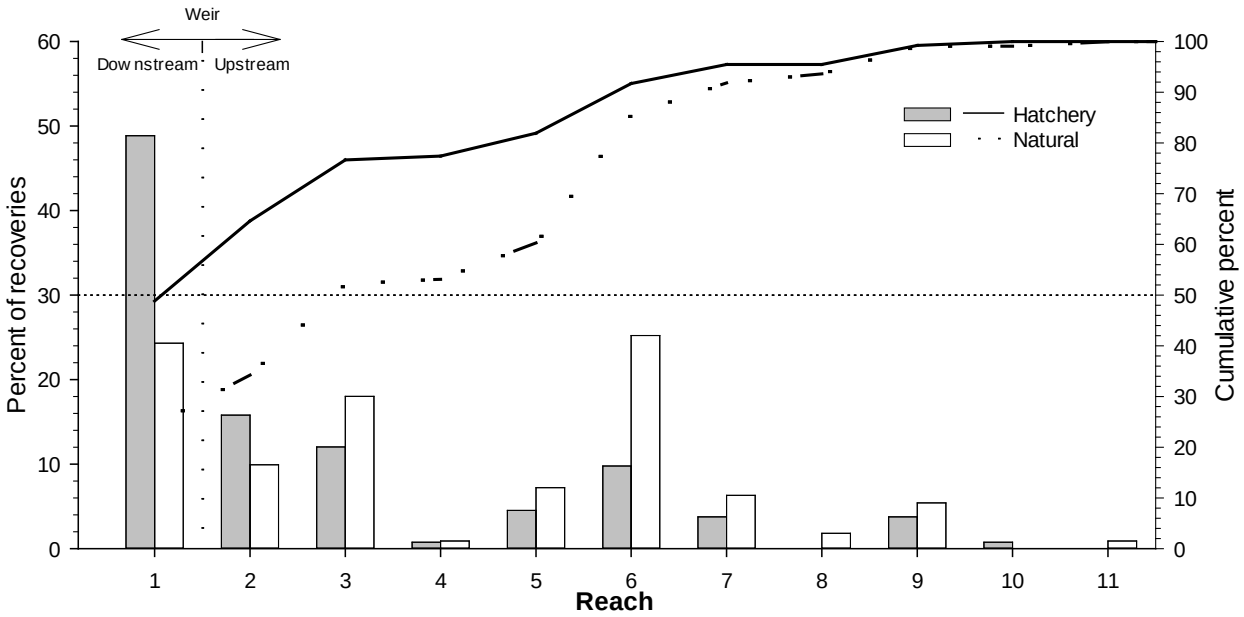

Figure 9. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on the Lostine River, 2015. Reach 1-Weir to the Mouth, Reach 2-McLain's Ranch to the Weir, Reach 3-Highway 82 Bridge in Lostine to McLain's Ranch, Reach 4-Westside Ditch to the trout farm, Reach 5-Lostine River Ranch Bridge to Westside Ditch, Reach 6-Acclimation Facility to Lostine River Ranch Bridge, Reach 7-Six Mile Bridge to Acclimation Facility, Reach 8-Pole Bridge to Six Mile Bridge, Reach 9-Above Walla Walla Campground to Williamson Campground, Reach 10-Lapover Meadows to Bowman Trailhead, Reach 11-Turkey Flat to Lapover Meadows.

Table 1. Production summaries for BY 2013 juvenile spring Chinook Salmon from the Conventional Hatchery Program released into the Imnaha and Grande Ronde river basins, 2015.

Stock	Number of females spawned	Number of green eggs taken	Eyed eggs	Number of eggs culled[a]	Number released as eyed eggs	Percent Survival			Total smolts released
						Green egg-to-eyed egg	Eyed egg-to-smolt[b]	Green egg-to-smolt[b]	
Imnaha River	87	390,184	359,106	0	0	92.0	92.4	85.0	331,702
Catherine Creek	49	186,125	155,649	0	0	83.6	94.0	78.6	146,310
Upper Grande Ronde Ronde River	66	251,184	230,290	0	0	91.7	97.5	89.4	224,443
Lookingglass Creek	67	249,742	201,754	4,617	0	80.8	89.5	72.0	176,440
Lostine River	69	294,759	263,330	0	0	89.3	94.7	84.6	249,369

[a] *Eggs were culled if enzyme-linked immunosorbent assay (ELISA) levels of female broodstock were > 0.2 for CHP production.*

[b] *Embryos culled from production or released as eyed eggs were subtracted from the calculation of green egg-to-smolt and eyed egg-to-smolt survival.*

Table 2. Estimates of percent adipose fin (Ad) clip and coded-wire tag application success for BY 2013 spring Chinook Salmon smolts produced from the Conventional Hatchery (CHP) program at Lookingglass Fish Hatchery and released in 2015.

Stock, CWT code	Raceway	Sample date	Number checked	% Ad clip, with CWT	% Ad clip, no CWT	% No Ad clip, with CWT	% No Ad clip, no CWT	Total smolts released
Imnaha River								
090801	5	1 OCT 2014	506	98.0	2.0	0.0	0.0	64,826
090802	6	1 OCT 2014	546	98.9	1.1	0.0	0.0	62,039
090803	9	1 OCT 2014	501	99.8	0.0	0.2	0.0	64,783
090804	8	1 OCT 2014	532	100	0.0	0.0	0.0	61,106
Total/mean			2,085	99.2	0.8	0.1	0.0	252,754
Ad-only	5-9	10 FEB 2015	505	n/a	99.6	n/a	0.4	78,948[a]
Catherine Creek								
090793	2	1 OCT 2014	547	100	0.0	0.0	0.0	37,580
090795	2	1 OCT 2014	[b]	[b]	[b]	[b]	[b]	15,336
090794	3	1 OCT 2014	[c]	[c]	[c]	[c]	[c]	34,681
090795	3	1 OCT 2014	517	99.2	0.4	0.4	0.0	18,080
Total/mean			1,064	99.6	0.2	0.2	0.0	105,677
Ad-only	2	1 OCT 2014	547	n/a	100	n/a	0.0	19,292
Ad-only	3	1 OCT 2014	517	n/a	100	n/a	0.0	21,341
			1,064	n/a	100	n/a	0.0	40,633
Upper Grande Ronde River								
090796	15	9 FEB 2015	531	98.1	0.8	1.1	0.0	53,998
090798	17	9 FEB 2015	512	97.7	1.9	0.4	0.0	54,918
Total/mean			1,043	97.9	1.3	0.8	0.0	108,916
090797	16	9 FEB 2015	521	n/a	n/a	96.0	4.0	52,088
090799	18	9 FEB 2015	549	n/a	n/a	95.8	4.2	63,439
Total/mean			1,070	n/a	n/a	95.9	4.1	115,527

Table 2 continued.

Stock, CWT code	Raceway	Sample Date	Number checked	% Ad clip, with CWT	% Ad clip, no CWT	% No Ad clip, with CWT	% No Ad clip, no CWT	Total smolts released
Lookingglass Creek								
090784	1	1 OCT 2014	503	98.8	1.2	0.0	0.0	25,856
090787	1	1 OCT 2014	[d]	[d]	[d]	[d]	[d]	6,739
090785	4	1 OCT 2014	556	99.8	0.2	0.0	0.0	26,020
090787	4	1 OCT 2014	[e]	[e]	[e]	[e]	[e]	6,275
090786	10	1 OCT 2014	520	98.5	1.5	0.0	0.0	26,228
090787	10	1 OCT 2014	[f]	[f]	[f]	[f]	[f]	7,574
Total/mean			1,579	99.0	1.0	0.0	0.0	98,692
Ad-only	1, 4, 10	1 OCT 2014	547	n/a	100	n/a	0.0	77,748[g]
Lostine River[a]								
090788	11[g]	1 OCT 2014	546	70.1	29.9	0.0	0.0	30,254
090789	12[g]	1 OCT 2014	551	88.0	12.0	0.0	0.0	29,082
090790	13	1 OCT 2014	547	97.8	2.2	0.0	0.0	28,604
090792	13	1 OCT 2014	[h]	[h]	[h]	[h]	[h]	13,687
090791	14	1 OCT 2014	527	99.8	0.2	0.0	0.0	28,537
090792	14	1 OCT 2014	[i]	[i]	[i]	[i]	[i]	15,255
Total/mean			2,171	88.9	11.1	0.0	0.0	145,419
Ad-only	11–14	1 OCT 2014	n/a[j]	n/a	100	n/a	0.0	103,950

[a] *Some of the smolts scheduled to receive only an Adipose fin clip (Ad) were placed into raceways with smolts that received an Ad clip and a CWT. We estimated that 1,240, 3,461, 3,622, and 2,347 smolts marked with only an Ad clip were placed into Raceways 5, 6, 8, and 9, respectively. Raceway 7 contained 68,278 Ad marked smolts. We assumed that the fin clip success rate of smolts from Raceway 7 was representative of smolts in Raceways 5,6, 8, and 9*

[b] *Tag code 090795 was mixed into Raceway 2 with tag code 090793 prior to the tag retention check.*

[c] *Tag code 090794 was mixed into Raceway 3 with tag code 090795 prior to the tag retention check.*

[d] *Tag code 090787 was mixed into Raceway 1 with tag code 090784 prior to the tag retention check.*

[e] *Tag code 090787 was mixed into Raceway 4 with tag code 090785 prior to the tag retention check.*

[f] *Tag code 090787 was mixed into Raceway 10 with tag code 090786 prior to the tag retention check.*

[g] *Representative groups of fish from Raceways 11 and 12, which were supposed to be 100% ADCWT, were set aside for tag retention checks. During the retention check, it was determined that fish marked with only an Ad clip were accidently mixed into these representative groups. We used the tag retention data from Raceways 13 and 14 to estimate marking success in Raceways 11 and 12.*

[h] *Tag code 090792 was mixed into Raceway 13 with tag code 090790 prior to the tag retention check.*

[i] *Tag code 090792 was mixed into Raceway 14 with tag code 090791 prior to the tag retention check.*

[j] *We used tag retention data from Raceways 11–14 to determine the proportion marked with an Ad clip. We estimated that there were 31,936 Ad only smolts in Raceway 11, 34,352 in Raceway 12, 20,173 in Raceway 13, and 17,489 in Raceway 14.*

Table 3. Mean size, total number released into the Imnaha and Grande Ronde river basins, number PIT-tagged, and survival rate to Lower Granite Dam of BY 2013 spring Chinook Salmon smolts produced from the Conventional Hatchery Programs and released in 2015. Fork length and weight data were collected at Lookingglass Fish Hatchery, 9-10 February 2015.

Stock, CWT code	Raceway	Release dates: Volitional	Release dates: Forced	Fork Length (mm): Mean	Fork Length (mm): SD	Weight (g): Mean	Weight (g): SD	Condition factor (K): Mean	Condition factor (K): SD	Total released	Number PIT-tagged	Survival rate to Lower Granite Dam
Imnaha River												
090801	5	1 APR	8 APR	112.6	7.0	17.3	3.7	1.2	0.1	66,066	4,232	0.60
090802	6	[a]	14 APR	113.8	9.4	18.9	4.6	1.2	0.1	65,500	4,109	0.71
090803	9	1 APR	8 APR	115.6	8.4	18.9	3.5	1.2	0.1	68,278	4,186	0.77
090804	8	1 APR	8 APR	112.1	9.7	16.4	4.0	1.2	0.1	64,728	4,169	0.57
Ad-only	7	[a]	15 APR	110.0	9.0	17.9	3.9	1.4	0.1	67,130	4,166	0.75
Total/mean										331,702	20,862	0.68
Catherine Creek												
090793/090795	2	19 MAR	15 APR	111.1	10.0	18.4	4.1	1.3	0.1	72,208	10,455	0.29
090794/090795	3	19 MAR	15 APR	115.1	9.5	18.2	4.8	1.2	0.1	74,102	10,399	0.25
Total/mean										146,310	20,854	0.27
Upper Grande Ronde River												
090796	15	1 APR	15 APR	116.1	7.9	18.8	4.5	1.2	0.1	53,998	497	0.30
090797	16	1 APR	15 APR	112.7	11.5	18.7	7.1	1.2	0.1	52,088	498	0.40
090798	17	18 MAR	30 MAR	113.8	8.5	17.8	4.2	1.2	0.1	54,918	498	0.48
090799	18	18 MAR	30 MAR	109.7	9.4	15.7	3.7	1.2	0.1	63,439	500	0.27
Total/mean										224,443	1,993	0.36

Table 3
continued

Stock, CWT code	Raceway	Release dates Volitional	Release dates Forced	Fork Length (mm) Mean	Fork Length (mm) SD	Weight (g) Mean	Weight (g) SD	Condition factor (K) Mean	Condition factor (K) SD	Total released	Number PIT-tagged	Survival rate to Lower Granite Dam
Lookingglass creek												
090784/090787	1	23 MAR	30 MAR	114.5	11.6	17.4	5.0	1.2	0.1	58,078	596	0.68
090785/090787	4	23 MAR	30 MAR	113.7	9.8	16.9	3.8	1.2	0.1	59,265	691	0.57
090786/090787	10	23 MAR	30 MAR	117.7	10.0	21.2	6.2	1.1	0.1	59,097	699	0.65
Total/mean										176,440	1,986	0.63
Lostine River												
090788	11	9 MAR	31 MAR	110.6	8.2	16.8	5.8	1.2	0.2	62,190	590	0.47
090789	12	9 MAR	31 MAR	113.0	9.1	17.6	4.9	1.3	0.2	63,434	600	0.57
090790/090792	13	31 MAR	22 APR	113.0	8.9	17.6	3.8	1.3	0.1	62,464	599	0.62
090791/090792	14	31 MAR	22 APR	113.8	8.8	18.3	5.0	1.2	0.1	61,281	504	0.88
Total/mean										249,369	2,293	0.64

[a] *Direct stream release at the Imnaha River weir.*

Table 4. Estimated numbers of BY 2014 spring Chinook Salmon parr from each supplemented population marked with an adipose (AD) fin clip and/or tagged with a coded-wire-tag (CWT), the number that were implanted with a passive integrated transponder (PIT) tag, and the estimated number of parr on hand at Lookingglass Fish Hatchery (LFH) on 31 December 2015. Note: tag retention checks are conducted in February 2016, after which we calculate estimates of the numbers of parr that were successfully marked/tagged.

	Estimated number of parr marked from 18-27 August 2015				Number PIT-tagged, October 2015	Estimated number of parr at LFH, 31 December 2015
Stock	AD clip with CWT	CWT, no AD clip	AD clip, no CWT	Total marked parr		
Imnaha River	342,176	0	179,746	521,922	20,950	519,824
Catherine Creek	114,845	0	52,359	167,204	20,947	166,510
Upper Grande Ronde River	122,039	119,843	0	241,882	1,997	240,997
Lookingglass Creek	142,654	0	162,683	305,337	4,999	313,109
Lostine River	139,366	0	121,044	260,410	2,403	259,597
Total	861,080	119,843	515,832	1,496,755	51,296	1,500,037

Table 5. Numbers of mature spring Chinook Salmon handled each week at northeast Oregon LSRCP trapping facilities in 2015. Totals for each stream exclude recaptured salmon. Total for Lookingglass Creek includes stray hatchery salmon from the Catherine Creek and Upper Grande Ronde River stocks, and excludes outplants from Catherine Creek. These numbers were not adjusted to account for unmarked hatchery returns.

Period	Week of year	Imnaha River[a]		Catherine Creek[b]		Upper Grande Ronde River[b]		Lookingglass Creek[a]		Lostine River[c]	
		Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural
Dates of trap operation:		18 MAY – 11 SEP		2 MAR – 29 JUL		2 MAR – 7 JUN		1 MAR – 18 SEP		15 FEB – 23 SEP	
19 – 25 APR	17	-	-	-	-	-	-	1	0	-	-
26 APR – 2 MAY	18	-	-	-	-	-	-	1	0	-	-
3 – 9 MAY	19	-	-	0	0	1	0	8	0	-	-
10 – 16 MAY	20	-	-	2	4	16	19	33	10	-	-
17 – 23 MAY	21	0	0	65	73	252	79	119	30	-	-
24 – 30 MAY	22	0	0	136	82	209	45	117	39	-	-
31 May – 6 JUN	23	0	1	93	50	261	52	197	109	3	0
7 – 13 JUN	24	64	45	116	71	40	6	180	47	18	12
14 – 20 JUN	25	25	15	22	19	-	-	43	14	84	49
21 – 27 JUN	26	147	73	4	4	-	-	43	8	98	53
28 JUN – 4 JUL	27	219	81	2	2	-	-	15	2	138	82
5 – 11 JUL	28	173	54	0	0	-	-	3	1	47	39
12 – 18 JUL	29	100	5	0	0	-	-	1	0	15	10
19 – 25 JUL	30	283	50	0	0	-	-	1	0	8	5
26 JUL – 1 AUG	31	63	7	0	0	-	-	3	0	2	4
2 – 8 AUG	32	97	16	-	-	-	-	1	0	4	6
9 – 15 AUG	33	18	3	-	-	-	-	2	2	3	3
16 – 22 AUG	34	65	14	-	-	-	-	2	1	0	0
23 – 29 AUG	35	186	55	-	-	-	-	7	7	64	49
30 AUG – 5 SEP	36	182	31	-	-	-	-	10	2	99	95
6 – 12 SEP	37	39	6	-	-	-	-	1	1	10	6
13 – 19 SEP	38	-	-	-	-	-	-	0	0	2	3
Total		1,661	456	440	305	779	201	788	273	595	416

[a] *Operated by Oregon Department of Fish and Wildlife*

[b] *Operated by Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Data provided by Mike McLean (CTUIR).*

[c] *Operated by Nez Perce Tribe (NPT). Data provided by Peter Cleary and Shane Vatland (NPT).*

Table 6. Numbers and dispositions, by origin, age, and sex of mature spring Chinook Salmon returning to northeast Oregon LSRCP trapping facilities in 2015. Numbers of Chinook trapped/passed above the weir were adjusted to account for the estimated numbers of returning unclipped hatchery salmon without a coded wire tag. Note: because of errors identifying sex at time of capture, the numbers of male and female salmon kept for broodstock may not match the sum of the numbers spawned, killed, not spawned, and pre-spawn mortality, at Lookingglass Fish Hatchery.

	Hatchery							Natural							
	Age 3		Age 4		Age 5			Age 3		Age 4		Age 5			Grand
Stock, Disposition	M	F	M	F	M	F	Total	M	F	M	F	M	F	Total	total
Imnaha River															
Trapped	375	1	587	608	45	45	1,661	57	1	233	116	12	37	456	2,117
Passed above the weir	0	0	89	180	23	23	315	57	1	188	92	10	21	369	684
Released below the weir	32	0	70	86	3	9	200	0	0	0	0	0	0	0	200
Outplanted	7	0	211	152	6	6	382	0	0	0	0	0	0	0	382
Foodbank/tribal distribution	176	0	121	91	3	1	392	0	0	0	0	0	0	0	392
Stream Enrichment	147	0	5	0	0	0	152	0	0	0	0	0	0	0	152
Trap Morts	0	1	0	0	0	0	1	0	0	1	2	0	0	3	4
Kept for broodstock[b]	13	0	89	107	4	6	219	0	0	43	23	2	16	84	303
Spawned[c]	0	0	84	94	4	6	188	0	0	39	20	2	15	76	264
Killed, not spawned	10	0	3	0	0	0	13	0	0	1	1	0	0	2	15
Pre-spawn mortality	3	0	2	3	0	0	8	0	0	3	2	0	1	6	14
Returned to Imnaha River	0	0	0	10	0	10	10	0	0	6[d]	0	0	0	6	16
Weir age & sex composition (%)	22.6	0.1	35.2	37.1	2.3	2.7	100	12.5	0.2	50.9	25.7	2.6	8.1	100	
Catherine Creek[a]															
Trapped	48	0	149	235	6	3	441	15	0	117	105	29	38	304	745
Passed above the weir	13	0	77	147	5	2	244	13	0	95	90	23	29	250	494
Outplanted: Indian Cr.	6	0	49	50	1	0	106	0	0	0	0	0	0	0	106
Outplanted: Lookingglass Cr.	0	0	0	2	0	0	2	0	0	0	0	0	0	0	2
Foodbank/tribal distribution	28	0	0	0	0	0	28	0	0	0	0	0	0	0	28
Trap Morts	0	0	1	3	0	0	4	0	0	0	1	0	2	3	7
Kept for broodstock[b]	1	0	22	33	0	1	57	2	0	22	14	6	7	51	108
Spawned[c]	1	0	21	33	0	0	55	2	0	22	13	6	7	50	102
Killed, not spawned	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Pre-spawn mortality	0	0	1	1	0	1	3	0	0	0	1	0	0	1	4
Weir age & sex composition (%)	10.8	0.0	33.8	53.3	1.4	0.7	100	4.9	0.0	38.5	34.5	9.5	12.6	100	

Table 6 continued.

	Hatchery							Natural							
	Age 3		Age 4		Age 5			Age 3		Age 4		Age 5			Grand
Stock, Disposition	M	F	M	F	M	F	Total	M	F	M	F	M	F	Total	total
Upper Grande Ronde River (UGR)[a]															
Trapped	11	0	266	488	6	9	780	1	0	50	93	13	43	200	980
Passed above the weir	7	0	196	428	5	6	642	0	0	35	73	9	34	151	793
Foodbank/tribal distribution	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trap Mort	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
Kept for broodstock[b]	4	0	71	59	1	3	138	1	0	14	20	4	9	48	186
Spawned[c]	4	0	67	54	1	3	129	1	0	13	15	4	8	41	170
Killed, not spawned	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Pre-spawn mortality	0	0	3	5	0	0	8	0	0	1	5	0	1	7	15
Weir age & sex composition (%)	1.4	0.0	34.1	62.6	0.8	1.1	100	0.5	0.0	25.0	46.5	6.5	21.5	100	
Lookingglass Creek															
All trapped Chinook[d]	103	1	278	387	13	6	788	35	0	86	145	6	1	273	1,061
Stray from UGR[e]	8	0	4	9	0	0	21	0	0	0	0	0	0	21	21
Stray from Catherine Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passed above weir	3	1	213	323	7	6	551	34	0	62	116	5	1	218	771
Released below weir	48	0	1	0	0	0	49	0	0	0	0	0	0	0	49
Removed/foodbank[f]	36	0	0	0	0	0	37	0	0	0	0	0	0	0	37
Killed at weir	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Trap Morts	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Kept for broodstock[b, g]	12	0	63	64	6	0	145	1	0	24	29	1	0	55	200
Kept for LFH broodstock	9	0	59	55	6	0	129	1	0	24	29	1	0	55	184
Spawned[d]	5	0	52	48	4	0	109	0	0	21	27	1	0	49	158
Killed, not spawned	2	0	2	0	0	0	4	0	0	1	0	0	0	1	5
Pre-spawn mortality	2	0	5	7	2	0	16	1	0	2	2	0	0	5	21
Weir age & sex composition (%)	13.1	0.1	35.3	49.1	1.6	0.8	100	12.8	0.0	31.5	53.1	2.2	0.4	100	

Table 6 continued.

Stock, Disposition	Hatchery							Natural							Grand total
	Age 3		Age 4		Age 5			Age 3		Age 4		Age 5			
	M	F	M	F	M	F	Total	M	F	M	F	M	F	Total	
Lostine River[h]															
Trapped	32	0	230	316	10	7	595	22	0	192	167	16	19	416	1,011
Passed above the weir	11	0	85	126	4	3	229	22	0	160	139	14	15	350	579
Tribal distribution/foodbank.	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
Outplant to Lower Wallowa R.[i]	3	0	77	109	3	2	194	0	0	0	0	0	0	0	194
Outplanted to Wallowa River: Wade Gulch[j]	11	0	24	25	0	0	60	0	0	0	0	0	0	0	60
Kept for broodstock	7	0	44	55	3	2	111	0	0	32	28	2	4	66	177
Spawned[c]	7	0	41	44	2	2	96	0	0	29	22	2	4	57	153
Killed, not spawned	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1
Pre-spawn mortality	0	0	3	11	0	0	14	0	0	3	6	0	0	9	23
Weir age & sex composition (%)	5.4	0.0	38.6	53.1	1.7	1.2	100	5.3	0.0	46.1	40.1	3.9	4.6	100	

[a] *Operated by Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Data provided by Mike McLean (CTUIR).*

[b] *Numbers kept for broodstock are based on weir record.*

[c] *Numbers spawned are based on records collected at Lookingglass Fish Hatchery.*

[d] *Six natural origin Imnaha River males were live spawned and returned to the Imnaha River.*

[e] *Totals include 21 trapped Chinook that were visually classified as strays from the Upper Grande Ronde CHP program because they had an intact adipose fin and a CWT was detected.*

[f] *Five assumed strays from the Upper Grande Ronde CHP program were foodbanked.*

[g] *Totals include three jacks and thirteen adults that were assumed to be strays from the Upper Grande Ronde CHP program that were incorporated into the Upper Grande Ronde broodstock.*

[h] *Operated by Nez Perce Tribe (NPT). Data provided by Shane Vatland (NPT).*

[i] *Released in the Wallowa River at the confluence of the Wallowa and Minam Rivers (N45.62174 E-117.72166; WGS84, decimal degrees) and recycled through the fishery.*

[j] *Released in the Wallowa River at Wade Gulch (N45.475166 E-117.387606; WGS84, decimal degrees) for the purpose of natural spawning.*

Table 7. Spawning summaries of spring Chinook Salmon from the Conventional Hatchery Programs at Lookingglass Fish Hatchery for the Imnaha and Grande Ronde basins, 2015.

	Number of parents									
	Hatchery			Natural						
		Males[a]			Males[a]					
Stock	F	Unique	Multiple[b]	F	Unique	Multiple[b]	Number of green eggs collected	Mean fecundity	Number of eyed eggs	Percent mortality to shocking
Imnaha River	100	88	93	35	41[c]	45	615,672	4,561	574,606	6.7
Catherine Creek	33	22	22	20	30	41	233,109	4,398	207,199	11.1
Upper Grande Ronde River	62	71	68	23	19	27	356,924	4,199	321,634	9.9
Lookingglass Creek	48	61	61	27	22	22	262,782	3,504	247,928	5.7
Lostine River	46	51	35	26	30	38	318,550	4,424	281,954	11.5

[a] *Male counts include jacks.*

[b] *The numbers of male parents is greater than the number of males that were spawned and the number of males kept because some males were spawned more than once and multiple males were usually spawned with one female in a 2x2 matrix.*

[a] *Six natural origin males were live spawned at Lookingglass Fish Hatchery and returned to the Imnaha River on 15 September 2015.*

Table 8. Numbers of female Chinook Salmon used in BY 2015 production and their mean egg weight (g) by stock, origin (hatchery or natural), and age. P-value for t-test comparing hatchery vs. natural salmon mean egg weights for each stock.

		Hatchery				Natural				
Stock		Age 3	Age 4	Age 5	Total/ mean	Age 3	Age 4	Age 5	Total/ mean	P-value
Imnaha River*	Females	NA	92	6	98	NA	19	15	34	
	Mean egg wt.	NA	0.238	0.255	0.239	NA	0.239	0.281	0.258	0.005
Catherine Creek	Females	NA	32	1	33	NA	13	7	20	
	Mean egg wt.	NA	0.221	0.264	0.222	NA	0.224	0.243	0.231	0.280
Upper Grande Ronde River*	Females	NA	57	3	60	NA	15	8	23	
	Mean egg wt.	NA	0.209	0.242	0.210	0.214	0.265	0.232	0.241	0.004
Lookingglass Creek*	Females	NA	47	0	47	NA	27	0	27	
	Mean egg wt.	NA	0.222	NA	0.222	NA	0.220	NA	0.220	0.709
Lostine River*	Females	NA	41	2	43	NA	22	4	26	
	Mean egg wt.	NA	0.219	0.266	0.222	NA	0.221	0.248	0.225	0.646

** The asterisk indicates stocks where the number of females with mean egg weights does not match the number of females spawned.*

Table 9. Catch and escapement summary of BY 2010–2012 smolts that were released into the Imnaha River and returned in 2015. Estimated coded-wire tag (CWT) recoveries were summarized through 3 May 2017 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2011)			Age 5 (BY 2010)			
Total Smolts Released	346,702			390,703			469,807			
% Ad + CWT	63.8%			55.6%			52.3%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	1	1	2	5	14	25	0	0	0	27
Columbia River										
Tribal	5	40	62	101	697	1,238	0	0	0	1,300
Non-tribal net	2	5	8	48	143	254	1	2	4	266
Sport	10	53	82	30	157	279	0	0	0	361
Snake River										
Sport[a]	0	0	0	1	10	17	0	0	0	17
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	9	9	14	13	19	34	0	0	0	48
Stray above LGD[a,b]	0	0	0	0	0	0	0	0	0	0
Recruitment to river[a]										
Sport Fisheries[c]	3	--	39	7	--	68	0	--	5	112
Tribal Fisheries[c]	0	--	2	0	--	301	0	--	20	323
Above weir estimate[d]	3	--	44	35	--	291	0	--	49	384
Below weir estimate[d]	6	--	190	36	--	516	2	--	37	743
Removed at weir[d]	138	--	344	158	--	776	1	--	26	1,146
Compensation area return	150	--	619	237	--	1,969	3	--	136	2,725
Total/Total estimated return	177	--	787	434	--	3,799	4	--	140	4,727

[a] *Indicates areas within LSRCP compensation area.*

[b] *Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.*

[c] *CWT samples were not collected from the fishery.*

[d] *Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Imnaha River hatchery salmon.*

Table 10. Total smolts released, and total returns (age 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and the Imnaha River for hatchery-reared spring Chinook Salmon released into the Imnaha River, complete brood years 1982-2009. SAR data were updated on 30 December 2016.

Brood Year	Total smolts released	To Lower Granite Dam		To river mouth	
		Total	SAR	Total	SAR
1982	29,184	208	0.713	208	0.713
1983	59,595	80	0.134	80	0.134
1984	35,782	112	0.313	111	0.313
1985	123,533[a]	207	0.168	206	0.168
1986	199,506	502	0.252	502	0.252
1987	142,320	389	0.274	389	0.274
1988	253,869	2,025	0.798	2,025	0.798
1989	267,670	672	0.251	672	0.251
1990	262,500	98	0.037	98	0.037
1991	157,659	103	0.065	103	0.065
1992	438,617	206	0.047	206	0.047
1993	590,118	1,062	0.180	1,062	0.180
1994	91,240	102	0.111	102	0.111
1995	50,903	536	1.053	536	1.053
1996	93,112	916	0.984	916	0.984
1997	194,958	3,381	1.734	3,379	1.733
1998	179,972	4,697	2.610	4,689	2.605
1999	123,009	1,248	1.015	1,242	1.010
2000	303,717	2,341	0.771	2,312	0.761
2001	268,420	1,816	0.677	1,811	0.675
2002	398,178	1,494	0.375	1,388	0.349
2003	435,187	1,358	0.312	1,358	0.312
2004	441,680	3,672	0.831	3,672	0.831
2005	432,530	3,488	0.806	3,488	0.806
2006	348,909	8,932	2.560	8,884	2.546
2007	293,801	3,696	1.258	3,696	1.258
2008	390,062	4,639	1.189	4,616	1.183
2009	252,588	1,257	0.498	1,256	0.497
2010	469,807	2,347	0.500	2,333	0.497
Mean	283,213	1,779	0.707	1,770	0.705

[a] *Smolts were scheduled for release into the Imnaha River, but were released into Lookingglass Creek on 20 April 20 because they were infected with Viral Erythrocytic Necrosis.*

Table 11. Catch and escapement summary of BY 2010–2012 Conventional Hatchery program smolts that were released into Catherine Creek and returned in 2015. Estimated coded-wire tag (CWT) recoveries were summarized through 3 May 2017 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2011)			Age 5 (BY 2010)			
Total Smolts Released	138,370			134,520			161,373			
% Ad + CWT	65.6%			63.3%			61.6%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	3	11	17	0	0	0	17
Non-tribal net	1	2	2	3	6	9	0	0	0	11
Sport	1	6	9	3	11	17	0	0	0	26
Snake River										
Sport[a]	0	0	0	1	4	6	0	0	0	6
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	0	0	0	0	0	0	0	0	0	0
Stray above LGD[a,b]										
Outside GR Basin	0	0	0	1	1	1	0	0	0	1
GR Basin[c]	4	--	10	3	--	13	1	--	9	32
Grande Ronde Pilot Fishery[a]	0	0	0	0	0	0	0	0	0	0
Recruitment to river[a]										
Sport Fisheries	0	--	0	0	--	0	0	--	0	0
Tribal Fisheries	0	--	0	0	--	0	0	--	0	0
Above weir estimate[c]	1	--	18	25	--	227	1	--	7	252
Below weir estimate[c]	0	--	2	0	--	8	0	--	0	10
Removed at weir[c]	19	--	35	47	--	160	0	--	2	197
Compensation area return	24	--	65	77	--	420	2	--	18	503
Total/Total estimated return	26	--	76	86	--	463	2	--	18	557

[a] *Indicates areas within LSRCP compensation area.*

[b] *Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.*

[c] *Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Catherine Creek hatchery salmon.*

Table 12. Catch and escapement summary of BY 2010–2012 Conventional Hatchery program smolts that were released into the Upper Grande Ronde River and returned in 2015. Estimated coded-wire tag (CWT) recoveries were summarized through 3 May 2017 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2012)			Age 4 (BY 2011)			Age 4 (BY 2010)			
Total Smolts Released	241,169			290,821			285,738			
% Ad + CWT	48.6%			49.4%			46.2%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	18	70	73	0	0	0	73
Non-tribal net	3	6	7	5	9	9	0	0	0	16
Sport	1	6	7	12	61	62	0	0	0	69
Snake River										
Sport[a]	0	0	0	0	0	0	0	0	0	0
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	1	0	1	0	0	0	0	0	0	1
Stray above LGD[a,b]										
Outside GR Basin	0	0	0	3	3	3	0	0	0	3
GR Basin[c]	15	--	20	17	--	58	0	--	0	78
Grande Ronde Pilot Fishery[a]	0	0	0	0	0	0	0	0	0	0
Recruitment to river[a]										
Sport Fisheries	0	--	0	0	--	0	0	--	0	0
Tribal Fisheries	0	--	0	0	--	13	0	--	0	13
Above weir estimate[c]	2	--	117	57	--	1,345	0	--	28	1,490
Below weir estimate[c]	0	--	0	0	--	0	0	--	0	0
Removed at weir[c]	4	--	4	131	--	131	0	--	0	139
Compensation area return	21	--	141	208	--	1,550	4	--	4	1,723
Total/Total estimated return	26	--	156	243	--	1,694	4	--	32	1,882

[a] *Indicates areas within LSRCP compensation area.*

[b] *Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.*

[c] *Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Upper Grande Ronde River hatchery salmon.*

Table 13. Catch and escapement summary for BY 2010–2012 Conventional Hatchery Program smolts that were released into Lookingglass Creek and returned in 2015. Estimated coded-wire tag (CWT) recoveries were summarized through 3 May 2017 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2012)			Age 3 (BY 2011)			Age 4 (BY 2010)			
Total Smolts Released	251,780			273,097			228,565			
% Ad + CWT	58.1%			46.8%			51.2%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	1	7	13	8	36	76	0	0	0	89
Non-tribal net	5	11	19	9	17	36	1	2	4	59
Sport	1	6	10	24	109	231	1	5	9	250
Snake River										
Sport[a]	0	0	0	0	0	0	0	0	0	0
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	1	1	2	0	0	0	0	0	0	2
Stray above LGD[a,b]										
Outside GR Basin	0	0	0	1	1	1	0	0	0	1
GR Basin[c]	1	--	12	3	--	29	0	--	0	41
Grande Ronde Pilot Fishery[a]	0	0	0	0	0	0	0	0	0	0
Recruitment to river[a]										
Sport Fisheries	1	--	47	4	--	121	0	--	3	171
Tribal Fisheries	0	--	3	0	--	317	0	--	9	329
Above weir estimate[c]	0	--	29	27	--	519	0	--	15	563
Below weir estimate[c]	9	--	19	34	--	125	0	--	4	148
Removed at weir[c]	7	--	44	63	--	115	3	--	6	165
Compensation area return	18	--	154	132	--	1,227	3	--	37	1,418
Total/Total estimated return	26	--	198	173	--	1,570	5	--	50	1,818

[a] *Indicates areas within LSRCP compensation area.*

[b] *Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.*

[c] *Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Lookingglass Creek basin hatchery salmon.*

Table 14. Catch and escapement summary for BY 2010–2012 Conventional Hatchery program smolts that were released into the Lostine River and returned in 2015. Estimated coded-wire tag (CWT) recoveries were summarized through 3 May 2017 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2012)			Age 4 (BY 2011)			Age 5 (BY 2010)			
Total Smolts Released	232,924			265,039			267,352			
% Ad + CWT	53.8%			49.5%			52.4%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	7	10	11	0	0	0	11
Columbia River										
Tribal	1	6	6	75	477	486	1	3	3	495
Non-tribal net	0	0	0	37	93	95	1	2	2	97
Sport	3	16	16	34	188	192	0	0	0	208
Snake River										
Sport[a]	0	0	0	0	0	0	0	0	0	0
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	1	1	1	3	3	3	0	0	0	4
Stray above LGD[a,b]										
Outside GR Basin	2	2	2	3	3	3	0	0	0	5
GR Basin[c]	0	--	0	11	--	129	0	--	0	129
Grande Ronde Pilot Fishery[a]	0	0	0	0	0	0	0	0	0	0
Recruitment to river[a]										
Sport Fisheries	0	--	4	0	--	129	0	--	4	137
Tribal Fisheries	0	--	10	0	--	545	0	--	17	572
Above weir estimate[c]	1	--	20	24	--	242	1	--	8	270
Below weir estimate[c]	0	--	11	31	--	256	0	--	8	275
Removed at weir[c]	3	--	21	47	--	335	2	--	10	366
Compensation area return	6	--	68	116	--	1,639	3	--	47	1,754
Total/Total estimated return	11	--	91	272	--	2,426	5	--	52	2,569

[a] *Indicates areas within LSRCP compensation area.*

[b] *Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.*

[c] *Expanded based on estimated total return to natal stream of mature (ages 3-5) of Lostine River hatchery salmon.*

Table 15. Total smolts released, and total returns (ages 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and Catherine Creek for hatchery-reared smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs and released into Catherine Creek, complete brood years 1998-2010. SAR data were updated on 3 May 2017.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
1998	CBS	37,982	425	1.119	419	1.103
1999	CBS	136,820	270	0.197	245	0.179
2000	CBS	180,340	693	0.384	673	0.373
2001	CBS	105,292	132	0.125	112	0.106
2001	CHP	24,392	80	0.328	78	0.320
2002	CBS	91,796	74	0.081	69	0.075
2002	CHP	70,072	210	0.300	200	0.285
2003	CBS	68,827	47	0.068	41	0.060
2003	CHP	120,754	132	0.109	121	0.100
2004	CBS	45,604	113	0.248	109	0.239
2004	CHP	23,216	88	0.379	84	0.362
2005	CBS	21,574	41	0.190	36	0.167
2005	CHP	49,696	246	0.495	227	0.457
2006	CHP	116,882	1,487	1.272	1,417	1.212
2007	CHP	138,842	855	0.616	763	0.550
2008	CBS	34,111	275	0.806	245	0.718
2008	CHP	110,242	1,073	0.973	992	0.900
2009	CBS	96,738	169	0.175	156	0.161
2009	CHP	58,737	171	0.291	162	0.276
2010	CHP	161,373	791	0.490	705	0.437
Mean	CBS/CHP	80,631	369	0.432	343	0.404

Table 16. Total smolts released, and total returns (ages 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and the Upper Grande Ronde River for hatchery-reared smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs and released into the Upper Grande Ronde River, complete brood years 1998–2010. SAR data were updated on 3 May 2017.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
1998	CBS	1,508	5	0.332	5	0.332
1999	CBS	2,559	11	0.430	11	0.430
2000	CBS	151,443	655	0.433	626	0.413
2001	CBS	210,113	326	0.155	311	0.148
2001	CHP	26,923	164	0.609	151	0.561
2002	CBS	75,063	3	0.004	3	0.004
2002	CHP	69,856	178	0.255	166	0.238
2003	CBS	1,019	0	0.000	0	0.000
2003	CHP	104,350	41	0.039	41	0.039
2004	CBS	76	0	0.000	0	0.000
2004	CHP	18,901	82	0.434	82	0.434
2005	CBS	20,620	121	0.587	115	0.558
2005	CHP	118,803	766	0.645	762	0.641
2006	CHP	259,932	3,011	1.158	2,856	1.099
2007	CBS	52,404	422	0.805	397	0.758
2007	CHP	94,148	602	0.639	579	0.615
2008	CBS	190,530	840	0.441	771	0.405
2008	CHP	41,819	540	1.291	508	1.215
2009	CBS	53,114	100	0.188	75	0.141
2009	CHP	189,271	573	0.303	502	0.265
2010	CHP	285,738	1,467	0.513	1,346	0.471
Mean	CBS/CHP	89,463	472	0.441	443	0.417

Table 17. Total smolts released, and total returns (ages 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and Lookingglass Creek for hatchery-reared smolts released into Lookingglass Creek from either the Catherine Creek Captive Broodstock (CBS) or Lookingglass Creek Conventional Hatchery (CHP) programs, complete brood years 2000–2010. SAR data were updated on 3 May 2017.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
2000	CBS	51,864[a]	78	0.150	65	0.125
2001	CBS	17,880[a]	65	0.364	65	0.366
2002	CBS	53,333	111	0.208	110	0.207
2003	CBS	98,023	167	0.170	164	0.167
2004	CHP	124,145	506	0.408	446	0.359
2005	CHP	0	NA	NA	NA	NA
2006	CBS	43,219	776	1.796	717	1.660
2007	CBS/CHP[b]	150,478	1,764	1.172	1,439	0.956
2008	CHP	262,910	2,955	1.124	2,937	1.117
2009	CHP	101,759	496	0.492	442	0.439
2010	CHP	228,565	2,431	1.064	2,220	0.971
Mean	CBS/CHP	118,048	1,684	1.130	1,551	1.029

[a] *Parr releases, not smolts.*

[b] *Released 100,450 Catherine Creek CBS smolts and 50,028 Lookingglass Creek CHP smolts. All smolts were marked with an adipose fin clip and a CWT.*

Table 18. Total smolts released, and total returns (ages 3-5), and smolt-to-adult return rates (SAR) to Lower Granite Dam and the Lostine River for hatchery-reared smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs and released into the Lostine River, complete brood years 1998–2010. SAR data were updated on 3 May 2017.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
1997	CHP	11,870	238	2.005	234	1.968
1998	CBS	34,985	588	1.681	574	1.641
1999	CBS	133,880	313	0.234	292	0.218
2000	CBS	77,312	673	0.870	642	0.830
2000	CHP	31,464	430	1.366	414	1.315
2001	CBS	141,867	439	0.309	433	0.305
2001	CHP	100,882	661	0.655	646	0.640
2002	CBS	133,729	192	0.144	184	0.137
2002	CHP	116,370	327	0.281	313	0.269
2003	CBS	62,149	114	0.183	113	0.182
2003	CHP	102,556	266	0.259	250	0.244
2004	CBS	40,982	120	0.293	111	0.271
2004	CHP	197,950	1,304	0.659	1,191	0.601
2005	CBS	24,604	219	0.890	207	0.840
2005	CHP	205,407	1,894	0.922	1,875	0.913
2006	CBS	10,470	201	1.920	201	1.919
2006	CHP	194,594	5,326	2.737	5,076	2.609
2007	CBS	61,927	1,324	2.138	1,318	2.129
2007	CHP	185,765	2,785	1.499	2,720	1.464
2008	CBS	60,997	899	1.474	878	1.439
2008	CHP	182,666	1,939	1.062	1,841	1.008
2009	CBS	1,905	22	1.155	11	0.577
2009	CHP	60,931	228	0.374	213	0.350
2010	CHP	267,352	2,310	0.864	2,285	0.855
Mean	CBS/CHP	97,705	951	0.999	918	0.947

Table 19. Summary of hatchery and natural origin Chinook Salmon carcasses recovered and number of redds observed by stream during spawning ground surveys in the Imnaha River and Grande Ronde River basins, 2015.

	Carcasses				
Basin, stream	Hatchery	Natural	Unknown origin	Percent hatchery[a]	Number of redds
Imnaha River Basin					
Big Sheep Creek	0	0	2	0.0	24
Imnaha River	221	114	3	66.0	595
Lick Creek	0	0	0	0.0	0
Total	221	114	5	66.0	619
Grande Ronde River Basin					
Bear Creek	1	5	0	16.7	9
Catherine Creek	58	31	2	65.2	222
Upper Grande Ronde River	61	8	6	88.4	123
Hurricane Creek	16	27	0	37.2	52
Limber Jim Creek	0	0	0	0.0	0
Lookingglass Creek[b,c]	182	37	28	83.1	276
Lostine River	136	112	3	54.8	257
McCoy Creek	0	0	0	0	0
Meadow Creek	0	0	0	0	0
Minam River[d]	4	23	0	14.8	198
Sheep Creek[e]	0	0	0	0	1
Wallowa River	9	11	0	45.0	34
Wenaha River	1	8	0	11.1	107
Total	468	262	39	64.1	1,279

[a] *Percent of carcasses of known origin.*
[b] *Data provided by CTUIR.*
[c] *Includes Little Lookingglass Creek.*
[d] *Includes Little Minam River.*
[e] *The one redd observed in Sheep Creek was <1 m^2 in size. Based on the small size, and lack of mature anadromous adult observations, the single redd in Sheep Creek was assumed to have been constructed by one of the Upper Grande Ronde Safety Net Program (SNP) adults that were placed into Sheep Creek from 2013-2015.*

Table 20. Summary of coded-wire tags (CWT) recovered from hatchery Chinook Salmon carcasses during spawning ground surveys in the Imnaha River and Grande Ronde River basins, 2015.

Recovery location	Brood year	CWT code	Number recovered	Release site
Imnaha River Basin				
Imnaha River	2010	090416	2	Imnaha River
	2011	090549	13	Imnaha River
		090550	22	Imnaha River
		090551	25	Imnaha River
		090552	10	Imnaha River
	2012	090764	1	Imnaha River
		090765	1	Imnaha River
		090766	3	Imnaha River
		090767	2	Imnaha River
Grande Ronde River Basin				
Catherine Creek	2010	090380	1	Catherine Creek
	2011	090432	12	Catherine Creek
		090540	13	Catherine Creek
	2012	090754	1	Catherine Creek
Hurricane Cr	2011	090541	1	Lookingglass Creek
		090547	5[a]	Lostine River
		090548	1	Lostine River
Lookingglass Creek[b]	2010	090381	1	Catherine Creek
	2011	090540	1	Catherine Creek
		090541	33	Lookingglass Creek
		090542	28	Lookingglass Creek
		090543	1	Upper Grande Ronde River
		090544	3	Upper Grande Ronde River
		090546	1	Upper Grande Ronde River
		090547	2	Lostine River
	2012	090754	2	Catherine Creek
		090756	2	Lookingglass Creek
		090757	7	Lookingglass Creek
		090760	1	Upper Grande Ronde River
		090761	1	Upper Grande Ronde River
Lostine River	2010	090283	1	Lostine River
	2011	090540	1	Catherine Creek
		090547	27	Lostine River
		090548	28	Lostine River
		190325	1	Easton Pond
	2012	090763	1	Lostine River

Table 20 continued.

Recovery location	Brood year	CWT code	Number recovered	Release site
Minam River[b]	2011	090542	1	Lookingglass Creek
		090547	1	Lostine River
	2012	090756	1	Lookingglass Creek
Upper Grande Ronde River	2011	090543	7	Upper Grande Ronde River
		090544	9	Upper Grande Ronde River
		090545	19	Upper Grande Ronde River
		090546	22	Upper Grande Ronde River
	2012	090759	1	Upper Grande Ronde River
		090761	1	Upper Grande Ronde River
Wallowa River	2011	090547	2[d]	Lostine River
Wenaha River	2011	090542	1	Lookingglass Creek

[a] *One of the CWT recoveries was from a hatchery salmon outplanted into the Wallowa River from the Lostine River.*
[b] *Data provided by CTUIR. Includes Little Lookingglass Creek.*
[c] *Includes the Little Minam River.*
[d] *The two CWT recoveries were from hatchery salmon outplanted into the Wallowa River from the Lostine River.*

Table 21. Numbers of female Chinook Salmon carcasses recovered on the spawning grounds that were classified as either a pre-spawn mortality (≥ 50% of eggs remained in carcass), spawned (< 50% of eggs remained in carcass), or unknown, and the pre-spawn mortality rates, 2015.

Recovery location	Pre-spawn mortality	Spawned	Unknown	% Pre-spawn mortality
Imnaha River Basin				
Imnaha River	27	153	8	15.0
Big Sheep Creek	0	0	1	0.0
Lick Creek	0	0	0	0.0
Grande Ronde River Basin				
Bear Creek	3	0	0	100
Catherine Creek	1	47	0	2.1
Hurricane Creek	0	22	0	0.0
Lookingglass Creek	31	95	2	24.6
Lostine River	33	112	6	22.8
McCoy Creek	0	0	0	0.0
Minam River	0	12	0	0.0
Sheep Creek	0	0	0	0.0
Upper Grande Ronde River	14	23	2	37.8
Wallowa River	1	8	2	11.1
Wenaha River	0	8	0	0.0

Table 22. Numbers and percentages of natural- and hatchery-reared mature Chinook Salmon from streams in the Grande Ronde River and Imnaha River basins sampled for BKD at Lookingglass Fish Hatchery or on spawning grounds surveys (SGS) with enzyme-linked immunosorbent assay (ELISA) optical density (OD) levels in each category and the mean ELISA OD level, 2015.

		ELISA category (OD units)							
		Low (< 0.2)		Moderate (0.2-0.799)		High (≥ 0.8)			Mean ELISA
Population, origin	Sample Location	N	%	N	%	N	%	Total N	OD level
Imnaha River									
Hatchery	LFH	100	97.1	1	1.0	2	1.9	103	0.117
	SGS	43	93.5	3	6.5	0	0.0	46	0.115
Natural	LFH	37	100	0	0.0	0	0.0	37	0.081
	SGS	33	97.1	1	2.9	0	0.0	34	0.105
Catherine Creek									
Hatchery	LFH	35	100	0	0.0	0	0.0	35	0.070
	SGS	24	92.3	2	7.7	0	0.0	26	0.125
Natural	LFH	22	100	0	0.0	0	0.0	22	0.071
	SGS	12	75.0	3	18.1	1	6.3	16	0.277
Upper Grande Ronde River									
Hatchery	LFH	71	100	0	0.0	0	0.0	71	0.073
	SGS	22	73.3	5	16.7	3	10.0	30	0.312
Natural	LFH	28	100	0	0.0	0	0	28	0.078
	SGS	2	100.0	0	0.0	0	0.0	2	0.107
Lookingglass Creek									
Hatchery	LFH	57	98.3	0	0.0	1	1.7	58	0.096
	SGS[a]	NA	0.0	NA	0.0	NA	0.0	NA	NA
Natural	LFH	30	100	0	0.0	0	0.0	30	0.076
	SGS[a]	NA	0.0	NA	0.0	NA	0.0	NA	NA
Lostine River									
Hatchery	LFH	100	98.0	0	0.0	2	2.0	102	0.123
	SGS	24	88.9	3	11.1	0	0.0	27	0.126
Natural	LFH	60	100.0	0	0.0	0	0.0	60	0.081
	SGS	28	96.6	1	3.4	0	0.0	29	0.119
Minam River									
Hatchery	SGS	0	0	0	0.0	0	0.0	0	0.000
Natural	SGS	2	100	0	0.0	0	0.0	0	0.095
Wenaha River									
Hatchery	SGS	0	0.0	0	0.0	0	0.0	0	0.000
Natural	SGS	0	0.0	0	0.0	0	0.0	0	0.000
Total		730	96.3	19	2.5	9	1.2	758	0.118

[a] *The kidney samples collected on the Lookingglass Creek spawning ground surveys were lost prior to analysis.*

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Appendix A: Methods for Individual Age Assignment

Methods for individual age assignment

We attempt to assign age to all mature (ages 3–5) Chinook Salmon returning to the Grande Ronde and Imnaha river basins of Northeast Oregon in order to determine their contribution to each brood year. We determine individual ages from scales (natural salmon) or coded-wire tags (CWTs; hatchery salmon). Additionally, a small portion of both hatchery and natural returns are implanted with a passive integrated transponder (PIT) tag as juveniles, from which we can determine a known age. However, all salmon are captured and not all that are captured can be sampled for age determination.

Mature Chinook Salmon are sampled in a variety of ways and at a variety of locations: weirs, spawning grounds, food bank distributions, and at Lookingglass Fish Hatchery during spawning. Each salmon captured at weirs will have one of six dispositions:

- released above the weir to spawn in nature (all are given a distinct opercle punch to show that they were handled at the weir)
- released below the weir for tribal and sport fisheries (also distinctly marked)
- outplanted into nearby streams for supplementation (also distinctly marked)
- taken to Lookingglass Fish Hatchery for use as broodstock
- killed for Oregon food banks or tribal subsistence
- accidental weir mortality

For a variety of reasons, the salmon are not sampled in proportion to their abundance based on age and origin. Hatchery salmon are sampled at a higher rate (all ages) than natural salmon because we capture more of them than we can use for broodstock or are allowed to release above the weir or outplant. We collect snouts from most of the salmon retained for Oregon food banks and about 20% of those sent to tribal subsistence distribution, many of which are hatchery-origin jacks. All natural salmon captured at a weir are either kept for hatchery broodstock or released to spawn in nature, making them less available for scale colletion. We recover only about 20–30% of the adult (age 4–5) carcasses on spawning ground surveys and carcasses of jacks are recovered at approximately half the rate at which adults are recovered. So natural jacks are the least sampled group and hatchery jacks are the most sampled group.

Although nearly all handled salmon are measured for fork length (FL; mm), it is not practical to collect scales or CWTs from each individual. All weir mortalities and salmon spawned at Lookingglass Fish Hatchery, and nearly all of those taken for Oregon food banks, tribal subsistence distribution, or recovered on spawning ground surveys have lengths measured and samples collected for ageing. However, many salmon may have their length measured but we cannot definitively assign an age, since logistical constraints may preclude scale or snout collection (e.g., the salmon will be released), some scale samples are found to be unreadable, or a CWT may be lost, and not all salmon with a clipped adipose fin have a CWT (by intention or accident). Also, not all salmon handled and released to spawn in nature are recovered on the spawning grounds. Therefore, we have a set of salmon for which we only have a length measurement but no way to definitively determine their age.

Compiling Data

At the end of the spawning season, we are left with a sample of the entire population, comprised of two groups: thosee with lengths only (un-aged) and those with both lengths and ages (aged). We now need to assign ages to those un-aged salmon when we know that the

assumption of equal sampling among age and size classes has been violated. Because of sample size limitations (for natural salmon, especially jacks) and previous analysis showing no significant difference in size-at-age of hatchery and natural salmon (Feldhaus et al. 2016), we pool both origins for these analyses.

To assign ages to the un-aged salmon, we first compile a data set comprised of all available FL and age data. Some of these FL measurements are duplicates because a subset of the salmon handled at the weir are measured during a separate sampling event when they are sorted for distribution to foodbanks, retention for hatchery broodstock, or released into nature and recovered on a spawning ground survey. Before the analysis can continue, we must first remove these duplicate earlier measurements that do have associated ages. Carcasses without a FL or that have an unknown opercle punch (OP) mark are excluded from all analyses.

To solve the problem of duplicates resulting from foodbank distribution and hatchery broodstock collection, we first remove all salmon from the weir database for which the disposition indicated that salmon were sent to an Oregon Foodbank, tribal subsistence distribution, or kept for hatchery broodstock. These salmon were sampled at a date after their collection at the weir and their length was re-measured and scales or a CWT were collected from most of them.

Salmon that were released into nature (above or below the weir or outplanted into other streams) and later recovered as carcasses on spawning ground surveys are another source of duplicate data that are more problematic. We must remove the earlier length measurement from the weir data and replace it with the carcass data. However, we only recover (as carcasses) approximately 25% of those salmon (half of that for jacks) on the spawning grounds and we do not know which carcass length goes with which weir length, as the salmon are not individually marked. This task is achieved by first assigning the data for both the salmon released above the weir and the OP-marked salmon recovered on the spawning grounds into 20 mm length intervals (bins). We use 20 mm bins to account for measuring error between live fish handled at the weir and dead salmon recovered on spawning grounds. Next, for each age and length datum we randomly remove one un-aged length datum from the weir data and replace it with an aged length datum from the appropriate length bin. For example, if 11 OP-marked salmon were recovered above the weir with fork lengths in the 740–759 mm bin, 8 with a known age of 4 and 3 with a known age of 5, we randomly replace 11 un-aged salmon from the 740–759 mm bin of the weir data set with the known age salmon. After removing all duplicate salmon from the weir data, we combine the weir data and any other un-aged salmon with the hatchery broodstock and foodbank data sets of aged salmon.

We next expand the spawning ground data to account for all of the salmon that we estimate were on the spawning grounds. We first calculate the adult carcass recovery rate by dividing the number of adult carcasses with an OP-mark by the sum of OP-marked and non-OP-marked adult carcasses. The jack recovery rate in northeast Oregon streams has consistently been ~50% of the adult recovery rate (ODFW unpublished data), so we assume that the jack recovery rate is one-half that of the adult recovery rate. We then expand the non-OP marked adult and jack recoveries by dividing the numbers recovered, by origin, sex, and FL, whenever possible, by their respective adult and jack recovery rates.

These expanded carcass recoveries, consisting of records with only FL data and both FL and known age data, are then merged with the weir records. This “final” data set is comprised of individuals with lengths and ages and individuals with only lengths, but there are no duplicates.

Calculating Mean and Standard Deviation of Fork Length and Age Composition

Next, we use the *mix* function from the *R* package mixdist (MacDonald and Du 2012) which uses a Newton-type algorithm and an expectation-maximization algorithm to separate age-length classes from length frequency data (Du 2012). The *mix* function uses the final data set containing both known aged and un-aged salmon to calculate means and standard deviations (SD) of fork lengths for each age class and estimated proportions that each age class comprises of the returning population (P_i; where *i* is the age class). The *mix* function model requires starting parameters: mean FL and SD for each age class are calculated from the salmon with known ages and the starting P_i for each age class can be estimated.

Assigning Individual Ages

Length distributions for each age of salmon usually overlap but not completely. To begin assigning ages to individual un-aged salmon, we first assign ages to salmon with FLs in 'uncontested' length ranges based on historic minima and maxima for each age class in each population. E.g., we have never had an Imnaha River Chinook Salmon with FL<496 mm and a known age that was older than 3 years or FL>1000 mm that was younger than 5 years. So, all un-aged salmon with a FL <496 mm and those >1000 mm are automatically assigned ages of 3 and 5, respectively. These limits could change in the future, if scales, tags or marks showed salmon that exceeded these limits.

For un-aged salmon in the "overlap zone", we assign ages, by bin, based on population and year-specific WALKs. Bins are 10 mm length intervals because our salmon are usually measured to the nearest 5 or 10 mm but any size can be used. Individual ages for un-aged salmon are assigned using a semi-random method for age assignment where un-aged salmon within each bin are randomly assigned ages in proportion to the ages present in the key (Isermann and Knight 2005; Ogle 2014). This method solves two common problems with this type of data: 1) bins for which there are no salmon of known age in that interval, and 2) lengths in overlap zones for which 100% of the known aged salmon are of only one age class. This method also prevents us from having to pool across wide bin sizes to solve these problems, which diminishes precision.

Weighted Age-Length Key

We use the mixdist results to construct a weighted age-length key (WALK), for each population and return year, that is based on normal distributions for each age class and weighted by P_i.To construct our Weighted Age-Length Key (WALK), we first decide on the desired bin size (e.g., 10 mm; Appendix Table A-1). Using the mean FL and SD for each age class present in our population, we calculate the proportion of that age class that should be occupy each bin (PB_i), given a normal distribution (Step 1 in Appendix Table A-1). The sum of each PB_i=1. Next, to compensate for the prevalence of that age class in the entire catch, we calculate weighted proportions (WP_i) by dividing each cell for each age class by the value of P_i for that age class ($WP_i=PB_i/P_i$; Step 2 in Appendix Table A-1). Lastly, we calculate the age proportion in each bin (APB_i) by dividing the WP_i by the sum of the WP for each bin ($APB_i=WP_i$/WP Sum; Step 3 in Appendix Table A-1). The APB_i are the values used to assign ages to the un-aged salmon using the semi-random age assignment method of Isermann and Knight (2005) using the R package (Ogle 2014).

WALK example

As an example using our WALK (see highlighted line in Appendix Table A-1), an un-aged salmon with FL=615 mm would be placed in the 610 mm bin. If the mean FLs (and SDs) at age for this population are 530 mm (37 mm) for age 3, 740 mm (45 mm) for age 4, and 910 mm (50 mm) for age 5, then the PB_is for the 610 mm bin will be 0.008, 0.002, and 0.000 for ages 3, 4, and 5, respectively. If our population is comprised of 45% age 3, 50% age 4, and 5% age 5, then the P_i values are $P_3 = 0.45$, $P_4 = 0.50$, and $P_5 = 0.05$. So the WP_i values in the 600 mm bin will be $WP_3=0.014/(1-0.45)=0.025$, $WP_4=0.001/(1-0.50)=0.002$, and $WP_5=0.000/(1-0.05)=0.0$. Lastly, the APB_i values for the 600 mm bin would be $APB_3=0.025/0.027=0.927$, $APB_4=0.002/0.027=0.073$, and $APB_5=0.000/0.027=0.000$. So, if there were 10 un-aged individuals in the 600 mm bin, nine (92.7%) would be randomly assigned to age 3, one (7.3%) would be assigned to age 4, and none would be assigned to age 5.

Appendix A Table 1. Example of a portion (FL=600-809) of a weighted age-length key containing three age classes (ages 3, 4, and 5) for Chinook Salmon. The shaded area is used in example text.

	Step 1			Step 2				Step 3			
	Fork Lengths (mm)			Proportion of salmon in each age class (P_i)							
Mean	530	740	910	P_3	P_4	P_5					
SD	37	45	50	0.45	0.50	0.05					
	Proportions for each bin by age (PB)			Weighted proportions (WP) = (PB/(1-P_i)				Age proportions in each bin (APB) = (WP_i/WP Sum			
Bin	PB_3	PB_4	PB_5	WP_3	WP_4	WP_5	WP Sum	APB_3	APB_4	APB_5	Bin Sum
600	0.014	0.001	0.000	0.025	0.002	0.000	0.027	0.927	0.073	0.000	1.000
610	0.008	0.002	0.000	0.014	0.004	0.000	0.018	0.789	0.211	0.000	1.000
620	0.004	0.003	0.000	0.007	0.007	0.000	0.014	0.519	0.481	0.000	1.000
630	0.002	0.006	0.000	0.004	0.012	0.000	0.016	0.233	0.767	0.000	1.000
640	0.001	0.010	0.000	0.002	0.019	0.000	0.021	0.077	0.923	0.000	1.000
650	0.000	0.015	0.000	0.001	0.030	0.000	0.031	0.022	0.978	0.000	1.000
660	0.000	0.022	0.000	0.000	0.044	0.000	0.044	0.006	0.994	0.000	1.000
670	0.000	0.031	0.000	0.000	0.063	0.000	0.063	0.002	0.998	0.000	1.000
680	0.000	0.042	0.000	0.000	0.084	0.000	0.084	0.000	1.000	0.000	1.000
690	0.000	0.054	0.000	0.000	0.108	0.000	0.108	0.000	1.000	0.000	1.000
700	0.000	0.065	0.000	0.000	0.131	0.000	0.131	0.000	1.000	0.000	1.000
710	0.000	0.076	0.000	0.000	0.152	0.000	0.152	0.000	1.000	0.000	1.000
720	0.000	0.084	0.000	0.000	0.167	0.000	0.167	0.000	0.999	0.001	1.000
730	0.000	0.088	0.000	0.000	0.176	0.000	0.176	0.000	0.999	0.001	1.000
740	0.000	0.088	0.000	0.000	0.176	0.000	0.176	0.000	0.998	0.002	1.000
750	0.000	0.084	0.001	0.000	0.167	0.001	0.168	0.000	0.996	0.004	1.000
760	0.000	0.076	0.001	0.000	0.152	0.001	0.153	0.000	0.992	0.008	1.000
770	0.000	0.065	0.002	0.000	0.131	0.002	0.133	0.000	0.983	0.017	1.000
780	0.000	0.054	0.004	0.000	0.108	0.004	0.111	0.000	0.967	0.033	1.000
790	0.000	0.042	0.006	0.000	0.084	0.006	0.090	0.000	0.933	0.067	1.000
800	0.000	0.031	0.009	0.000	0.063	0.009	0.072	0.000	0.871	0.129	1.000
	↓	↓	↓								
Sum	1.000	1.000	1.000								

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Appendix B: Estimating Total Escapement

There are currently five supplemented spring-summer Chinook (*Oncorhynchus tshawytscha*) populations in Northeast Oregon: Imnaha River, Catherine Creek, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River. We estimate total escapement to each stream using data from weirs, spawning ground surveys, recreational and tribal fisheries, and salmon collected for hatchery broodstock and Oregon and tribal foodbanks. Many separate estimates are calculated, based on age and origin of the salmon, all of which are summed to calculate the total estimated escapement to each population.

Each supplemented population has a weir on its stream for hatchery broodstock collection. A portion of the salmon captured at those weirs are marked with an opercle punch and released to spawn in nature above the weir. For each of these supplemented populations, a minimum of three spawning ground surveys are conducted every year, above and below the weirs.

At weirs, we characterize each salmon as a jack (age 3) or adult (ages 4–5) based on fork length. For the Imnaha River and Lostine River, adults have a fork length >630 mm and jacks are ≤630 mm. In Catherine Creek, the Upper Grande Ronde River, and Lookingglass Creek, adults are >600 mm and jacks are ≤600 mm. Because of differences in recovery rates of jacks and adults, we calculate separate population estimates for each of these size classes.

Weir Management

The number of salmon above a weir is heavily influenced by weir efficiency (e.g., installation date and its effectiveness) and how the fish population is managed (e.g., sliding scale criteria). If the weir is 100% efficient (installed before the first salmon arrive and captures all salmon attempting to pass its location), then all salmon above the weir will have been captured at the weir and intentionally released above it. However, weir efficiency varies annually and is rarely 100% for any of our populations. Therefore, the number of salmon above a weir is a combination of those salmon that were not handled at the weir (poor weir efficiency) and those handled at the weir and released to spawn in nature.

The number of salmon released into nature is dependent upon how each stream is managed. All natural salmon caught at a weir that are not kept for broodstock are released above the weir to spawn in nature. Sliding scales are used by co-managers to dictate how many hatchery Chinook Salmon can be placed above each weir. Managers use sliding scales to restrict the hatchery fraction (the percentage of salmon spawning in nature that are of hatchery origin) in order to maximize the number of salmon spawning in nature but without swamping the natural salmon with hatchery salmon. Either a late weir installation date or environmental conditions that render the weir ineffective during the Chinook Salmon run can result in a hatchery fraction above the weir that may not accurately represent the ratio of hatchery and natural adults handled and intentionally passed above the weir.

Above Weir Adult Chinook Salmon Population Estimates

When a weir is 100% efficient, the number of salmon above the weir is known and does not have to be estimated. In the absence of perfect weir efficiency, we estimate adult escapement above a weir using the Chapman (1951) modification to the Petersen mark-recapture estimator which is calculated as:

$$\tilde{N} = \frac{(M+1)(C+1)}{R+1} - 1$$

The number of Chinook Salmon marked (M) with an opercle (OP) punch and released above the weir are recorded in annual trapping data. During spawning ground surveys, we examine each salmon carcass for OP punches. Recaptures (R) are carcasses which have identifiable OP punches and captures (C) are the total number of adult sized carcasses (punched or unpunched) recovered from all of the spawning ground surveys completed above the weir. Carcasses with unknown OP punches (e.g., the head was eaten) are excluded from the above weir population estimates. For our mark-recapture estimate, we make the following assumptions:

- The OP mark is not lost. Although the skin on the gill plate can grow over the OP mark, it is still identifiable when surveyors examine the underside of the gill plate.
- Equal recovery rate of OP and non-OP marked carcasses.
- Equal recovery rate of hatchery and natural carcasses.
- Adult Chinook Salmon passed above the weir do not escape below the weir.

Our preference is to calculate separate mark-recapture estimates for hatchery and natural adults above the weir. Therefore, the estimated total number of adults above the weir is the sum of the independent mark-recapture estimates for hatchery and natural adults and the adult hatchery fraction above the weir is calculated as the hatchery adult estimate divided by the sum of the above weir hatchery and natural adult estimates. However, it is not always possible to calculate origin specific mark-recapture estimates. Robson and Regier (1964) showed that "bias in the Petersen estimator is negligible only when the product of the two samples sizes (M x C) exceeds the populations size (N) by a factor of 3 or 4." In order for the probability of bias to be less than 2%, their recommendation was that MC should be greater than four times the true population N (i.e., MC/N>4). We adhere to this recommendation and pool hatchery and natural adults into a single Petersen estimate if one or both of the origin-specific adult mark-recapture estimates has a ratio of MC/N$\leq$ 4.

When we must pool the hatchery and natural adults to calculate the above weir adult estimate, we separate hatchery and natural adult estimates using the adult hatchery fraction, which is calculated as:

$$\frac{Hatchery\ adults\ handled\ at\ the\ weir + expanded\ unpunched\ hatchery\ adult\ carcasses\ recovered\ above\ the\ weir}{Total\ adults\ handled\ at\ the\ weir + total\ expanded\ adult\ carcasses\ recovered\ above\ the\ weir}$$

We expand adult recoveries without an OP mark by the pooled marked adult recovery rate because the number and origin of adults passed above the weir is known and we only need to expand for untrapped adults. The pooled marked adult recovery rate is calculated as the number of OP marked adult recoveries divided by the number of OP marked adults released. The estimated number of hatchery adults above the weir is then calculated as:

$$Above\ Weir\ Total\ Adult\ Estimate\ *\ Adult\ Hatchery\ Fraction.$$

And the estimated number of natural adults above the weir is calculated as:

$$Above\ Weir\ Total\ Adult\ Estimate - Above\ Weir\ Hatchery\ Estimate$$

Below Weir Adult Chinook Salmon Estimates

We begin by multiplying the total adult population estimate above the weir by the above weir pre-spawn survival rate to estimate the total number of spawners above the weir. The pre-spawn survival rate is the percentage of all female carcass recoveries with an estimated egg retention <50%. Next, we divide the total number of spawners above the weir by the number of above weir redds to calculate the total number of adult spawners/redd above the weir. We estimate the total number of spawning adult Chinook Salmon below weirs by multiplying the number of redds recorded below the weir times the total number of adult spawners/redd calculated from above the weir. We calculate the total adults below the weir by dividing the number of spawners below weir by the below weir pre-spawn survival rate. The sum of the adults above the weir and the adults below the weir is the estimated number of "Fish In River."

If we do not recover at least 20 female carcasses below the weir, we are not confident in our estimate of pre-spawn survival. On the Imnaha River, the pre-spawn survival below the weir has been a mean of 10% lower than that above the weir (1996–2015 for years with ≥ 20 female carcass recoveries below the weir). Therefore, if <20 female carcasses are recovered below the Imnaha River weir, we subtract 10% from the above weir pre-spawn survival rate and divide the number of spawners below the weir by this adjusted pre-spawn survival rate to estimate total adults below the weir. On the Lostine River and Lookingglass Creek, we often do not recover at least 20 female carcasses below the weir. In those years, we pool the above and below weir female carcasses into a single survival rate. There are usually zero redds and zero carcasses found below the weirs on Catherine Creek and the Upper Grande Ronde River, so we use all carcass recoveries to estimate a single pre-spawn survival rate and estimate the number of adults below the weir by multiplying the number of spawners below the weir by the overall pre-spawn survival rate.

We adjust for pre-spawn survival below the weir to calculate adults below the weir because spring Chinook Salmon populations in Northeastern Oregon spawn earlier upstream than downstream, making those salmon spawning downstream more susceptible to pre-spawn mortality. Additionally, an assumption of our methodology is that the final redd counts occur after the salmon have completed redd building. If the final redd count above the weir occurs before Chinook Salmon have ceased spawning, the above weir adult spawner/redd estimate will be biased high. Similarly, if the above weir redd count occurs after all the adults have completed spawning above the weir, but spawning below the weir is still occurring after the final redd count or there is undocumented spawning below the weir, the below weir redd count may be biased low, which would underestimate adult spawners below the weir.

Estimating Chinook Salmon jack returns

Jack estimates are challenging. First, based on PIT tag detections, the median date of the jack return over Lower Granite Dam is 1-2 weeks later than the median date of the adult return. This differential run timing means that weir efficiency for adults and jacks is likely to be different if a weir is installed after the first salmon arrive at the weir site. Furthermore, sliding scale management agreements severely limit the number of hatchery jacks that can be released above a weir and the carcass recovery rates for jacks is consistently one-half that of adults (ODFW unpublished data). Therefore, in most years, there are not enough jacks passed above the weir and recovered on spawning ground surveys to calculate a Lincoln-Petersen mark-recapture estimate for jacks.

When the data are available, our preference is to use the same methods to estimate and partition out hatchery and natural jacks above the weir that we use to estimate hatchery and

natural adults above the weir. If data are insufficient for a mark-recapture estimate, we expand jack carcasses recovered without an OP mark above the weir by 50% of the adult carcass recovery rate. For example, if 25% of the OP marked adults are recovered, then the jack recovery rate is assumed to be 25% * 0.5 = 12.5%. Therefore, if we recovery 15 jack carcasses lacking an OP mark above the weir and the estimated jack recovery rate is 12.5%, the estimated number of untrapped jacks above the weir is 120. If we cannot calculate separate hatchery and natural jack estimates by mark-recapture, we apportion the hatchery- and natural origin jack components using the ratio of hatchery:natural jacks released above the weir and the number of expanded unpunched jack carcass recoveries. Since the number of jacks passed above the weir is known, we only need to expand the number of untrapped jacks (i.e., jack carcasses recovered on SGS surveys without an OP mark). The total number of jacks above the weir is our estimate of untrapped jacks plus the number of jacks that were released above the weir.

The number of jacks on the spawning grounds below weir is estimated by expanding the number of jack carcasses below the weir by the above weir jack recovery rate. For example, if jack carcasses above the weir are expanded by half the adult recovery rate, we expand jacks below the weir by the same recovery rate. To separate the single below weir jack estimate into separate estimates by origin, we multiply the point estimate by the weighted hatchery jack fraction, which is calculated as:

$$\frac{Hatchery\ jacks\ handled\ at\ the\ weir + expanded\ Non{-}OP\ hatchery\ jack\ carcasses\ recovered\ below\ the\ weir}{Total\ jacks\ handled\ at\ the\ weir + total\ expanded\ jack\ carcasses\ recovered\ below\ the\ weir}$$

The number of natural jacks below the weir is calculated as:

$$1 - (below\ weir\ jack\ estimate\ *\ weighted\ hatchery\ jack\ fraction).$$

It would not be appropriate to apply a "jack/redd" expansion calculated from the estimated number of jacks above the weir because the estimated number of jack salmon above the weir is directly related to weir efficiency and efforts by managers to limit the number of hatchery jacks passed above the weir.

Estimating Total Escapement

The above detailed methodologies provide estimates for the number of salmon that were in nature (i.e., Total Fish in River) for each population. However, a number of salmon are removed from each population and are not accounted for in the estimate of Total Fish in River. These include fisheries (tribal and recreational) and those removed at the weir for broodstock, foodbanks, outplants, or due to mortality, and are either known or estimated. Sport harvest is estimated using a roving creel survey (see Yanke at al. 2013 for detailed methods). Tribal harvest is determined through interviews (methods described in Oatman and Sharma 2016). Harvest estimates of jacks and adults are apportioned into origin and age-class using the percentages, of salmon trapped at the weir (by origin and age). Numbers of salmon removed for broodstock, foodbanks, outplants, and trap mortalities are census numbers provided by Lookingglass Fish Hatchery. The estimated total escapement, or “Total Return to the River”, is the sum of the Total Fish in River and all salmon removed from each population.

Estimating Spawners

The number of actual spawners above the weir is calculated by multiplying the above weir jack and adult population estimates by the pre-spawn survival rate. The pre-spawn survival rate is the percentage of female carcass recoveries with an estimated egg retention ≥50%. We divide the adult spawner estimate by the number of redds counted above the weir to calculate a "adult spawner/redd" estimate. Adult spawners below the weir are calculated by multiplying the adult spawner/redd value by the number of redds counted below the weir. Jack spawners below the weir are estimated by multiplying the jack estimate below the weir by the below weir pre-spawn survival rate.

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