LOWER SNAKE RIVER COMPENSATION PLAN:
Oregon Spring Chinook Salmon Evaluation Studies
2014 Annual Progress Report

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

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

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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 2014. 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 2014 work statement (Carmichael et al. 2014).

We used coded-wire tag (CWT) data collected from 2012-2014 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) 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 2012 were released, Chinook Salmon from BYs 2009-2011 returned to spawn in 2014, and some of those mature Chinook Salmon were used to create BY 2014.

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EXECUTIVE SUMMARY

For 2012 brood year (BY) Imnaha River Chinook Salmon smolts released in 2014, the green egg-to-smolt survival rate was 70.9% and we released 346,702 smolts. We estimated that 99.7% 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 2012 smolts from the Grande Ronde Basin Spring Chinook Salmon Conventional Hatchery Program (CHP) into four Grande Ronde Basin streams. No smolts were reared or released from the Grande Ronde Basin Captive Broodstock Program (CBS). Green egg-to-smolt survival rate of BY 2012 Catherine Creek CHP smolts released into Catherine Creek was 81.1%. We released 138,370 CHP smolts into Catherine Creek and estimate that 100% were identifiable as hatchery origin. The green egg-to-smolt survival rate of Upper Grande Ronde River CHP smolts was 90.2%. We released 241,169 CHP smolts into the Upper Grande Ronde River and 98.3% were identifiable as hatchery origin. The green egg-to-smolt survival rate of Lookingglass Creek CHP smolts released into Lookingglass Creek was 84.6%, we released 251,780 smolts, and 99.0% were identifiable as hatchery smolts. The green egg-to-smolt survival rate of the 232,924 CHP smolts released into the Lostine River was 86.2%, and 99.0% 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 70% for Lookingglass Creek CHP smolts released from Lookingglass Fish Hatchery.

After accounting for the estimated number of unmarked mature hatchery returns, the Oregon Department of Fish and Wildlife trapped 2,676 hatchery and 642 natural Chinook Salmon at the Imnaha River weir and 815 hatchery and 217 natural Chinook Salmon in Lookingglass Creek. In the Grande Ronde Basin, the Confederated Tribes of the Umatilla Indian Reservation captured 553 hatchery and 580 natural Chinook Salmon in Catherine Creek and 375 hatchery and 252 natural Chinook Salmon in the Upper Grande Ronde River. The Nez Perce Tribe captured 1,138 hatchery and 576 natural Chinook Salmon in the Lostine River.

During the 2014 spawn year at Lookingglass Fish Hatchery, we spawned 99 hatchery and 41 natural females from the Imnaha River and collected 621,831 green eggs. From Catherine Creek, we spawned 19 hatchery and 25 natural females and collected 188,435 green eggs. In the Upper Grande Ronde River, we spawned 44 hatchery and 24 natural females, and collected 257,706 green eggs. In Lookingglass Creek, we spawned 58 hatchery females and 24 natural females and collected 324,484 green eggs. In the Lostine River, we spawned 48 hatchery females and 26 natural females and collected 314,769 green eggs. A greater number of eggs were collected from age 4 (93.3%) than age 5 (6.7%) females and the mean egg weight of age 5 females (0.27 g) was greater than that of age 4 females (0.24 g).

We estimated that 4,851 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River in 2014, 30.2% of the total mitigation goal of 16,050 mature hatchery salmon. We also estimated that 3,923 mature Imnaha River hatchery Chinook Salmon returned to the Lower Snake River Compensation Plan area above Lower Granite Dam in 2014, achieving 122.2% of the hatchery compensation goal (3,210) for the Imnaha River Basin. In addition, we estimated that 945 mature natural origin Chinook Salmon returned to the Imnaha River. An estimated 283 mature hatchery Chinook Salmon were harvested in sport (ODFW) and

tribal (CTUIR and NPT) fisheries in the Imnaha River and an estimated 918 mature Chinook Salmon were harvested in fisheries below Lower Granite Dam, 7.2% of the downstream harvest mitigation goal (12,840)

We estimated that 7,354 Grande Ronde Basin hatchery Chinook Salmon returned to the Columbia River in 2014, 25.1% of the total mitigation goal of 29,300 mature hatchery Chinook Salmon. We estimated that 6,211 mature hatchery salmon (702 Catherine Creek, 1,358 Grande Ronde River, 1,857 Lookingglass Creek, and 2,294 Lostine River) returned to the compensation area, achieving 106.0% of the compensation goal (5,860) for the Grande Ronde Basin. In 2014, we estimated that 624 hatchery and 651 natural salmon returned to Catherine Creek, 1,272 hatchery and 817 natural salmon returned to the Upper Grande Ronde River, 1,624 hatchery and 324 natural salmon returned to Lookingglass Creek, and 2,185 hatchery and 1,206 natural salmon returned to the Lostine River. In Lookingglass Creek, CTUIR and NPT reported that tribal fishers harvested a total of 342 mature hatchery salmon and ODFW estimated that sport fishers harvested 272 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 201 mature hatchery salmon in the Lostine River and the ODFW estimated sport fishers harvested 18 mature hatchery salmon in the Wallowa River. Additionally, ODFW estimated that 18 mature hatchery salmon were harvested in the Lower Grande Ronde River Pilot fishery near Troy, OR (Bratcher et al. 2014). Below Lower Granite Dam, we estimated 1,130 Grande Ronde Basin hatchery Chinook Salmon were harvested in fisheries, 4.8% of the downstream harvest mitigation goal (23,440).

In the Imnaha River, the BY 2009 recruits-per-spawner (R:S) ratio was 0.1 for naturally spawning salmon, and 5.6 for the hatchery component. In the Grande Ronde Basin, BY 2009 R:S for the CHP component was 2.0 in Catherine Creek, 4.2 in the Upper Grande Ronde River, 6.6 in Lookingglass Creek, and 2.0 in the Lostine River. The natural component R:S for BY 2009 was 1.0 in Catherine Creek, 2.6 in the Upper Grande Ronde River, 0.4 in Lookingglass Creek, and 0.3 in the Lostine River.

In 2014, we observed 764 redds and recovered 363 carcasses during spawning ground surveys in the Imnaha River Basin. Hatchery salmon comprised 58.1% of known origin carcass recoveries. In the Grande Ronde Basin, we observed 2,333 redds and recovered 1,823 carcasses. We recovered 37 hatchery salmon outside of the stream into which they were released as smolts (i.e., in-basin strays). The percentage of known hatchery salmon recovered on spawning ground surveys was 45.7% in Catherine Creek, 73.1% in the Upper Grande Ronde River, 80.8% in Lookingglass Creek, and 53.3% in the Lostine River.

To estimate pre-spawn mortality (PSM) rates, we examined female carcasses for egg retention. For streams with ≥20 female carcass recoveries, PSM rates ranged from 0.0% to 27.7%. For the two wilderness streams, the Minam River and the Wenaha River, the estimated PSM rates were 1.3% and 0.0%, respectively. Estimated PSM rates for the Imnaha River, Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River were 13.0%, 1.3%, 3.9%, 27.7%, 17.4%, and 8.3%, respectively.

To monitor bacterial kidney disease (BKD), we collected 190 Chinook Salmon kidney samples from Imnaha River Basin streams and 584 kidney samples from Grande Ronde Basin streams in 2014. 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 2014. 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) 2012 of juvenile Chinook Salmon smolts, the collection of eggs for BY 2014, numbers and characteristics (e.g., age composition) of mature Chinook Salmon in the 2014 return year, the 2014 spawning year at Lookingglass Fish Hatchery and in nature, bacterial kidney disease (BKD) monitoring, and survival information (e.g., SAR, R:S) for BY 2009. 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 off 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 2014, spring Chinook Salmon from BY 2012 produced from the Conventional Hatchery Program (CHP) were released into Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, the Lostine River, and Imnaha River. No Spring Chinook Salmon from the Captive Broodstock Program (CBS) were reared or released into any stream. Mature Chinook Salmon from BYs 2009-2011 returned to spawn and some of these returns were collected from each population to use as broodstock to create offspring for the BY 2014 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.

2012 Brood Year Juvenile Rearing and Release

<u>2012 Brood Year Egg to Smolt Survival</u>

Green egg-to-smolt survival rate for BY 2012 Imnaha River Chinook Salmon released in 2014 was 70.9% (79.7% green egg-to-eyed egg; 88.9% eyed egg-to-smolt; Table 1). Green egg-to-smolt survival rate for Catherine Creek CHP salmon was 81.1% (87.0% green egg-to-eyed egg; 93.2% eyed egg-to-smolt). For the Upper Grande Ronde River, the green egg-to-smolt survival rate was 90.2% (91.7% green egg-to-eyed egg; 98.4% eyed egg-to-smolt) for CHP offspring. For Lookingglass Creek CHP salmon, the green egg-to-smolt survival rate was 84.6% (94.0% green egg-to-eyed egg; 90.1% eyed egg-to-smolt). For Lostine River CHP salmon, the green egg-to-smolt survival rate was 86.2% (89.8% green egg-to-eyed egg; 96.0% eyed egg-to-smolt).

In an effort to reduce the incidence of BKD in Chinook Salmon offspring, the Fish Health recommendation is that eggs from female Chinook Salmon from the CHP program with enzyme-linked immunosorbent assay (ELISA) optical density values ≥ 0.2 should be culled. No eggs were culled from any females spawned in 2012.

2012 Brood Year Production and Tagging

The release of 346,702 Imnaha River BY 2012 smolts in 2014 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 138,370 CHP smolts from the BY 2012 CHP production into Catherine Creek in 2014, achieving 92.2% of the juvenile production goal. The Upper Grande Ronde River BY 2012 production released 241,169 CHP smolts in 2014, 96.5% of the juvenile production goal. In Lookingglass Creek, we released 251,780 smolts from the Lookingglass Creek CHP, achieving 100.7% of the juvenile production goal. In the Lostine River, we released 232,924 CHP smolts, 93.2% of the juvenile production goal. Consistent challenges that have sometimes limited smolt production include bacterial kidney disease, low returns of mature salmon, low capture rates at weirs, and space limitations at Lookingglass Fish Hatchery.

We evaluated BY 2012 smolts released in 2014 for coded-wire-tag (CWT) and mark application success from 10-13 February 2014, a few weeks prior to their release. We sampled at least 500 smolts from each raceway at Lookingglass Fish Hatchery and checked them for the presence of a CWT and adipose fin clip quality (Table 2). Target numbers of parr to be tagged and marked differed among stocks. Hatchery origin smolts are identified by either an adipose fin clip, a CWT, or and adipose fin clip and a CWT.

We attempted to mark 100% of the Imnaha River smolts in four of six raceways with both an adipose fin clip and a CWT (Table 2). Smolts in the remaining two raceways received only adipose fin clips (100%). For the portion of smolts receiving both an adipose fin clip and a CWT, we estimated that 95.1% were successfully marked with both marks, 3.7% received an adipose fin clip but no CWT, 1.1% had a CWT but no adipose fin clip, and 0.1% were released without a adipose fin clip or a CWT. Fin clip application success was estimated at 99.2% for the portion receiving just adipose clips. For smolts released from all six raceways combined, we estimated that 99.7% of the smolts were identifiable as hatchery origin.

For smolts released into Catherine Creek, we attempted to mark 100% of the smolts in two of three raceways with both adipose fin clips and CWTs while the third raceway received only adipose fin clips (Table 2). For the portion of smolts receiving both adipose fin clips and CWTs, we estimated that 97.8% of the smolts received both an adipose fin clip and a CWT, 0.7% received an adipose fin clip but no CWT, 1.5% had a CWT but no adipose fin clip, and 0% of the smolts released had no identifiable mark or CWT. Fin clip application success was estimated at 97.7% for the portion to receive just adipose fin clips. For smolts released from all three raceways combined, we estimated that 100% 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 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 95.4% were successfully marked with both marks, 3.7% were only marked with an adipose fin clip, 0.7% were only marked with a CWT, and 0.2% were released unmarked. For the two raceways marked with only a CWT, 96.7% were successfully tagged and 3.3% were released untagged. For all smolt released combined, we estimate that 100% of the smolts were identifiably marked with either an adipose fin clip or a CWT. For smolts released from all four raceways combined, we estimated that 98.3% of the smolts were identifiable as hatchery origin.

We reared four raceways of Lookingglass Creek CHP smolts and attempted to mark 100% of the smolts in two raceways with both an adipose fin clip and a CWT (Table 2). The two remaining raceways were only marked with an adipose fin clip. For the raceways receiving both adipose fin clips and CWTs, we estimated that 97.6% of the smolts received both marks, 1.8% were only marked with an adipose fin clip, 0.5% had a CWT but no adipose fin clip, and 0.1% of the smolts released had no identifiable mark. For the two raceways that were only marked with an adipose fin clip, we estimated that 97.6% were successfully marked and 2.4% were released unmarked. For smolts released from all four raceways combined, we estimated that 99.0% of the smolts were identifiable as hatchery origin.

We reared four raceways of Lostine River CHP smolts and attempted to mark 50% of the smolts with an adipose fin clip and a CWT and 50% with only an adipose fin clip (Table 2). We estimated that 53.8% received both marks, 45.0% were only marked with an adipose fin clip, 0.2% were only marked with a CWT, and 1.0% were released unmarked. We estimated that 99.0% of the Lostine River smolts were identifiable as hatchery origin.

2012 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.

Four raceways containing BY 2012 Imnaha River Chinook Salmon smolts were transported to the Imnaha River Acclimation and Trapping Facility on 21 March 2014 (Table 3). Two raceways were released directly into the Imnaha River at the Imnaha River Acclimation Facility on 3 April 2014. Volitional release of the acclimated smolts began on 1 April 2014. All remaining smolts in the acclimated group were forced out on 14 April 2014. Mean survival rate to LGD for smolts directly released into the Imnaha River at the acclimation facility was 65% and 69% for those that were acclimated. The overall mean survival rate to LGD for Imnaha River smolts released in 2014 was 68% (Figure 1).

Three raceways of Catherine Creek CHP smolts were transferred to the Catherine Creek Acclimation Facility on 19 March 2014 (Table 3). Volitional release began on 21 March 2014 and smolts were forced out on 15 April 2014. Mean survival rate to LGD for CHP smolts released into Catherine Creek was 27%, slightly better than the BY 2011 survival rate of 22%. The lowest mean survival rate for BY 2012 smolts released in the Grande Ronde Basin were for those smolts released into Catherine Creek (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 20 March 2014 and the remaining two raceways were transferred on 4 April 2014 (Table 3). Volitional release of CHP smolts from the first transfer began on 22 March 2014, with force-out occurring on 3 April 2014. Volitional release of CHP smolts from the second transfer began on 6 April 2014, with force-out occurring on 15 April 2014. The mean survival rate to LGD for smolts released from the Upper Grande Ronde River Acclimation facility was 43% for the early release, 42% for the late release, and the overall survival rate was 42% (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 1 April 2014, with force-out occurring on 14 April 2014 (Table 3). Mean survival rate to LGD for CHP smolts released into Lookingglass Creek was 70%, the 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 12 March 2014 (Table 3). This group was volitionally released beginning on 21 March 2014, with force-out occurring on 31 March 2014. The two remaining raceways of Lostine River CHP smolts were transferred to the acclimation facility on 1 April 2014. Volitional release started on 12 April 2014 and smolts were forced out on 22 April 2014. The mean survival rate to LGD for CHP smolts released into the Lostine River was 62% for the early release, 74% for the late release, and the overall survival was 67% (Figure 1).

2013 Brood Year Parr at Lookingglass Fish Hatchery

From 19–28 August 2014, brood year 2013 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 adipose fin clip, a CWT, or an adipose fin clip and a CWT.

Marking and tagging rates varied among stocks and were based on management and monitoring requirements. We estimated from tagging records that 76% of the Imnaha River parr were marked with both an adipose fin clip and CWT and 24% were only marked with an adipose fin clip (Table 4). Approximately 72% of the Catherine Creek parr were marked with an adipose fin clip and CWT and 28% were only marked with an adipose fin clip. About 48% of the parr from the Upper Grande Ronde River were marked with both an adipose fin clip and a CWT and 52% were marked with only a CWT. Of the Lookingglass Creek parr, 56% received an adipose fin clip and CWT and 44% received only an adipose fin clip. We estimate 58% of the Lostine River parr were marked with an adipose fin clip and CWT and 52% were only marked with an adipose fin clip. Mark and tag retention checks will be conducted in February 2015, 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 2014. We estimated that 20,862 Imnaha River, 20,854 Catherine Creek, 1,993 Upper Grande Ronde River, 1,986 Lookingglasss Creek, and 2,293 Lostine River parr were successfully PIT-tagged (Table 4). The PIT tags were distributed approximately evenly across all raceways for each population.

2014 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.

One 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 that is not under anesthesia. It is particularly difficult to determine the sex of early arriving salmon, especially if the salmon has not been immobilized. These errors in sex determination result in data discrepancies between the numbers of males and females collected at the weir and those 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 reduce 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.

It is also necessary to account for unidentifiable hatchery returns (i.e., lacking a CWT or an adipose fin clip). To adjust for unidentifiable hatchery returns, we first assign a known age to each salmon based on known ages (CWTs, PIT tags, and 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 or 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 June to 10 September 2014 (Table 5). After adjusting for unclipped returns, we estimated that 2,676 hatchery and 642 natural origin mature salmon were captured (Table 6). We retained 215 hatchery and 89 natural mature salmon for broodstock. To limit the number of hatchery salmon on spawning grounds, 147 hatchery salmon were outplanted to Big Sheep Creek, 1,111 were distributed to Oregon or Nez Perce Tribal food banks, and 651 were killed and their carcasses disposed of either below the weir or in Big Sheep Creek (i.e., stream enrichment). To provide additional harvest opportunities, 39 hatchery salmon were returned to the river below the weir. There were 13 hatchery and six natural origin trap mortalities in 2014. The remaining salmon collected at the weir were released above the weir to spawn naturally (500 hatchery, 547 natural). Of the hatchery salmon captured at the weir, 68.0% were age 3, 27.9% were age 4, and 4.1% were age 5. Natural origin returns captured at the weir were comprised of 8.8% age 3, 80.7% age 4, and 10.5% age 5.

Catherine Creek

The Catherine Creek weir was operated by CTUIR from 3 March to 31 July 2014 (Table 5). The first Chinook was captured on 27 May 2014 and the last new (i.e., not a recapture) salmon was captured on 26 July 2014. After adjusting for unmarked hatchery returns, we estimated that a total of 553 hatchery and 580 naturally-produced salmon were captured (Table 6). CTUIR retained 47 hatchery and 59 natural origin salmon for broodstock. There were zero hatchery or natural origin trap mortalities. To reduce the number of hatchery salmon on the spawning ground, 67 hatchery salmon were killed for tribal foodbanks and zero were outplanted. The remaining 439 hatchery and 521 natural mature salmon, were passed above the weir to spawn naturally.

This is the 10th complete BY of mature Catherine Creek hatchery salmon returns from the CBS program (BYs 1998–2005, 2008-2009) and the ninth for CHP production (BYs 2001-2009). All smolts released into Catherine Creek from BY 2011 (age 3 returns) and BY 2010 (age 4) were from the CHP program. As juveniles, CBS program smolts from BY 2009 (age 5) were marked with an adipose fin clip and a CWT, and were the last returns from the Catherine Creek CBS program. The BY 2009 CHP smolts were marked with an adipose fin clip, CWT, and green visual implant elastomer (VIE) tag. The age structure of mature hatchery Chinook Salmon captured at the weir was 15.7% age 3 (100% CHP); 79.4% age 4 (100% CHP), and 4.9% age 5 (62% CBS and 44% CHP). Based on fork length and marks (i.e.,VIE tags and PIT tags), we estimated that 18 CBS and 11 CHP salmon from BY 2009 were handled at the weir. Natural origin returns were comprised of 6.1% age 3, 86.5% age 4, and 7.4% age 5.

Upper Grande Ronde River

The Upper Grande Ronde River weir was operated by CTUIR from 4 March to 1 July 2014 (Table 5). Between 27 May and 1 July 2014, 375 hatchery and 252 natural salmon were captured (Table 6). CTUIR retained 83 hatchery and 62 natural salmon for broodstock, 10 hatchery salmon were killed at the weir, there were five hatchery and one natural trap mortalities, and 277 hatchery and 189 natural mature Chinook Salmon were released above the weir to spawn naturally. The age structure of hatchery salmon captured at the weir was 5.6% age 3, 92.5% age 4, and 1.9% age 5. Natural origin salmon were comprised of 4.0% age 3, 91.2% age 4, and 4.8% age 5.

This is the 11th year of complete brood year returns of mature Upper Grande Ronde River hatchery salmon from the CBS program (BYs 1998 – 2005, 2009) and the ninth for the CHP production (BYs 2001 – 2009). The CBS smolts released into Upper Grande Ronde River River from BY 2011 (age 3) were all marked with an adipose fin clip and a CWT and the CHP smolts were only marked with a CWT. No CBS salmon from BY 2010 (age 4) were released into the Upper Grande Ronde River. The BY 2010 CHP smolts were released with either an adipose fin clip (53.8%) or an adipose fin clip and a CWT (46.2%). All CBS program smolts from BY 2009 (age 5) were marked with both an adipose fin clip and a CWT and CHP smolts were only marked with a CWT. Age structure of CBS returns handled at the weir was 47.6% age 3, 0% age 4 (no CBS smolts were released from BY 2010), and 66.7% age 5. Age structure of the CHP weir captures was 52.4% age 3, 100% age 4, and 33.3% age 5.

Lookingglass Creek

The Lookingglass Creek weir was operated by Lookingglass Fish Hatchery (ODFW) personnel from 1 March to 16 September 2014 and had unique captures of 815 hatchery and 217 natural mature salmon (Tables 5 and 6). The trap total includes 27 assumed strays from the Upper Grande Ronde CHP program based the absence of an adipose fin clip and the presence of a CWT. Eighteen of the assumed Upper Grande Ronde River strays were kept for the Grande Ronde River CHP program, one was passed below the weir, and eight were killed.

Totals of 473 hatchery and 161 natural origin Chinook were passed above the weir to spawn naturally; 27 hatchery salmon were released below the weir, 30 hatchery salmon were killed (foodbank or landfill), and 116 hatchery and 56 natural mature salmon were kept for the Lookingglass Creek CHP program broodstock. Hatchery salmon captured at the weir (includes strays) were comprised of 26.5% age 3, 72.7% age 4, and 0.8% age 5. Natural origin returns captured at the weir were comprised of 15.7% age 3, 82.5% age 4, and 1.8% age 5.

Lostine River

The Lostine River weir was operated by the NPT from 15 February to 21 September 2014 (Table 5). The NPT had unique captures of 1,138 hatchery and 576 natural mature salmon at the weir, of which 101 hatchery and 64 natural origin mature salmon were retained for broodstock (Table 6). To reduce the number of hatchery salmon on the spawning grounds, 250 hatchery salmon were released at the confluence of the Wallowa and Minam Rivers to provide additional harvest opportunities for anglers. Additionally, 477 hatchery jack salmon were released into Bear Creek, a tributary of the Wallowa River. One hatchery salmon was kept by the Nez Perce Tribe for ceremonial purposes. The remaining salmon were passed above the weir to spawn naturally (309 hatchery, 512 natural).

This is the 12^{th} year we had a complete BY return of mature Lostine River hatchery salmon from the CBS program (BYs 1998-2009) and the 11^{th} for the CHP program (BYs 1997, 2000-2009). Mature salmon used as broodstock in BY 2014 were both natural and hatchery origin. The only Chinook salmon smolts released into the Lostine River from BY 2011 (age 3) and BY 2010 (age 4) were from the CHP production. The BY 2011 CHP smolts were released with either an adipose fin clip (49.3%) or an adipose fin clip and CWT (50.7%). Similarly, BY 2010 CHP smolts were marked with either an adipose fin clip (46.8%) or an adipose fin clip and CWT (53.2%). Of the mature hatchery salmon captured at the weir, 58.0% were age 3 (100 % CHP), 41.2% were age 4 (100% CHP), and 0.7% were age 5 (eight age 5 adults). Because CBS and CHP smolts released from BY 2009 were not differentially marked (i.e., all smolts were released with a CWT but no adipose fin clip), we were unable to differentiate between mature age 5 CBS and CHP salmon handled at the weir. Age structure of the natural origin salmon captured at the weir was 12.3% age 3, 84.9% age 4, and 2.8% age 5.

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 salon on natural populations. Consequently, to reduce numbers of hatchery salmon on the spawning grounds, it has been necessary to outplant surplus hatchery salmon to other tributary streams (e.g., Bear Creek, Big Sheep Creek, Lick Creek, and Wallowa River) and to distribute them 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 salmon 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 number of salmon sent to foodbanks or returned to nature with the trapping records.

One unique challenge with counting returns to Lookingglass Creek that occurred in 2012, but not 2013 or 2014, was that hatchery salmon collected from the Catherine Creek weir that were released into Lookingglass Creek below the weir to supplement fisheries. Although these salmon were are marked with an OP punch, this mark can sometimes be lost or missed during later handling (e.g., carcasses recovered on the spawning ground), as the punch can heal and not be obvious. This results 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 there is no biological information 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 (i.e., the benefit to the fishery of these outplants).

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. Marking all hatchery releases with an adipose fin clip and CWT would help reduce errors associated with differentiating hatchery and natural returns.

2014 Brood Year Hatchery Spawning

Imnaha River

We spawned 99 hatchery and 41 natural females with 95 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 production. We collected 621,831 green eggs which were incubated at Lookingglass Fish Hatchery where mortality rate to shocking was 5.7%, resulting in 586,293 eyed eggs.

Catherine Creek

Mature salmon used as broodstock to create the Catherine Creek 2014 BY were from both natural and hatchery origin (CHP progeny only – returning CBS progeny were allowed to spawn naturally or were removed but were not collected for CHP broodstock due to domestication concerns). We spawned 19 hatchery and 25 natural females with 24 unique hatchery and 32 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 188,435 green eggs and mortality rate to shocking was 7.4%, resulting in 174,568 eyed eggs.

Upper Grande Ronde River

Mature salmon used as broodstock to create the Upper Grande Ronde River 2014 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 44 hatchery and 24 natural females with 43 unique hatchery and 32 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 257,706 green eggs and mortality rate to shocking was 5.6%, resulting in 243,174 eyed eggs.

Lookingglass Creek

We spawned 58 hatchery and 24 natural females with 50 unique hatchery and 27 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 324,484 green eggs and morality rate to shocking was 3.6%, resulting in 312,682 eyed eggs.

Lostine River

We spawned 48 hatchery and 26 natural females with 42 unique hatchery and 26 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 314,769 green eggs and morality rate to shocking was 6.1%, resulting in 295,673 eyed eggs.

Egg Weight

For all stocks, a greater number of eggs were collected from age 4 than age 5 salmon (Table 8). One age 3 natural origin female was spawned from the Upper Grande Ronde River Stock and the mean egg weight for this female was 0.239 g. 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 ($P \geq 0.646$). The largest mean egg weight (0.252 g) was from the Catherine Creek natural females and the smallest mean egg weight (0.237 g) was from the Lostine River hatchery and Lookingglass Creek natural females.

Compensation Goals

Coded-wire tag recovery methods

At least a portion of the 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 30 December 2016.

We compiled the 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 we did not have any 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) for the 2014 return year above LGD.

Imnaha River

Coded-wire tag recoveries

We recovered 1,010 hatchery-reared Imnaha River Chinook Salmon with a CWT from BYs 2009–2011: 785 CWT from BY 2011 (age 3), 213 from BY 2010 (age 4), and 12 from BY 2009 (age 5; Table 9). From these CWT recoveries, we estimate that zero Imnaha River salmon were harvested in ocean fisheries and 919 were harvested in the Columbia River, where an estimated 379 salmon were harvested in treaty net fisheries, 88 in non-tribal net fisheries, and 452 in sport fisheries. We estimated that 53 Imnaha River salmon were harvested in Snake River sport fisheries, and zero were harvested in Snake River tribal fisheries. Below LGD, three stray CWT-marked salmon were recovered in the Deschutes River and two were recovered in the Umatilla River. We estimated that these CWT recoveries below Lower Granite Dam represented nine stray Imnaha River Chinook Salmon. Above LGD, one CWT-marked salmon was recovered in the Snake River below its confluence with the Salmon River and one was recovered at the Lostine River weir. These stray recoveries above LGD represented two Imnaha River salmon.

Within the Imnaha River Basin, we recovered 869 CWT-marked salmon (Table 9). ODFW estimated that 132 Chinook Salmon were caught in the Imnaha River sport fishery (Bratcher et al. 2014) and eight CWTs were recovered. No CWTs were collected from the tribal fishers, but the NPT and CTUIR reported a total harvest of 151 hatchery salmon (Joe Oatman, NPT, personal communication, 6 November 2015; Preston Bronson, CTUIR, personal communication, 23 November 2015). A total of 2,137 mature salmon were collected at the Imnaha River trapping facility, and we estimate that 1,448 mature hatchery salmon remained in nature, 782 below and 666 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 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 2014 return year, we estimated that 4,851 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River, 30.2% of the total mitigation goal of 16,050 mature hatchery salmon. We also estimated that 3,923 mature hatchery salmon returned to the LSRCP compensation area, 122.2% 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 283 mature hatchery salmon were harvested in fisheries, 8.8% of the compensation area mitigation goal. We estimated 919 mature Imnaha River hatchery Chinook Salmon were harvested in fisheries below Lower Granite Dam, 5.7% of the downstream harvest mitigation goal.

Return to the River

We estimated that 3,868 hatchery and 945 natural origin salmon returned to the Imnaha River in 2014. The estimated total return to the river of hatchery salmon was comprised of 2,573 age 3, 1,127 age 4, and 168 age 5 returns. For natural salmon, we estimated that 101 age 3, 744 age 4, and 100 age 5 returned.

Estimated total return to the river includes 99 hatchery jacks and 33 hatchery adults harvested by sport anglers (Bratcher et al. 2014). 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 5–27 July 2014. Additionally, NPT reported that 27 hatchery jacks, 122 hatchery adults, zero natural jacks, and 40 natural adults were harvested (Joe Oatman, NPT, personal communication, 6 November 2015). CTUIR reported harvest of two hatchery jacks, zero hatchery adults, zero natural jacks, and two natural adults (Preston Bronson, CTUIR, personal communication, 23 November 2015). The combined sport and tribal harvest of 283 hatchery Chinook Salmon represents 7.3% 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. Returns represent the best estimate of the total number of mature salmon that returned to the mouth of the Imnaha River (i.e., Total Return). 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 salmon 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. The R:S ratio for BY 2009 was 0.560 for those spawned in the hatchery (any origin) and 0.1 for those spawned in nature (Figure 2). The BY 2009 smolt-to-adult return rate (SAR) for hatchery salmon that returned to the mouth of the Imnaha River was 0.497% (Table 10).

<u>Grande Ronde Basin</u>

Catherine Creek coded-wire tag recoveries

We recovered 204 hatchery-reared Catherine Creek Chinook Salmon with a CWT from BYs 2009–2011: 54 from BY 2011 (age 3), 140 from BY 2010 (age 4), and 10 from BY 2009 (age 5; Table 11). From these recoveries we estimated that zero Catherine Creek Chinook Salmon were recovered in ocean fisheries, 98 were caught in the Columbia River, and 14 were caught in the Snake River sport fishery. Of the Columbia River harvest, we estimated that 14 salmon were caught in tribal net fisheries, 21 were caught in non-tribal net fisheries, and 63 we caught in sport fisheries. In the Snake River, we estimated that 14 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, zero CWTs were recovered outside the Grande Ronde Basin.

Within the Grande Ronde Basin, we recovered 12 stray Catherine Creek Salmon that we estimated to represent 59 mature salmon. Nine stray CWT-marked Catherine Creek salmon were recovered in Lookingglass Creek (three on the spawning ground, five from the salmon trap, and one from the sport fishery), two strays were recovered from spawning ground surveys on the Lostine River, and one stray was recovered from the Upper Grande Ronde River trap (Table 11). One CWT-marked Catherine Creek salmon that we estimated to represent five mature salmon were recovered in the Lower Grande Ronde River pilot fishery that was opened from 27-30 June and 5-7 July 2014 (Bratcher et al. 2014). No salmon from Catherine Creek were outplanted into Lookingglass Creek in 2014. Within Catherine Creek, 91 CWT-marked salmon were recovered.

A total of 115 mature hatchery salmon were collected at the Catherine Creek weir, and we estimated that 482 were on the spawning grounds above the weir, and 27 were below the weir.

Upper Grande Ronde River coded-wire tag recoveries

We recovered 350 hatchery-reared Upper Grande Ronde River Chinook Salmon with a CWT from BYs 2009–2011: 67 from BY 2011 (age 3), 278 from BY 2010 (age 4), and five from BY 2009 (age 5; Table 12). From these recoveries, we estimated that zero were caught in ocean fisheries, 114 were caught in the Columbia River, and 11 were caught in the Snake River. Below Lower Granite Dam, zero stray CWT-marked salmon were recovered. Above LGD, no CWT-marked salmon were recovered outside the Grande Ronde Basin.

Within the Grande Ronde Basin, 29 CWT-marked salmon were recovered as in-basin strays that were estimated to represent 75 strays. We recovered 24 CWT-marked salmon in Lookingglass Creek (six from the spawning grounds and 18 from the salmon trap), two from the Catherine Creek weir, one each from the spawning grounds on the Lostine River, Hurricane Creek, and the Imnaha River. We recovered 288 CWT-marked salmon from the Upper Grande Ronde River. A total of 98 mature hatchery salmon were collected at the Upper Grande Ronde River salmon trap. We estimated that 1,148 were on the spawning grounds above the weir, and 17 were below the weir.

The limited number of CWT recoveries outside the Upper Grande Ronde River is probably because only 49.2% of the 2011, 46.2% of the 2010, and 21.2% of BY 2009 were marked with both a CWT and an adipose fin clip. Nearly all of the remainder 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 354 hatchery-reared Chinook Salmon released into Lookingglass Creek with a CWT from the BYs 2009–2011: 117 from the BY 2011 (age 3), 232 from BY 2010 (age 4), and five from BY 2009 (age 5; Table 13). We estimated that five Lookingglass Creek salmon were caught in ocean fisheries. In the Columbia River, we estimated that 500 mature salmon were recovered: 142 in treaty net fisheries, 60 in non-tribal net fisheries, and 298 in sport fisheries. We estimated that nine mature hatchery salmon were harvested in Snake River sport fisheries and zero were harvested in Snake River tribal fisheries. Below LGD, one CWT-marked salmon, which expanded to two salmon, was recovered at the Round Butte trap on the Deschutes River. Above Lower Granite Dam, two stray CWT-marked salmon from Lookingglass Creek were recovered at the Johnson Creek trap in Idaho.

Above LGD and within the Grande Ronde basin, 15 CWT-marked salmon were recovered in the Wenaha River, two in the Upper Grande Ronde River salmon trap, one in the Lostine River salmon trap, and two on the Lostine River spawning grounds (Table 13). These 20 CWT recoveries expanded to 217 salmon. One CWT-marked Lookingglass Creek salmon that we estimated to represent five mature salmon was recovered in the Lower Grande Ronde River pilot fishery that opened from 27-30 June and 5-7 July 2014 (Bratcher et al. 2014). Within Lookingglass Creek, 264 CWT-marked salmon were recovered. We recovered 45 CWTs from the sport fishery, where ODFW estimated that 272 Lookingglass Creek hatchery salmon were harvested. No CWTs were collected from the tribal fishers, but NPT and CTUIR reported a total harvest of 342 hatchery salmon (Joe Oatman, NPT, personal communication, 6 November 2015; Preston Bronson, CTUIR, personal communication, 23 November 2015). A total of 288 mature Lookingglass Creek CHP hatchery salmon were collected at the Lookingglass Creek salmon trap, and we estimated that 475 were on the spawning grounds above the weir, and 247 were below the weir.

Lostine River coded-wire tag recoveries

We recovered 275 hatchery-reared Chinook Salmon released into the Lostine River with a CWT from BYs 2009–2011: 54 CWTs from BY 2011 (age 3), 220 from BY 2010 (age 4), and one from BY 2009 (age 5; (Table 14). We estimated that 12 mature Lostine River Chinook Salmon were caught in ocean fisheries. In the Columbia River we estimated that 212 were recovered in tribal net fisheries, 20 in non-tribal net fisheries, and 169 in sport fisheries. Below LGD, one CWT-marked salmon was recovered in the Deschutes River and one was recovered in the Tucannon River for an estimate of 11 stray salmon. Within the Snake River, four CWT-marked salmon were recovered from sport fisheries for an estimate of 10 salmon. No Lostine River salmon were recovered in Snake River tribal fisheries. Above LGD, one Lostine River salmon was recovered in Johnson Creek, a tributary to the South Fork Salmon River, and one was recovered at the Imnaha River weir.

Within the Grande Ronde Basin, four CWT-marked Lostine River salmon were recovered in Hurricane Creek, one each in the Wallowa River, the Minam River, and the Upper Grande Ronde River salmon trap (Table 14). These seven CWT recoveries were expanded to represent 93 in-basin stray salmon. One CWT-marked Lostine River salmon, estimated to represent four jack salmon, was recovered in the Lower Grande Ronde River pilot fishery that opened from 27-30 June and 5-7 July 2014 (Bratcher et al. 2014). Within the Lostine River, 175 CWT-marked salmon were recovered. A total of 579 mature hatchery salmon were collected at the Lostine River salmon trap, and we estimated that 1,018 were on the spawning grounds above the weir, and 367 were below the weir.

Return to Compensation Area

The annual total production goal of mature salmon for Grande Ronde Basin hatchery Chinook Salmon is 29,300 (Corps of Engineers 1975), and we estimated that the total production in 2014 was 7,354, 25.1% 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 1,130 Grande Ronde Basin hatchery salmon were harvested in fisheries below Lower Granite Dam, 4.8% of the downstream mitigation goal (Tables 11-14). Harvest below Lower Granite Dam was comprised of an estimated 98 Catherine Creek, 114 Upper Grande Ronde River, 505 Lookingglass Creek, and 413 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 702 Catherine Creek, 1,358 Upper Grande Ronde River, 1,857 Lookingglass Creek, and 2,294 Lostine River mature hatchery Chinook Salmon returned to the compensation area, a combined return of 6,211 hatchery salmon, 106.0% of the compensation goal (Tables 11-14). Of the total escapement above Lower Granite Dam, we estimated that 860 hatchery salmon were harvested in sport and tribal fisheries, 14.7% of the compensation area return. No sport fisheries were open on Catherine Creek or the Upper Grande Ronde River. ODFW estimated that sport fishers harvested 14 hatchery Chinook salmon in the Lower Grande Ronde River pilot fishery, 18 in the Wallowa River fishery, and 272 in Lookingglass Creek (Bratcher et al. 2014). The remaining 556 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 2014 met the compensation area mitigation goal (106%) but fell short of the total adult production goal (25.1%). 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 bacterial kidney disease 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 102 age 3, 491 age 4, and 31 age 5 hatchery salmon and 42 age 3, 561 age 4, and 48 age 5 natural salmon returned to Catherine Creek in 2014 (Table 11). There was no sport fishery in Catherine Creek and tribal fishers reported zero catch in Catherine Creek.

We estimated that 164 age 3, 1,089 age 4, and 19 age 5 hatchery salmon and 78 age 3, 699 age 4, and 40 age 5 natural salmon returned to the Upper Grande Ronde River in 2014 (Table 12). There were no sport fisheries in the Upper Grande Ronde River. Tribal fishers reported harvest of 10 hatchery and two natural adults (Preston Bronson, CTUIR, personal communication, 23 November 2015).

We estimated that 345 age 3, 1,264 age 4, and 15 age 5 hatchery salmon released as smolts into Lookingglass Creek and 46 age 3, 273 age 4, and five age 5 natural salmon returned to Lookingglass Creek in 2014 (Table 13). CTUIR tribal harvest estimates were one hatchery jack, 11 hatchery adults, zero natural origin jacks, and one natural origin adult (Preston Bronson, CTUIR, personal communication, 23 November 2015). NPT tribal harvest estimates were 17 hatchery jacks, 313 hatchery adults, zero natural jacks, and 18 natural adults (Joe Oatman, NPT, personal communication, 6 November 2015). The sport fishery was open from 31 May – 18 June 2014 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. 2014). Sport fishery harvest estimates were 75 hatchery jacks and 197 hatchery adults. Additionally, ODFW estimated that 12 natural origin jacks and 53 natural origin adults were released by sport anglers for an estimated take of four natural origin adults. Unlike 2012, there were no mature Chinook Salmon from Catherine Creek released into Lookingglass Creek for harvest augmentation in 2014.

We estimated that 920 age 3, 1,233 age 4, and 32 age 5 hatchery and 71 age 3, 1,080 age 4, and 55 age 5 natural salmon returned to the Lostine River in 2014 (Table 14). CTUIR tribal harvest estimates were zero hatchery jacks, zero hatchery adults, zero natural origin jacks, and six natural origin adults (Preston Bronson, CTUIR, personal communication, 23 November 2015). NPT tribal harvest estimates were 78 hatchery jacks, 123 hatchery adults, zero natural jacks, and 88 natural adults (Joe Oatman, NPT, personal communication, 6 November 2015). The sport fishery in the Wallowa River was open from 21 June – 27 July 2014. The area open to anglers extended from the Minam State Park upstream to the mouth of the Lostine River (Bratcher et al. 2014). Sport fishery harvest estimates were 8 hatchery jacks and 10 hatchery adults. It was estimated that 28 natural origin jacks and two natural origin adults were released for an estimated of one natural origin jack and zero natural origin adults.

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) with the Grande Ronde River. The R:S ratio for the hatchery component was calculated by dividing the number of mature offspring 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 2009 was 2.0 for the hatchery CHP component and 1.0 for the natural component. BY 2009 SAR rates to the mouth of Catherine Creek were 0.161% and 0.276% for the CBS and CHP programs, respectively. (Table 15).

In the Upper Grande Ronde River, the R:S ratios for the hatchery CHP and natural components from the 2009 brood year were 4.2 and 2.6, respectively. BY 2009 SAR rates to the Upper Grande Ronde River were 0.141% and 0.265% for CBS and CHP programs, respectively (Table 16).

In Lookingglass Creek, the R:S ratios for the hatchery and natural component from BY 2009 were 6.6 and 0.4, respectively. The SAR rate to the mouth of Lookingglass Creek for BY 2009 returns of CHP smolts released into Lookingglass Creek was 0.439% (Table 17).

In the Lostine River, the R:S ratios for BY 2009 were 2.0 and 0.3 for hatchery CHP and natural returns, respectively. The SAR rates to the mouth of the Lostine River for BY 2009 smolts released into the Lostine River were 0.577% and 0.350% for CBS and CHP returns, respectively (Table 18).

Escapement Monitoring

We surveyed 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 2014, we counted 764 redds and recovered 363 carcasses in the Imnaha River Basin (Table 19). The number of redds/river kilometer (rkm) in 2014 (9.1 redds/rkm) was higher than 2013 when 5.8 redds/rkm were observed (Figure 3). With an estimated 964 natural salmon returning to the Imnaha River Basin, 2014 is the 13th 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 58.1% of known origin carcasses recovered on spawning ground surveys in the Imnaha River Basin (Figure 5). Adult (age 4-5) hatchery salmon returns to the Imnaha River have exceeded natural adult returns for the last 18 consecutive years and 22 of the 29 years that hatchery salmon have returned to the Imnaha River. On two tributary streams to the Imnaha River, two hatchery and two natural origin carcasses were recovered in Big Sheep Creek and one hatchery origin carcass was recovered in Lick Creek. One hatchery salmon released into the Upper Grande Ronde River was recovered as an out-of-basin stray in the Imnaha River (Table 20).

In the Grande Ronde Basin, we counted 2,333 redds and recovered 1,823 carcasses. The number of redds/rkm in 2014 (10.5 redds/km) was higher than 2013 when 3.2 redds/rkm were observed (Figure 3). Hatchery salmon comprised the majority (55.6%) of known origin carcasses recovered on spawning ground surveys in the Grande Ronde Basin (Table 19). A total of 108 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 15 August 2014. We observed 30 redds in Sheep Creek, and based on the size of one redd (>1 m^2), we estimated that one of the 29 redds might have been constructed by a mature (i.e., not an SNP female) Chinook Salmon. Hatchery Chinook Salmon have comprised the majority of returns in 11 of the last 14 return years in Catherine Creek, ten of the last 13 return years in the Upper Grande Ronde River, 11 of the last 14 return years in the Lostine River, and eight of the last ten years in Lookingglass Creek.

In the Grande Ronde Basin, we recovered 37 in-basin strays: four Lostine River and one Upper Grande Ronde River salmon in Hurricane Creek; three Catherine Creek and six Upper Grande Ronde River salmon in Lookingglass Creek; two Catherine Creek, two Lookingglass Creek, and one Upper Grande Ronde River salmon in the Lostine River; one Lookingglass Creek and one Lostine River salmon in the Minam River; and 16 Lookingglass Creek salmon in the Wenaha River (Table 20). In addition, we recovered one out-of basin stray salmon in the Wenaha River that had been released released from the Kooskia National Fish Hatchery (Kooskia, ID).

In 2014, 477 hatchery jacks were collected at the Lostine River weir and released into Bear Creek, a tributary to the Wallowa River in Wallowa, OR, and 487 hatchery salmon (394 jacks and 93 adults) were released into the Wallowa River. All outplants were marked with an opercle (OP) punch. We recovered six hatchery Chinook Salmon in Bear Creek, and four were marked with an OP punch. Five of the 12 hatchery salmon recovered in the Wallowa River were marked with an OP punch. No other salmon were collected at weirs within the Grand Ronde Basin in 2014 and outplanted elsewhere.

In Grande Ronde Basin streams with hatchery supplementation, Chinook Salmon returns over the last seven years have been largely comprised of hatchery salmon (Figure 6). The percentage of hatchery salmon recovered on the spawning grounds in 2014 was 45.7%, 73.1% , 80.8%, and 53.3%, 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 a female as a pre-spawn mortality (PSM) if ≥ 50% of the eggs were retained and spawned if < 50% of the eggs were retained. We do not estimate spawning success for male carcasses and assume that the PSM rate for males is the same as that of females. If we could not determine egg retention for a female carcass, it was not included in the calculation of PSM. 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 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 estimate. For the Wallowa-Lostine populations (i.e., the Lostine River, Bear Creek, Hurricane Creek, and the Wallowa River), we combine all of the female carcass data from these streams into annual PSM estimates. 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 ≥ 20 female carcasses in 2014, the estimated PSM rate ranged from 0.0% to 27.7% (Table 21). In the Imnaha River, the estimated PSM rate was 13.0%. For the two wilderness streams, the Minam River and the Wenaha River, the estimated PSM rates were 1.3% (*N* = 75 females) and 0.0% (*N* = 40 females), respectively. For streams with hatchery supplementation programs in the Grande Ronde Basin, PSM rates were 3.9%, 27.7%, 17.4%, and 8.3%, for Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the 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 190 kidney samples from Imnaha River Chinook Salmon in 2014 (Table 22). Of those, 128 came from hatchery-reared salmon and 62 from natural salmon; 140 samples were collected at Lookingglass Fish Hatchery and 50 from carcasses recovered on spawning ground surveys. The enzyme-linked immunosorbent assay (ELISA) OD levels were <0.2 for 98.6% of hatchery salmon and 94.0% of natural origin salmon.

We collected 584 kidney samples from Grande Ronde Basin salmon in 2014: 341 from hatchery-reared salmon and 243 from natural salmon; 268 from salmon spawned at Lookingglass Fish Hatchery and 316 recovered during spawning ground surveys (Table 21). ELISA OD levels were <0.2 for 94.1% of hatchery salmon and 93.0% of natural origin salmon.

The highest ELISA OD level was measured from a hatchery origin female salmon collected in the Imnaha River (2.236; Table 22). In the Minam River, ELISA OD levels were <0.2 for 33 natural salmon, moderate (0.2–0.799 OD units) for two natural origin salmon, and high (>0.799 OD units) for one natural origin salmon The two hatchery origin salmon sampled from the Minam River had low ELISA OD levels. From the other wilderness stream, the Wenaha River, seven of eight hatchery and nine of 13 natural origin salmon recovered had 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. 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.

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, 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. In addition, the Nez Perce Tribe 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, a cooperative agreement with the Oregon Department of Fish and Wildlife.

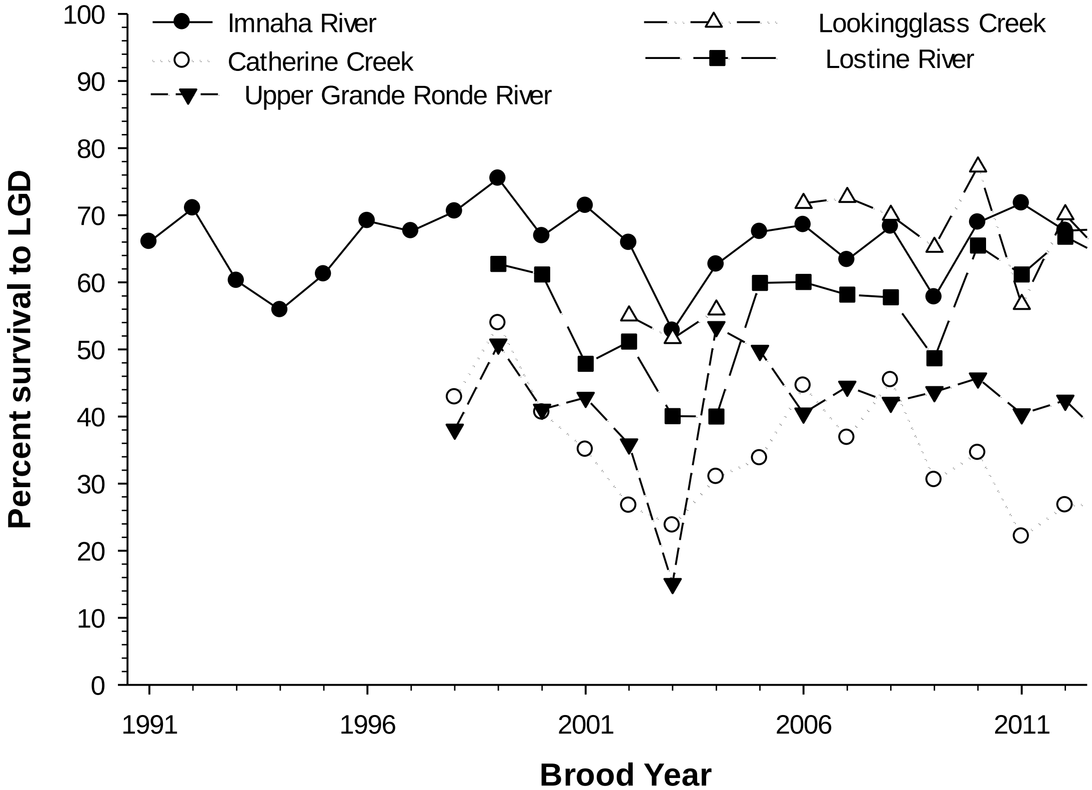

Figure 1. Mean survival rate to Lower Granite Dam (LGD) of PIT-tagged Chinook Salmon smolts released into the Imnaha River, Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek and the Lostine River, BYs 1991-2012.

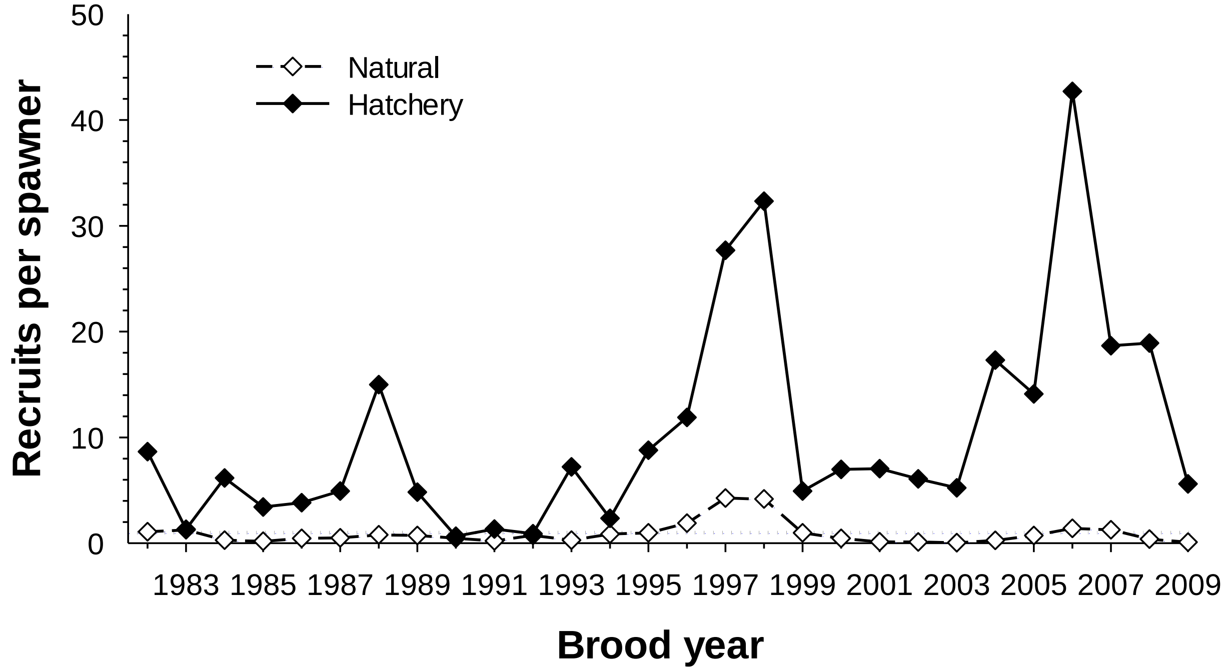

Figure 2. Total (including jacks) recruits-per-spawner ratios for completed brood years of Imnaha River Chinook Salmon, completed BYs 1982–2009. Note: dotted line indicates recruits-per-spawner ratio=1.

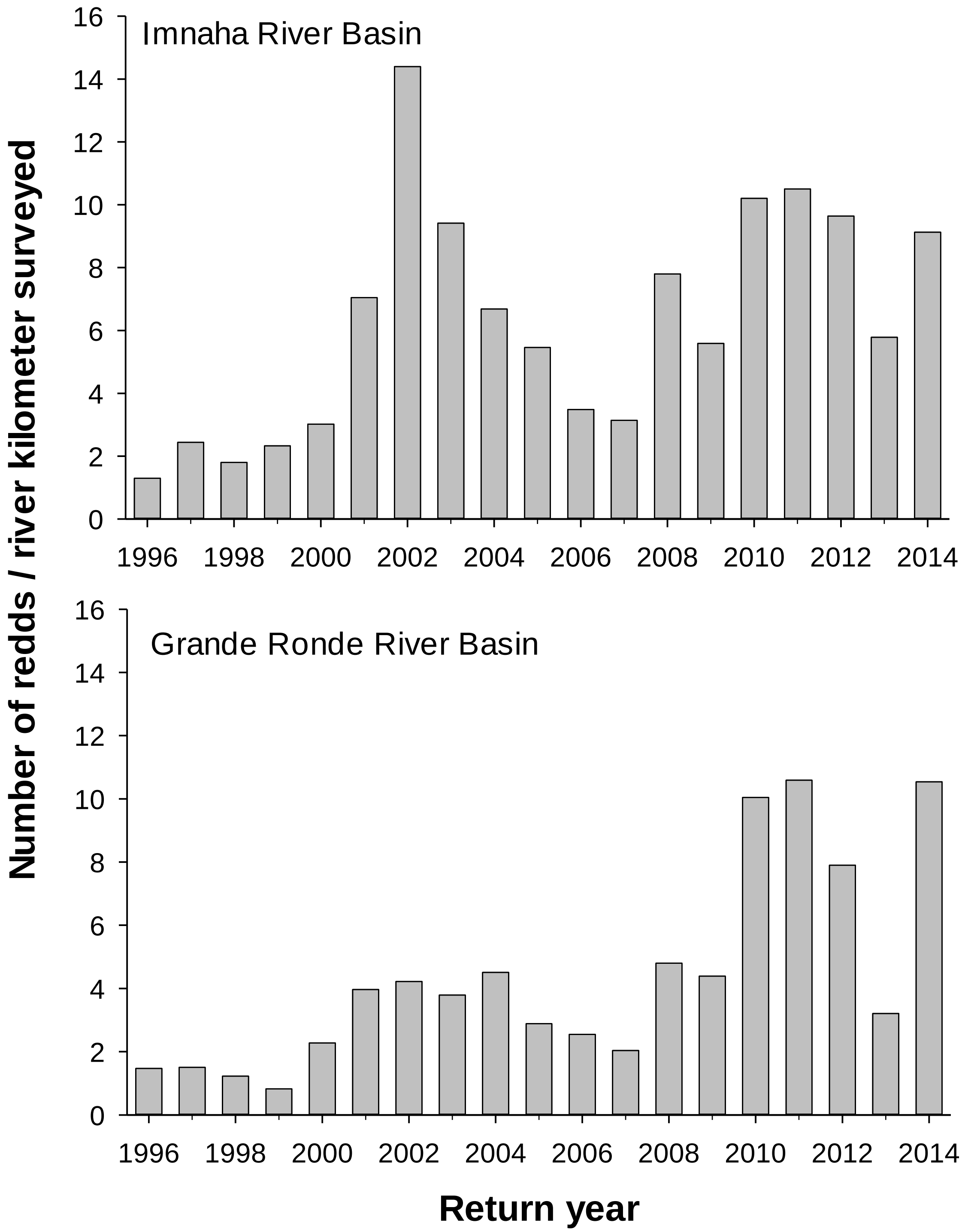

Figure 3. Total redds/river kilometer surveyed in the Imnaha and Grande Ronde river basins, 1996-2014.

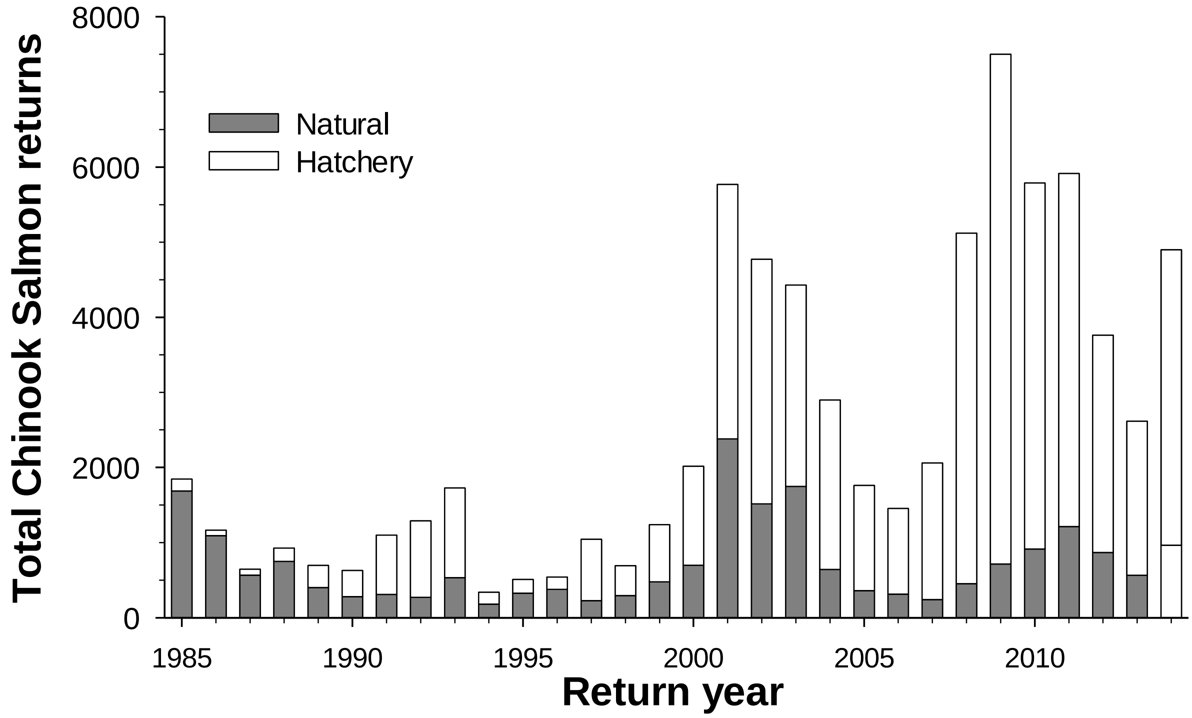

Figure 4. Estimated numbers of mature natural- and hatchery-origin Chinook Salmon that returned to the Imnaha River, 1985-2014.

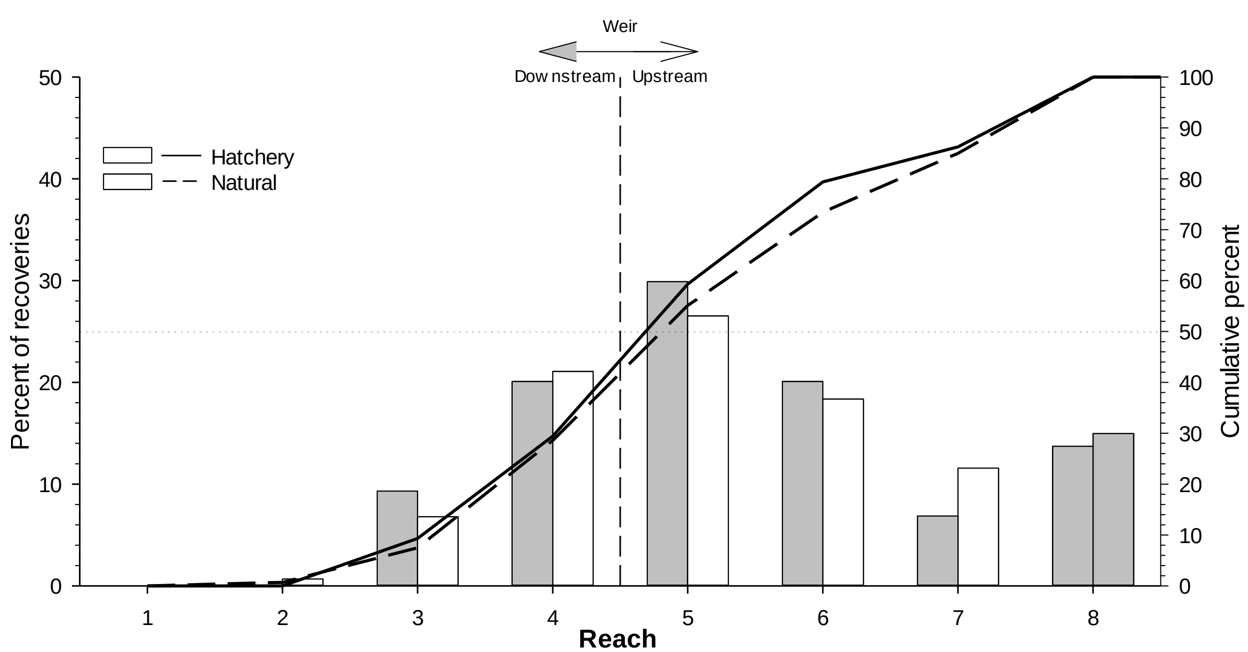

Figure 5. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on the Imnaha River, 2014. Reach 1- Gorge to Freezeout Creek, Reach 2-Grouse Creek to the Gorge, Reach 3-Crazyman Creek to Grouse Creek, Reach 4-Weir to Crazyman Creek, Reach 5-Macs Mine to the weir, Reach 6-Log to Macs Mine, Reach 7-Indian Crossing to Log, Reach 8-Blue Hole to Indian Crossing.

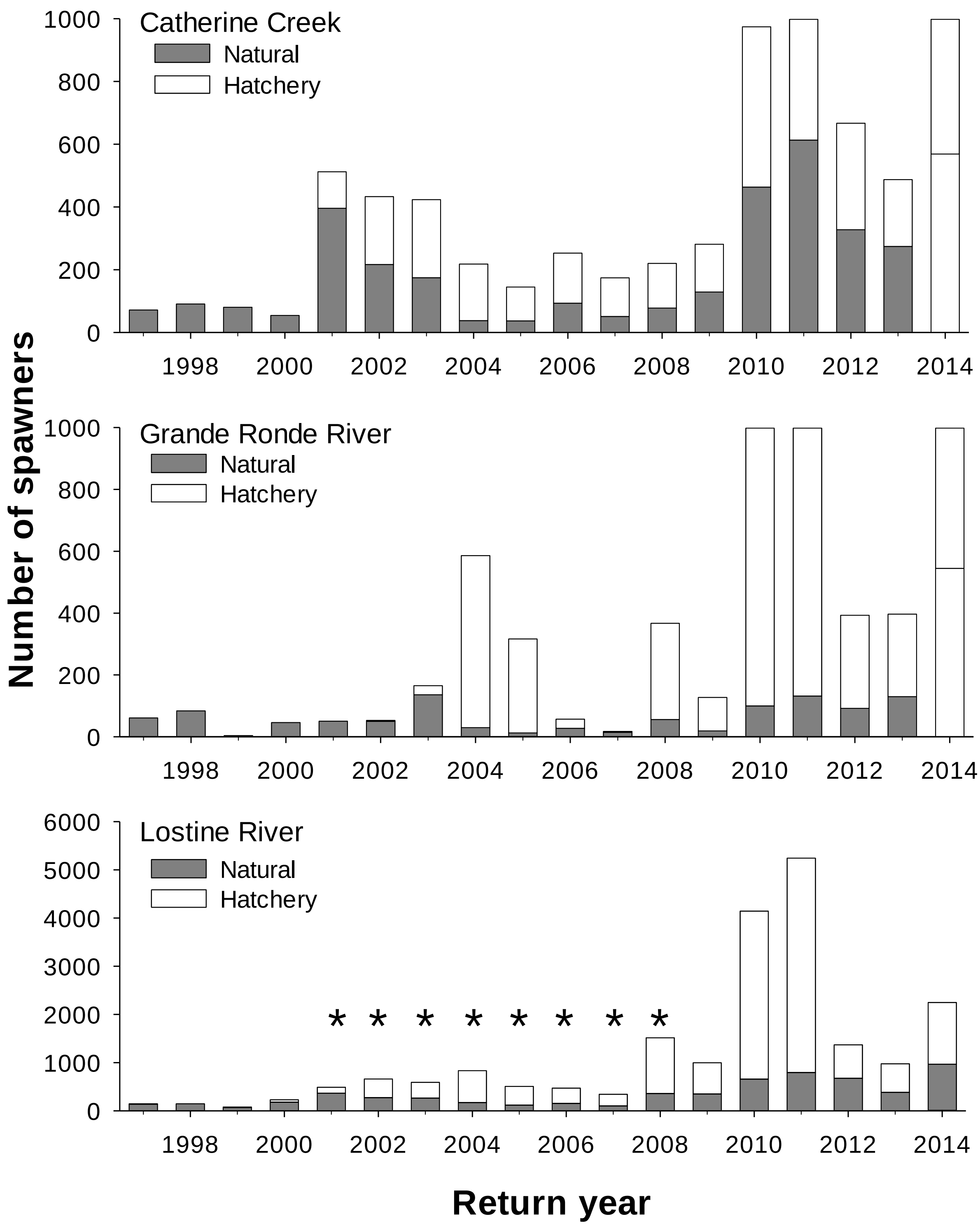

Figure 6. Estimated numbers of mature natural- and hatchery-origin Chinook Salmon that spawned naturally in Catherine Creek, the Upper Grande Ronde River, and Lostine River, 1997-2014. *Lostine River data from 2001–2008 are not reliable because the Nez Perce Tribe reported that some members of the hatchery production staff falsified weir data.

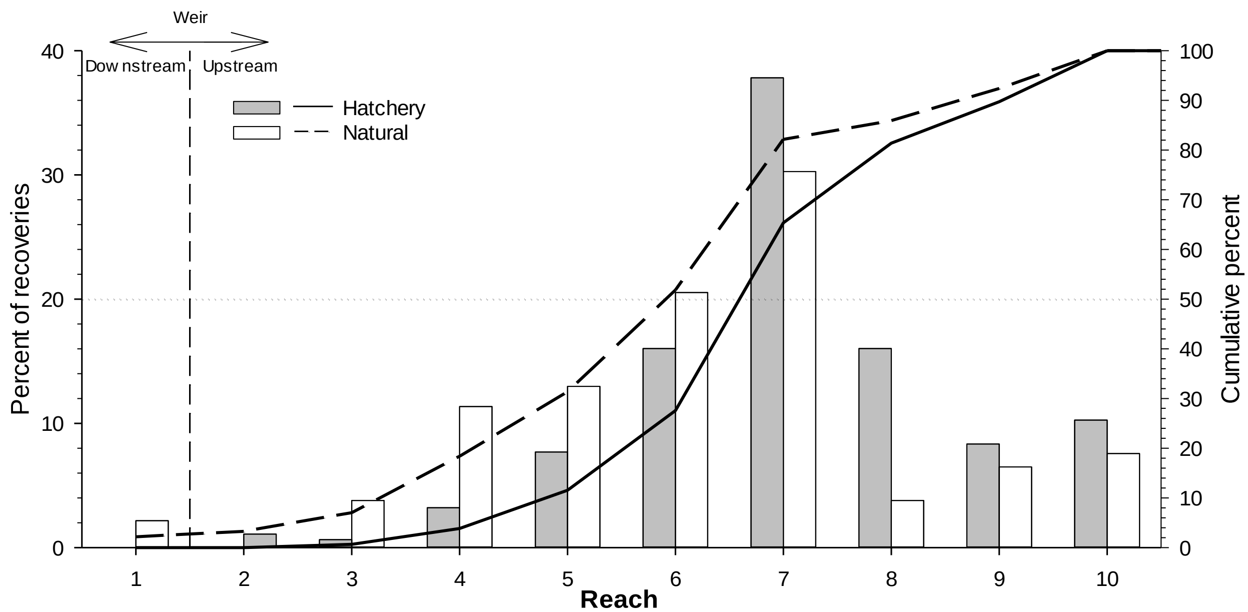

Figure 7. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on Catherine Creek, 2014. Reach 1-Weir to 2nd Union Bridge, Reach 2-Bottom of Southern Cross Ranch to the Weir, Reach 3-Mile Post 5 to top of Southern Cross Ranch, Reach 4-Badger 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.

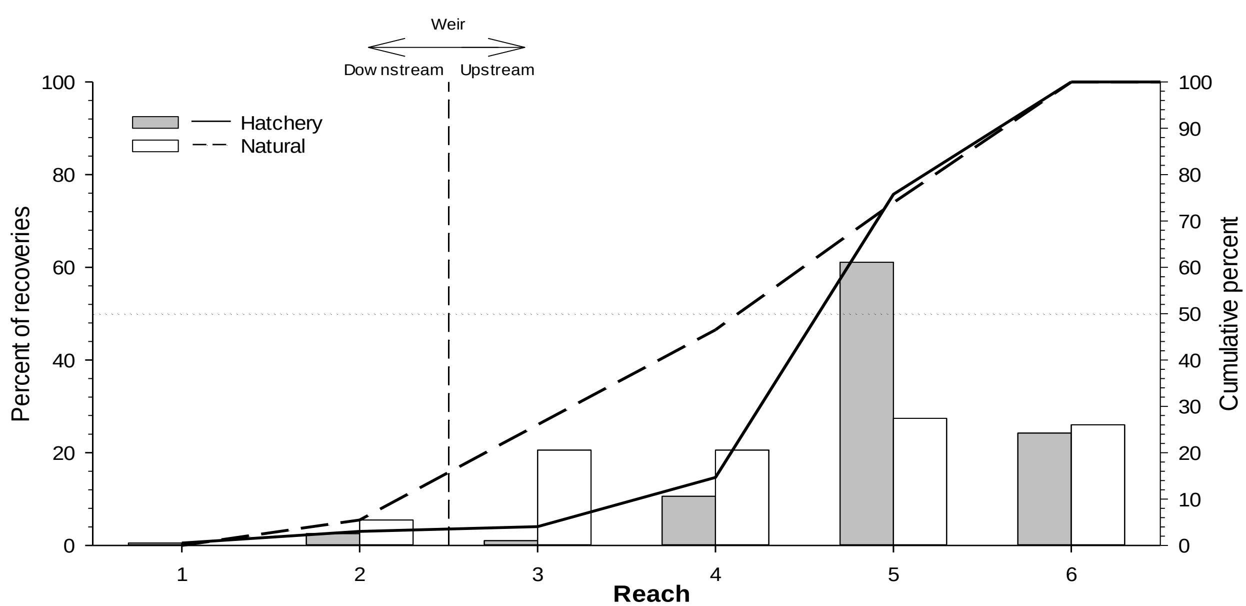

Figure 8. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on the Upper Grande Ronde River, 2014. Reach 1-Weir to Starkey Store, Reach 2-Spoolcart Campground to the Weir, Reach 3-Time and a Half Campground to Spoolcart Campground, Reach 4-Forest 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.

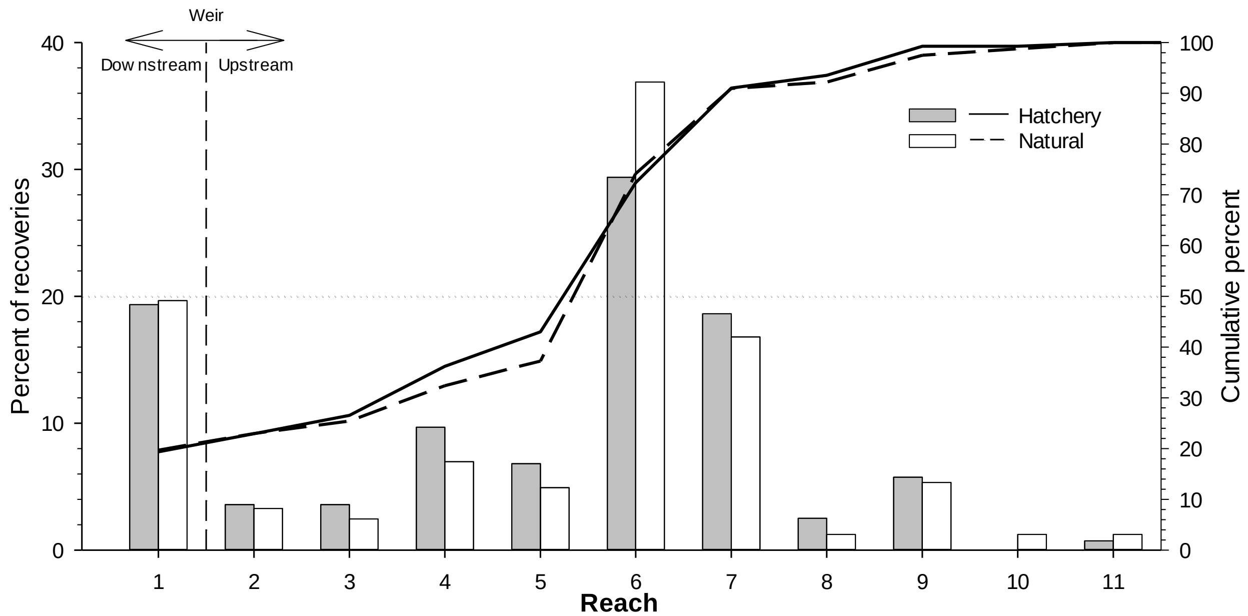

Figure 9. Percent of natural- and hatchery-origin Chinook Salmon carcasses recovered in each spawning ground survey reach on the Lostine River, 2014. Reach 1-Weir to the Mouth, Reach 2-McLain's Ranch to the Weir, Reach 3-Highway 82 Bridge in Lostine to McLain's Ranch, Reach 4-Westside Ditch to the trout 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. Rearing summaries for BY 2012 juvenile spring Chinook Salmon from the Conventional Hatchery Program released into the Imnaha and Grande Ronde river basins, 2014.

Stock	Number of Females	Number of green eggs taken	Eyed eggs	Number culled[a]	Number released as eyed eggs	Percent Survival: Green egg-to-eyed egg	Percent Survival: Eyed egg-to-smolt[b]	Percent Survival: Green egg-to-smolt[b]	Total smolts released
Imnaha River	109	489,189	389,802	0	0	79.7	88.9	70.9	346,702
Catherine Creek	45	170,686	148,514	0	0	87.0	93.2	81.1	138,370
Upper Grande Ronde Ronde River	74	267,394	245,116	0	0	91.7	98.4	90.2	241,169
Lookingglass Creek	81	297,475	179,533	0	0	94.0	90.1	84.6	251,780
Lostine River	62	270,211	242,616	0	0	89.8	96.0	86.2	232,924

[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 2012 spring Chinook Salmon smolts produced from the Conventional Hatchery (CHP) program at Lookingglass Fish Hatchery and released in 2014.

Stock, CWT code	Raceway	Program	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								
090764	12	CHP	522	92.9	5.2	1.7	0.2	58,110
090765	13	CHP	509	96.3	2.4	1.4	0.0	58,110
090766	14	CHP	508	96.5	2.8	0.6	0.2	56,245
090767	15	CHP	502	94.7	4.7	0.6	0.0	58,137
Total/mean			2,046	95.1	3.7	1.1	0.1	232,527
Ad-only	16-17	CHP	1,004	n/a	99.2	n/a	0.8	114,175
Catherine Creek								
090754	1	CHP	505	98.0	0.6	1.4	0.0	46,337
090755	2	CHP	510	97.6	0.8	1.6	0.0	46,492
Total/mean			1,015	97.8	0.7	1.5	0.0	92,829
Ad-only	3	CHP	512	n/a	97.7	n/a	2.3	45,541
Upper Grande Ronde River								
090761	4	CHP	510	n/a	n/a	96.1	3.9	58,257
090760	5	CHP	508	n/a	n/a	97.2	2.8	59,893
Total/mean			1,018	n/a	n/a	96.7	3.3	118,150
090758	6	CHP	507	96.6	2.4	0.6	0.4	59,664
090759	7	CHP	168	94.2	5.1	0.8	0.0	63,355
Total/mean			675	95.4	3.7	0.7	0.2	123,019

Table 2 continued.

Stock, CWT code	Raceway	Program	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								
090756	AHPC	CHP	508	98.4	1.2	0.4	0.0	75,269
090757	AHPD	CHP	506	96.8	2.4	0.6	0.2	74,429
Total/mean			1,014	97.6	1.8	0.5	0.1	149,698
Ad-only	AHPA,B	CHP	1,010	n/a	97.6	n/a	2.4	102,082
Lostine River[a]								
090763	8	CHP	316	48.6	50.7	0.3	0.3	58,460
090763	9	CHP	348	61.5	37.2	0.4	0.9	57,428
090762	10-11	CHP	595	52.5	45.9	0.1	1.4	117,036
Total/mean			1,259	53.8	45.0	0.2	1.0	232,924

[a] *Smolts marked with only an Adipose fin clip (Ad) were mixed with smolts that received both an Ad clip and a CWT before an estimated number of smolts with an Ad clip but no CWT (i.e., % Ad clip, no CWT) could be determined. We estimated the number of smolts that were Ad clipped but did not receive a CWT by calculating the average proportion of smolts from all stocks that were Ad clipped without a CWT for brood years 2009-2012. This proportion was applied to the BY 2012 Lostine River smolts to estimate "% ad clip, no CWT."*

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 2012 spring Chinook Salmon smolts produced from the Conventional Hatchery Programs (CHP) and released in 2014. Length and weight data were collected at Lookingglass Fish Hatchery, 10-13 February 2014.

Stock, CWT code	Raceway	Program	Release dates		Fork Length (mm)		Weight (g)		Condition factor (K)		Total released	Number PIT-tagged	Survival rate to Lower Granite Dam
			Volitional	Forced	Mean	SD	Mean	SD	Mean	SD			
Imnaha River													
090764	12	CHP	1 APR	14 APR	111.5	8.9	15.7	2.9	1.2	0.1	58,110	3,481	0.69
090765	13	CHP	1 APR	14 APR	111.0	8.9	16.9	5.4	1.2	0.1	58,110	3,488	0.72
090766	14	CHP	[a]	3 APR	111.7	8.9	17.0	3.2	1.2	0.1	58,170	3,479	0.65
090767	15	CHP	[a]	3 APR	112.8	7.1	17.6	3.6	1.2	0.1	58,137	3,402	0.65
Ad-only	16	CHP	1 APR	14 APR	113.0	6.8	18.3	2.9	1.2	0.1	58,044	3,481	0.66
Ad-only	17	CHP	1 APR	14 APR	112.7	8.0	17.6	3.8	1.2	0.1	56,131	3,485	0.69
Total/mean											346,702	20,816	0.68
Catherine Creek													
090754	1	CHP	21 MAR	15 APR	112.1	6.8	17.3	4.1	1.2	0.1	46,337	6,956	0.26
090755	2	CHP	21 MAR	15 APR	111.8	7.9	16.7	3.0	1.2	0.1	46,492	6,936	0.26
Ad-only	3	CHP	21 MAR	15 APR	110.9	9.6	16.3	4.0	1.2	0.1	45,541	6,880	0.28
Total/mean											138,370	20,772	0.27
Upper Grande Ronde River													
090761	4	CHP	22 MAR	3 APR	111.2	9.1	16.6	4.2	1.2	0.1	58,257	499	0.41
090760	5	CHP	6 APR	15 APR	111.0	7.3	17.7	3.0	1.2	0.1	59,893	498	0.40
090758	6	CHP	6 APR	15 APR	111.4	8.5	16.8	3.4	1.2	0.1	59,664	497	0.44
090759	7	CHP	22 MAR	3 APR	111.5	7.4	16.9	3.2	1.2	0.1	63,355	494	0.44
Total/mean											241,169	1,988	0.42

Table 3 continued.

Stock, CWT code	Raceway	Program	Release Date		Fork Length (mm) Mean	SD	Weight (g) Mean	SD	Condition Factor (K) Mean	SD	Total released	Number PIT-tagged	Survival rate to Lower Granite Dam
Lookingglass Creek													
Ad-only	AHPA	CHP	1 APR	14 APR	111.8	15.4	15.0	3.8	1.2	0.1	49,548	787	0.68
Ad-only	AHPB	CHP	1 APR	14 APR	108.8	12.0	15.5	9.6	1.2	0.1	52,534	691	0.75
090756	AHPC[b]	CHP	1 APR	14 APR	109.0	12.0	15.8	6.1	1.2	0.1	49,965	792	0.69
090757	AHPD[b]	CHP	1 APR	14 APR	110.2	15.4	16.5	6.4	1.1	0.1	48,924	691	0.68
090756-757	18[b]	CHP	1 APR	14 APR	107.5	11.2	13.8	3.8	1.1	0.1	50,809	N/A[c]	N/A[c]
Total/mean											251,780	2,961	0.70
Lostine River													
090763	8	CHP	21 MAR	31 MAR	112.9	10.1	18.0	4.3	1.2	0.1	58,460	990	0.65
090763	9	CHP	21 MAR	31 MAR	111.3	7.5	16.7	3.5	1.2	0.1	57,428	998	0.58
090762	10	CHP	12 APR	22 APR	109.0	7.9	14.8	3.3	1.2	0.1	5 8,251	998	0.69
090762	11	CHP	12 APR	22 APR	113.2	8.0	17.3	3.2	1.2	0.1	58,785	986	0.75
Total/mean											232,924	3,972	0.67

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

[b] *To lower densities, 25,304 fish from AHPC (CWT 090756) and 25,505 fish from AHPD (CWT 090757) were moved to Raceway 18 on 1 NOV 2013. These fish were PIT tagged on 8 OCT 2013 and we do not know which PIT tags were transferred into Raceway 18.*

[c] *Raceway 18 contained an unknown number of PIT tagged smolts so the Number PIT-tagged and Survival rate to Lower Granite Dam were unable to be calculated.*

Table 4. Estimated numbers of BY 2013 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 2014. Note: tag retention checks will be conducted in February 2015, after which we will calculate estimates of the numbers of parr that were successfully marked/tagged.

Stock	Estimated number of parr marked from 19-29 August 2014				Number PIT-tagged, October 2014	Estimated number of parr at LFH, 31 December 2014
	AD clip with CWT	CWT, no AD clip	AD clip, no CWT	Total marked parr		
Imnaha River	253,968	0	79,698	333,666	20,862	332,593
Catherine Creek	106,367	0	41,213	147,580	20,854	146,905
Upper Grande Ronde River	109,488	116,416	0	225,904	1,993	225,116
Lookingglass Creek	99,365	0	78,996	178,361	1,986	176,865
Lostine River	146,006	0	105,100	251,106	2,293	250,207
Total	715,194	116,416	305,007	1,136,617	47,988	1,131,686

Table 5. Number of mature spring Chinook Salmon handled each week at northeast Oregon LSRCP trapping facilities in 2014. 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.

	Week of	Imnaha River[a]		Catherine Creek[b]		Upper Grande Ronde River[b]		Lookingglass Creek[a]		Lostine River[c]	
Period	year	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural
Dates of trap operation:		18 JUN – 10 SEP		3 MAR – 31 JUL		4 MAR – 1 JUL		1 MAR – 16 SEP		15 FEB – 21 SEP	
11 – 17 MAY	20	-	-	0	0	0	0	3	1	-	-
18 – 24 MAY	21	-	-	0	0	0	0	22	15	-	-
25 – 31 MAY	22	-	-	52	43	25	17	84	29	-	-
1 – 7 JUN	23	-	-	243	273	303	187	60	16	1	0
8 – 14 JUN	24	-	-	130	127	20	32	106	17	0	0
15 – 21 JUN	25	0	0	40	41	12	4	145	23	61	35
22 – 28 JUN	26	57	64	57	58	13	7	142	42	13	9
29 JUN – 5 JUL	27	106	67	12	12	5	2	85	14	70	38
6 – 12 JUL	28	179	74	18	18	-	-	57	17	28	39
13 – 19 JUL	29	454	142	1	6	-	-	17	3	250	127
20 – 26 JUL	30	489	101	0	2	-	-	9	3	23	10
27 JUL – 2 AUG	31	498	48	0	0	-	-	1	0	234	66
3 – 9 AUG	32	265	16	-	-	-	-	4	0	64	20
10 – 16 AUG	33	189	26	-	-	-	-	23	11	85	57
17 – 23 AUG	34	99	34	-	-	-	-	19	11	28	20
24 – 30 AUG	35	259	58	-	-	-	-	31	11	131	93
31 AUG – 6 SEP	36	61	8	-	-	-	-	7	4	116	47
7 – 13 SEP	37	24	0	-	-	-	-	0	0	34	15
14 – 20 SEP	38	-	-	-	-	-	-	-	-	0	0
21 – 27 SEP	39	-	-	-	-	-	-	-	-	0	0
Total		2,680	638	553	580	378	249	815	217	1,138	576

[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. Number and disposition, by origin, age, and sex of mature spring Chinook Salmon returning to northeast Oregon LSRCP trapping facilities in 2014. Numbers of Chinook trapped/passed above the weir were adjusted to account for the estimated number 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	1,816	5	307	438	41	69	2,676	56	1	296	222	38	29	642	3,318
Passed above the weir	43	1	137	250	21	48	500	56	1	251	183	32	24	547	1,047
Released below the weir	39	0	0	0	0	0	39	0	0	0	0	0	0	0	39
Outplanted	37	1	61	41	2	5	147	0	0	0	0	0	0	0	147
Foodbank/tribal distribution	1,020	0	32	53	1	5	1,111	0	0	0	0	0	0	0	1,111
Stream Enrichment	648	3	0	0	0	0	651	0	0	0	0	0	0	0	651
Trap Morts	12	0	1	0	0	0	13	0	0	4	2	0	0	6	19
Kept for broodstock[b]	17	0	76	94	17	11	215	0	0	41	37	6	5	89	304
Spawned	11	0	66	89	16	10	192	0	0	36	36	5	5	82	274
Killed, not spawned	2	0	4	0	0	0	6	0	0	3	0	0	0	3	9
Pre-spawn mortality	4	0	6	5	1	1	17	0	0	2	1	1	0	4	21
Weir age & sex composition (%)	67.9	0.1	11.5	16.4	1.5	2.6	100	8.7	0.1	46.1	34.6	6.0	4.5	100	
Catherine Creek[a]															
Trapped	87	0	149	287	16	11	553	34	1	216	286	25	18	580	1,033
Passed above the weir	19	0	127	269	14	10	439	32	1	188	263	21	16	521	960
Outplanted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foodbank/tribal distribution	66	0	1	0	0	0	67	0	0	0	0	0	0	0	67
Trap Morts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kept for broodstock[b]	2	0	22	20	2	1	47	2	0	28	23	4	2	59	106
Spawned[c]	2	0	20	19	2	1	44	1	0	26	23	4	2	57	101
Killed, not spawned	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-spawn mortality	0	0	2	1	0	0	3	1	0	0	0	0	0	2	5
Weir age & sex composition (%)	15.7	0.0	27.1	52.3	2.9	2.0	100	5.9	0.2	37.2	49.3	4.3	3.1	100	

Table 6 continued.

Stock, Disposition	Hatchery							Natural							
	Age 3		Age 4		Age 5			Age 3		Age 4		Age 5			Grand
	M	F	M	F	M	F	Total	M	F	M	F	M	F	Total	total
Upper Grande Ronde River (UGR)[a]															
Trapped	21	0	124	223	4	3	375	8	2	119	111	5	7	252	627
Passed above the weir	3	0	84	185	4	1	277	5	1	85	88	4	6	189	466
Foodbank/tribal distribution	10	0	0	0	0	0	10	0	0	0	0	0	0	0	10
Trap Mort	3	0	0	2	0	0	5	0	0	1	0	0	0	0	5
Kept for broodstock[b]	5	0	40	36	0	2	83	3	1	33	23	1	1	62	145
Spawned[c]	4	0	35	35	0	2	76	2	1	30	22	0	1	56	132
Killed, not spawned	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Pre-spawn mortality	1	0	4	1	0	0	6	1	0	3	1	1	0	6	12
Weir age & sex composition (%)	5.6	0.0	33.1	59.4	1.1	0.8	100	3.2	0.8	47.2	44.0	2.0	2.8	100	
Lookingglass Creek															
All trapped Chinook[d]	216	0	253	339	6	1	815	34	0	80	99	4	0	217	1,032
Stray from UGR[e]	9	0	11	7	0	0	27	0	0	0	0	0	0	0	27
Stray from Catherine Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passed above weir	1	0	193	274	4	1	473	34	0	51	72	4	0	161	634
Released below weir	27	0	0	0	0	0	27	0	0	0	0	0	0	0	27
Removed/foodbank	30	0	0	0	0	0	30	0	0	0	0	0	0	0	30
Kept for broodstock[b, f]	9	0	60	65	2	0	136	0	0	29	27	0	0	56	192
Kept for LFH broodstock	9	0	40	60	6	1	116	0	0	29	27	0	0	56	172
Spawned[d]	8	0	36	58	6	0	108	0	0	27	24	0	0	51	159
Killed, not spawned	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Pre-spawn mortality	0	0	4	2	0	1	7	0	0	2	3	0	0	5	12
Weir age & sex composition (%)	26.5	0.0	31.1	41.6	0.7	0.1	100	15.7	0.0	36.9	45.6	1.8	0.0	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[g]															
Trapped	660	1	187	282	6	2	1,138	71	0	253	236	12	4	576	1,714
Passed above the weir	0	0	107	196	4	2	309	71	0	220	209	9	3	512	821
Released below the weir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribal distribution/foodbank	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Outplanted to Bear Creek	477	0	0	0	0	0	477	0	0	0	0	0	0	0	477
Recycled through Fishery[h]	177	1	38	32	2	0	250	0	0	0	0	0	0	0	250
Kept for broodstock	6	0	41	54	0	0	101	0	0	33	27	3	1	64	165
Spawned[c]	2	0	39	48	0	0	89	0	0	27	26	1	0	54	143
Killed, not spawned	4	0	0	0	0	0	4	0	0	0	2	0	0	0	4
Pre-spawn mortality	0	0	2	6	0	0	8	0	0	5	5	0	0	10	18
Weir age & sex composition (%)	58.0	0.0	16.4	24.8	0.5	0.2	100	12.3	0.0	43.9	41.0	2.1	0.7	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] *Totals include 27 trapped Chinook that were classified as strays from the Upper Grande Ronde CHP program because they had an intact adipose fin and a CWT was detected.*
[e] *Of these 27 assumed strays from the Upper Grande Ronde River CHP program, one jack, 10 age 4 males, and seven age 4 males were kept for Upper Grande Ronde River broodstock; one jack was recycled downstream and 8 jacks were killed.*
[f] *Broodstock collection includes 27 stray Chinook that were kept for the Upper Grande Ronde River CHP program.*
[g] *Operated by Nez Perce Tribe (NPT). Data provided by Shane Vatland (NPT) & Peter Cleary (NPT).*
[h] *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.*

Table 7. Spawning summaries of spring Chinook Salmon from the Conventional Hatchery Programs at Lookingglass Fish Hatchery for the Imnaha and Grande Ronde basins, 2014.

	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	99	95	156	41	41	74	621,831	4,442	586,293	5.7
Catherine Creek	19	24	37	25	32	48	188,435	4,283	174,568	7.4
Upper Grande Ronde River	44	43	57	24	32	55	257,706	3,790	243,174	5.6
Lookingglass Creek	58	50	78	24	27	49	324,484	3,957	312,682	3.6
Lostine River	48	42	73	26	27	49	314,769	4,254	295,673	6.1

[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.*

Table 8. Number of female Chinook Salmon used in BY 2014 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	84	10	94	NA	33	5	38	
	Mean egg wt.	NA	0.240	0.282	0.245	NA	0.243	0.286	0.251	0.578
Catherine Creek	Females	NA	18	1	19	NA	23	2	25	
	Mean egg wt.	NA	0.241	0.240	0.241	NA	0.249	0.283	0.252	0.174
Upper Grande Ronde River*	Females	NA	42	2	44	1	21	1	23	
	Mean egg wt.	NA	0.246	0.303	0.249	0.238	0.236	0.342	0.241	0.336
Lookingglass Creek*	Females	NA	53	0	53	NA	22	0	22	
	Mean egg wt.	NA	0.241	NA	0.241	NA	0.237	NA	0.237	0.557
Lostine River	Females	NA	46	1	47	NA	19	4	23	
	Mean egg wt.	NA	0.237	0.242	0.237	NA	0.249	0.205	0.241	0.643

* *The asterisk indicates stocks where the number of females with mean egg weights does not match the number of females spawned because the eggs from females with high BKD ELISA values were culled.*

Table 9. Catch and escapement summary of BY 2009–2011 smolts that were released into the Imnaha River and returned in 2014. Estimated coded-wire tag (CWT) recoveries were summarized through 30 December 2016 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 2011)			Age 4 (BY 2010)			Age 5 (BY 2009)			
Total Smolts Released	390,703			469,807			252,588			
% Ad + CWT	55.6%			52.3%			69.9%			
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	13	47	83	39	155	287	2	65	9	379
Non-tribal net	6	13	23	13	30	55	3	7	10	88
Sport	31	169	300	14	82	152	0	0	0	452
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	8	18	32	5	11	21	0	0	0	53
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	2	2	4	2	2	4	1	1	1	9
Stray above LGD[a,b]	2	2	2	0	0	0	0	0	0	2
Recruitment to river[a]										
Sport Fisheries[c]	8	--	99	3	--	29	0	--	4	132
Tribal Fisheries[c]	0	--	27	0	--	108	0	--	16	151
Above weir estimate[d]	24	--	169	37	--	422	0	--	75	666
Below weir estimate[d]	12	--	540	11	--	210	0	--	32	782
Removed at weir[d]	679	--	1,738	89	--	358	6	--	41	2,137
Compensation area return	733	--	2,607	145	--	1,148	6	--	168	3,923
Total/Total estimated return	785	--	3,017	213	--	1,646	12	--	188	4,851

[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	1,256	0.497	1,256	0.497
Mean	236,504	1,758	0.715	1,750	0.712

[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 2009–2011 Captive Broodstock and Conventional Hatchery program smolts that were released into Catherine Creek and returned in 2014. Estimated coded-wire tag (CWT) recoveries were summarized through 30 December 2016 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 2011)			Age 4 (BY 2010)			Age 5 (BY 2009)			
Total Smolts Released	134,520			161,373			155,475			
% Ad + CWT	63.3%			61.6%			96.3%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	2	9	14	0	0	0	14
Non-tribal net	1	2	3	5	11	16	1	2	2	21
Sport	1	1	2	11	37	57	1	4	4	63
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	0	0	0	3	9	14	0	0	0	14
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	0	0	0	0	0	0	0
GR Basin[c]	1	--	1	11	--	58	0	--	0	59
Grande Ronde Pilot Fishery[a]	0	0	0	1	5	5	0	0	0	5
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]	4	--	30	80	--	426	7	--	26	482
Below weir estimate[c]	0	--	4	0	--	21	0	--	2	27
Removed at weir[c]	47	--	68	27	--	44	1	--	3	115
Compensation area return	52	--	103	122	--	568	8	--	31	702
Total/Total estimated return	54	--	108	140	--	655	10	--	40	800

[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 2009–2011 Captive Broodstock and Conventional Hatchery program smolts that were released into the Upper Grande Ronde River and returned in 2014. Estimated coded-wire tag (CWT) recoveries were summarized through 30 December 2016 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 2011)			Age 4 (BY 2010)			Age 5 (BY 2009)			
Total Smolts Released	143,649			285,738			242,385			
% Ad + CWT	49.4%			46.2%			21.2%			
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	2	9	9	2	28	28	0	0	0	37
Non-tribal net	2	5	5	9	19	19	0	0	0	24
Sport	3	13	13	11	40	40	0	0	0	53
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	0	0	0	4	11	11	0	0	0	11
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	0	0	0	0	0	0	0
GR Basin[c]	16	--	22	12	--	52	1	--	1	75
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	--	10	0	--	0	10
Above weir estimate[c]	30	--	145	146	--	986	2	--	17	1,148
Below weir estimate[c]	0	--	2	0	--	15	0	--	0	17
Removed at weir[c]	14	--	18	94	--	78	2	--	2	98
Compensation area return	60	--	187	256	--	1,152	5	--	20	1,359
Total/Total estimated return	67	--	214	278	--	1,239	5	--	20	1,473

[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 2009–2011 Conventional Hatchery Program smolts that were released into Lookingglass Creek and returned in 2014. Estimated coded-wire tag (CWT) recoveries were summarized through 30 December 2016 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 2011)			Age 4 (BY 2010)			Age 5 (BY 2009)			
Total Smolts Released	273,097			228,565			101,343			
% Ad + CWT	46.8%			51.2%			98.7%			
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	1	3	5	0	0	0	5
Columbia River										
Tribal	1	3	7	6	68	129	1	6	6	142
Non-tribal net	3	6	13	12	25	47	0	0	0	60
Sport	5	20	42	34	132	252	1	4	4	298
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	1	2	5	1	2	4	0	0	0	9
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	0	0	0	1	1	2	0	0	0	2
Stray above LGD[a,b]										
Outside GR Basin	1	1	1	1	1	1	0	0	0	2
GR Basin[c]	1	--	17	18	--	188	1	--	12	217
Grande Ronde Pilot Fishery[a]	0	0	0	1	5	5	0	0	0	5
Recruitment to river[a]										
Sport Fisheries	12	--	75	33	--	195	0	--	2	272
Tribal Fisheries	0	--	18	0	--	320	0	--	4	342
Above weir estimate[c]	1	--	8	52	--	462	0	--	5	475
Below weir estimate[c]	2	--	65	27	--	180	1	--	2	247
Removed at weir[c]	90	--	179	45	--	107	1	--	2	288
Compensation area return	108	--	368	178	--	1,462	3	--	27	1,857
Total/Total estimated return	117	--	430	232	--	1,897	5	--	37	2,364

[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 2009–2011 Captive Broodstock and Conventional Hatchery program smolts that were released into the Lostine River and returned in 2014. Estimated coded-wire tag (CWT) recoveries were summarized through 30 December 2016 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 2011)			Age 4 (BY 2010)			Age 5 (BY 2009)			
Total Smolts Released	265,039			267,352			62,836			
% Ad + CWT	49.5%			52.4%			0.0%			
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	1	12	12	0	0	0	12
Columbia River										
Tribal	4	14	14	43	197	198	0	0	0	212
Non-tribal net	1	4	4	7	16	16	0	0	0	20
Sport	15	90	92	13	76	77	0	0	0	169
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	1	2	2	3	8	8	0	0	0	10
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	0	0	0	2	11	11	0	0	0	11
Stray above LGD[a,b]										
Outside GR Basin	1	1	1	1	1	1	0	0	0	2
GR Basin[c]	6	--	62	1	--	31	0	--	0	93
Grande Ronde Pilot Fishery[a]	1	4	4	0	0	0	0	0	0	4
Recruitment to river[a]										
Sport Fisheries	0	--	8	0	--	10	0	--	0	18
Tribal Fisheries	0	--	78	0	--	124	0	--	2	203
Above weir estimate[c]	9	--	182	81	--	810	1	--	26	1,018
Below weir estimate[c]	12	--	169	17	--	193	0	--	4	366
Removed at weir[c]	4	--	483	51	--	96	0	--	0	579
Compensation area return	34	--	988	154	--	1,273	1	--	32	2,294
Total/Total estimated return	54	--	1,099	220	--	1,587	1	--	32	2,718

[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 1998-2009. SAR data were updated on 30 December 2016.

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	857	0.617	763	0.550
2008	CBS	34,111	275	0.806	245	0.718
2008	CHP	110,242	1,074	0.974	992	0.900
2009	CBS	96,738	169	0.175	156	0.161
2009	CHP	58,737	176	0.300	162	0.276
Mean	CBS/CHP	76,596	347	0.430	324	0.402

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 1998–2009. SAR data were updated on 30 December 2016.

Brood		Total smolts	To Lower Granite Dam		To river mouth	
Year	Program	released	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	846	0.444	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	539	0.285	502	0.265
Mean	CBS/CHP	80,117	421	0.437	398	0.415

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 2000–2009. SAR data were updated on 30 December 2016.

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	100,759	496	0.492	442	0.439
Mean	CBS/CHP	104,108	1,498	1.146	1,384	1.043

[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 1998–2009. SAR data were updated on 30 December 2016.

Brood		Total smolts	To Lower Granite Dam		To river mouth	
Year	Program	released	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	421	1.338	414	1.315
2001	CBS	141,867	439	0.309	433	0.305
2001	CHP	100,882	666	0.660	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	1,305	0.659	1,191	0.601
2005	CBS	24,604	219	0.890	207	0.840
2005	CHP	205,407	1,898	0.924	1,875	0.913
2006	CBS	10,470	201	1.920	201	1.919
2006	CHP	194,594	5,294	2.721	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	1,911	1.046	1,095	0.600
2009	CBS	1,905	22	1.155	11	0.577
2009	CHP	60,931	237	0.389	213	0.350
Mean	CBS/CHP	90,636	889	1.003	826	0.933

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, 2014.

	Carcasses				
Basin, stream	Hatchery	Natural	Unknown origin	Percent hatchery[a]	Number of redds
Imnaha River Basin					
Big Sheep Creek	2	2	0	50.0	31
Imnaha River	204	147	7	58.1	725
Lick Creek	1	0	0	0.0	8
Total	207	149	7	58.1	764
Grande Ronde River Basin					
Bear Creek	6	7	0	46.2	38
Catherine Creek	156	185	6	45.7	383
Upper Grande Ronde River	198	73	4	73.1	261
Hurricane Creek	12	29	1	29.3	66
Limber Jim Creek	0	0	0	0.0	0
Lookingglass Creek[b,c]	287	68	7	80.8	310
Lostine River	279	244	14	53.3	500
McCoy Creek	0	0	0	0	1
Meadow Creek	0	0	0	0	0
Minam River[d]	10	115	1	8.0	316
Sheep Creek[e]	2	0	0	0	30
Wallowa River	12	20	1	37.5	94
Wenaha River	33	50	2	39.8	334
Total	995	791	36	55.7	2,333

[a] *Percent of carcasses of known origin.*
[b] *Data provided by CTUIR.*
[c] *Includes Little Lookingglass Creek.*
[d] *Includes Little Minam River.*
[e] *All hatchery carcasses were Upper Grande Ronde River Safety Net Program (UGR SNP) Chinook Salmon which were released to spawn in nature on 15 August 2014;based on redd size (>1 m^2), we estimated that one of the 30 redds might have been constructed by a mature (i.e., not an SNP female) Chinook Salmon.*

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, 2014.

Recovery location	Brood year	CWT code	Number recovered	Release site
Imnaha River Basin				
Imnaha River	2010	090398	1	Upper Grande Ronde River
		090416	20	Imnaha River
		090417	2	Imnaha River
		090418	9	Imnaha River
		090419	16	Imnaha River
	2011	090549	13	Imnaha River
		090550	6	Imnaha River
		090551	8	Imnaha River
		090552	9	Imnaha River
Lick Creek	2011	090551	1	Imnaha River
Grande Ronde River Basin				
Bear Creek	2011	090548	2[a]	Lostine River
Catherine Creek	2009	090288	1	Catherine Creek
		090378	6	Catherine Creek
	2010	090380	37	Catherine Creek
		090381	43	Catherine Creek
	2011	090432	2	Catherine Creek
		090540	2	Catherine Creek
Hurricane Cr	2010	090282	1[b]	Lostine River
		090283	1	Lostine River
		090399	1	Upper Grande Ronde River
	2011	090547	1	Lostine River
		090548	2	Lostine River
Lookingglass Creek[c]	2009	090361	1	Lookingglass Creek
	2010	090380	1	Catherine Creek
		090381	2	Catherine Creek
		090394	47	Lookingglass Creek
		090395	32	Lookingglass Creek
		090396	1	Upper Grande Ronde River
		090397	3	Upper Grande Ronde River
		090399	1	Upper Grande Ronde River
	2011	090541	3	Lookingglass Creek
		090546	1	Upper Grande Ronde River
Lostine River	2009	090284	1	Lostine River
	2010	090282	48	Lostine River
		090283	50	Lostine River
		090380	1	Catherine Creek

Table 20 continued.

Recovery location	Brood year	CWT code	Number recovered	Release site
Lostine River	2010	090381	1	Catherine Creek
		090394	1	Lookingglass Creek
		090395	1	Lookingglass Creek
	2011	090546	1	Upper Grande Ronde River
		090547	10	Lostine River
		090548	11	Lostine River
	2012	090762	1	Lostine River
Minam River[d]	2010	090394	1	Lookingglass Creek
	2011	090547	1	Lostine River
Upper Grande Ronde River	2009	090285	1	Upper Grande Ronde River
		090287	1	Upper Grande Ronde River
	2010	090396	27	Upper Grande Ronde River
		090397	18	Upper Grande Ronde River
		090398	65	Upper Grande Ronde River
		090399	36	Upper Grande Ronde River
	2011	090543	6	Upper Grande Ronde River
		090544	4	Upper Grande Ronde River
		090545	7	Upper Grande Ronde River
		090546	13	Upper Grande Ronde River
Wallowa River	2011	090548	1[b]	Lostine River
Wenaha River	2009	090361	1	Lookingglass Creek
	2010	054598	1	Kooskia National Fish Hatchery
		090394	6	Lookingglass Creek
		090395	9	Lookingglass Creek

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

Table 21. Numbers of female Chinook Salmon carcasses recovered on the spawning grounds that were classified as either a pre-spawn mortality (i.e., % spawn ≤ 50%), spawned (i.e., % spawn > 50%), or unknown, and the pre-spawn mortality rate, 2014.

Recovery location	Pre-spawn mortality	Spawned	Unknown	% Pre-spawn mortality
Imnaha River Basin				
Imnaha River	17	114	33	13.0
Big Sheep Crek	0	1	0	0.0
Lick Creek	0	0	0	0.0
Grande Ronde River Basin				
Bear Creek	0	3	0	0.0
Catherine Creek	8	197	8	3.9
Hurricane Creek	1	12	0	7.7
Lookingglass Creek	35	166	3	17.4
Lostine River	26	286	15	8.3
McCoy Creek	0	1	0	0.0
Minam River	1	74	0	1.3
Sheep Creek	1	1	0	50.0
Upper Grande Ronde River	36	94	0	27.7
Wallowa River	0	14	0	0.0
Wenaha River	0	40	0	0.0

Table 22. Number and percent 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, 2014.

		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	98	99.0	1	1.0	0	0.0	99	0.102
	SGS	26	89.7	2	6.9	1	3.4	29	0.205
Natural	LFH	40	97.6	1	2.4	0	0.0	41	0.102
	SGS	21	100	0	0.0	0	0.0	21	0.109
Catherine Creek									
Hatchery	LFH	18	94.7	1	5.3	0	0.0	19	0.129
	SGS	28	87.5	3	9.4	1	3.1	32	0.171
Natural	LFH	25	100	0	0.0	0	0.0	25	0.087
	SGS	31	100	0	0.0	0	0.0	31	0.120
Upper Grande Ronde River									
Hatchery	LFH	45	100	0	0.0	0	0.0	45	0.088
	SGS	23	79.3	3	10.3	3	10.3	29	0.243
Natural	LFH	22	95.7	0	0.0	1	4.3	23	0.129
	SGS	11	84.6	2	15.4	0	0.0	13	0.172
Lookingglass Creek									
Hatchery	LFH	58	100	0	0.0	0	0.0	58	0.102
	SGS	55	91.7	5	8.3	0	0.0	60	0.120
Natural	LFH	24	100	0	0.0	0	0.0	24	0.106
	SGS	15	83.3	3	16.7	0	0.0	18	0.128
Lostine River									
Hatchery	LFH	47	97.9	1	2.1	0	0.0	48	0.103
	SGS	38	95.0	2	5.0	0	0.0	40	0.121
Natural	LFH	24	92.3	1	3.8	1	3.8	26	0.180
	SGS	32	94.1	2	5.9	0	0.0	34	0.118
Minam River									
Hatchery	SGS	2	100	0	0.0	0	0.0	2	0.110
Natural	SGS	33	91.7	2	5.6	1	2.8	36	0.166
Wenaha River									
Hatchery	SGS	7	87.5	0	0.0	1	12.5	8	0.330
Natural	SGS	9	69.2	4	30.8	0	0.0	13	0.176
Total		732	94.6	33	4.3	9	1.2	774	0.142

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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≤ 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:

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

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:

$$\textit{Above Weir Total Adult Estimate} * \textit{Adult Hatchery Fraction}.$$

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

$$\textit{Above Weir Total Adult Estimate} - \textit{Above Weir Hatchery Estimate}$$

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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