LOWER SNAKE RIVER COMPENSATION PLAN:
Oregon Spring Chinook Salmon Evaluation Studies
2013 Annual Progress Report

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

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LOWER SNAKE RIVER
COMPENSATION PLAN

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Photo cover: Spring Chinook Salmon spawning in Hurricane Creek, a tributary to the Wallowa River near Enterprise, OR : Photo by Joseph W. Feldhaus.

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Preface

This annual progress report provides summary information for Lower Snake River Compensation Plan (LSRCP) spring Chinook Salmon programs operated by the Oregon Department of Fish and Wildlife (ODFW) in the Imnaha and Grande Ronde river basins during 2013. 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 2013 work statement (Carmichael et al. 2013).

We used coded-wire tag (CWT) data collected from 2011-2013 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) and United States v. Oregon production report (Carmichael et al. 1986b).

In this report, data are organized into salmon culture monitoring for juveniles 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) 2012 were hatched, ponded and tagged, Chinook Salmon smolts from BY 2011 were released, Chinook Salmon from BYs 2008-2010 returned to spawn in 2013, and some of those mature Chinook Salmon were used to create BY 2013.

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EXECUTIVE SUMMARY

For 2011 brood year (BY) Imnaha River Chinook Salmon smolts released in 2013, the green egg-to-smolt survival rate was 79.4% and we released 390,703 smolts. We estimated that 99.2% of these smolts were identifiably marked with an adipose fin clip (ad clip) and/or coded-wire tag. In addition, we released BY 2011 smolts from the Grande Ronde Basin Spring Chinook Salmon Conventional Hatchery Program (CHP) into four Grande Ronde Basin streams. Green egg-to-smolt survival rate of BY 2011 Catherine Creek CHP smolts released into Catherine Creek was 89.5%. We released 134,520 CHP smolts into Catherine Creek with 98.0% identifiably marked. Green egg-to-smolt survival rate of Upper Grande Ronde River CHP smolts was 81.6%. We released 135,557 CHP smolts into the Upper Grande Ronde River and 94.5% were identifiably marked. Green egg-to-smolt survival rate for Upper Grande Ronde River Captive Broodstock (CBS) was 72.8% and we released 155,264 smolts, with 99.9% being identifiably marked. The green egg-to-smolt survival rate of Lookingglass Creek CHP smolts released into Lookingglass Creek was 84.6% and we released 273,097 smolts with 99.6% identifiably marked. The green egg-to-smolt survival rate of Lostine River CHP smolts was 87.6%. We released 265,039 CHP smolts into the Lostine River, with 98.8% identifiably marked.

Mean survival rate of Imnaha River smolts from the release site to Lower Granite Dam was 72%. In the Grande Ronde Basin, the lowest mean smolt survival rate from the release site to Lower Granite Dam was 22% from Catherine Creek CHP smolts released at the Catherine Creek Acclimation site. The highest mean survival rate was 61% for Lostine River CHP smolts released from the Lostine River Acclimation Facility.

After accounting for the estimated number of unmarked hatchery returns, the Oregon Department of Fish and Wildlife trapped 890 hatchery and 180 natural Chinook Salmon at the Imnaha River weir and 775 hatchery and 123 natural Chinook Salmon in Lookingglass Creek. In the Grande Ronde Basin, the Confederated Tribes of the Umatilla Indian Reservation captured 462 hatchery and 339 natural Chinook Salmon in Catherine Creek and 122 hatchery and 52 natural Chinook Salmon in the Upper Grande Ronde River. The Nez Perce Tribe captured 557 hatchery and 247 natural Chinook Salmon in the Lostine River.

During the 2013 spawn year at Lookingglass Fish Hatchery, we spawned 68 hatchery and 19 natural females from the Imnaha River and collected 390,184 green eggs. From Catherine Creek, we spawned 23 hatchery and 26 natural females and collected 186,125 green eggs. In the Upper Grande Ronde River, we spawned 53 hatchery and 13 natural females, and collected 251,184 green eggs. In Lookingglass Creek, we spawned 52 hatchery females and 15 natural females and collected 249,742 green eggs. In the Lostine River, we spawned 39 hatchery females and 30 natural females and collected 294,759 green eggs. A greater number of eggs were collected from age 4 (73.3%) than age 5 (26.7%) females and the mean egg weight of age 5 females (0.26 g) was greater than that of age 4 females (0.22 g).

We estimated that 2,397 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River in 2013, 14.9% of the total mitigation goal of 16,050 mature hatchery salmon. We estimated that 2,030 mature Imnaha River hatchery Chinook Salmon returned to the Lower Snake River Compensation Plan compensation area above Lower Granite Dam in 2013, achieving 63.2% of the hatchery compensation goal (3,210) for the Imnaha River Basin. In addition, we estimated that 521 mature natural origin Chinook Salmon returned to the Imnaha River. An estimated 293 mature hatchery Chinook Salmon were harvested in sport

(ODFW) and tribal (CTUIR and NPT) fisheries in the Imnaha River and an estimated 332 mature Chinook Salmon were harvested in fisheries below Lower Granite Dam, 2.6% of the downstream harvest mitigation goal (12,840)

We estimated that 4,537 Grande Ronde Basin hatchery Chinook Salmon returned to the Columbia River in 2013, 15.5% of the total mitigation goal of 29,300 mature hatchery Chinook Salmon. We estimated that 4,121 mature hatchery salmon (540 Catherine Creek, 928 Grande Ronde River, 1,374 Lookingglass Creek, and 1,279 Lostine River) returned to the compensation area, achieving 70.3% of the compensation goal (5,860) for the Grande Ronde Basin. In 2013, we estimated that 467 hatchery and 343 natural salmon returned to Catherine Creek, 830 hatchery and 382 natural salmon returned to the Upper Grande Ronde River, 1,303 hatchery and 181 natural salmon returned to Lookingglass Creek, and 1,216 hatchery and 497 natural salmon returned to the Lostine River. In Lookingglass Creek, CTUIR and NPT reported that tribal fishers harvested a combined 189 mature hatchery salmon and ODFW estimated that sport fishers harvested 132 age 3 hatchery salmon. There were no sport or tribal fisheries in Catherine Creek, the Upper Grande Ronde River, Wallowa River, or Lostine River in 2013. We estimated 215 Grande Ronde Basin hatchery Chinook Salmon were harvested in fisheries below Lower Granite Dam, 0.9% of the downstream harvest mitigation goal (23,440).

In the Imnaha River, the BY 2008 R:S ratio was 0.4 for naturally spawning salmon, and 18.9 for the hatchery component. In the Grande Ronde Basin, BY 2008 R:S for the CHP component was 17.4 in Catherine Creek, 20.4 in the Upper Grande Ronde River, 19.7 in Lookingglass Creek and 18.6 in the Lostine River . The natural component R:S for BY 2008 was 2.2 in Catherine Creek, 0.9 in the Upper Grande Ronde River, 1.1 in Lookingglass Creek, and 0.7 in the Lostine River.

In 2013, we observed 484 redds and recovered 302 carcasses during spawning ground surveys in the Imnaha River Basin. Hatchery salmon comprised 71.3% of carcass recoveries. In the Grande Ronde Basin, we observed 709 redds and recovered 561 carcasses. We recovered 29 hatchery salmon outside of the stream into which they were released as smolts. The percentage of hatchery salmon recovered on spawning ground surveys was 54.5% in Catherine Creek, 74.1% in the Upper Grande Ronde River, 85.8% in Lookingglass Creek, and 41.6% in the Lostine River.

To monitor bacterial kidney disease (BKD), we collected 133 Chinook Salmon kidney samples from Imnaha River Basin streams and 369 kidney samples from Grande Ronde Basin streams in 2013. ELISA 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 Chinook Salmon monitoring data collected by ODFW for the Lower Snake River Compensation Plan (LSRCP) facilities in 2013. 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 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 modify salmon culture practices, as needed, in order to optimize egg-to-smolt survival rate, smolt quality, and smolt-to-adult survival rate, and track spawning in nature by hatchery-reared salmon.

This report provides information on rearing and release operations for BY 2011 of juvenile Chinook Salmon smolts, the collection of eggs for BY 2013, numbers and characteristics of mature Chinook Salmon in the 2013 return year, the 2013 spawning year at Lookingglass Fish Hatchery and in nature, bacterial kidney disease (BKD) monitoring, and recruit summary and age composition of BY 2008. 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 identifiable sexually mature salmon ages 3–5.

LSRCP Chinook Salmon Program Objectives

1. 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.
2. Establish adequate broodstock to meet annual production goals.
3. 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).
4. Re-establish historic tribal and recreational fisheries.
5. Minimize impacts of hatchery programs on resident stocks of game fish.
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.

RESULTS AND DISCUSSION

During 2013, spring Chinook Salmon from BY 2011 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. Additionally, there were 155,264 smolts from BY 2011 Upper Grande Ronde River Spring Chinook Salmon Captive Broodstock Program (CBS) released into the Upper Grande Ronde River. Mature Chinook Salmon from BYs 2008-2010 returned to spawn. A portion of these returns were collected for use as

broodstock from each population to create the 2013 CHP brood year. These salmon were reared at Lookingglass Fish Hatchery, except for the Lookingglass Creek stock which was reared at Irrigon Fish Hatchery (from the eyed egg stage until the following September) due to capacity limitations at Lookingglass Fish Hatchery. Coded-wire-tag recoveries from mature hatchery salmon returns 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.

2011 Brood Year Juvenile Rearing and Release

2011 Brood Year Egg to Smolt Survival

Green egg-to-smolt survival rate for BY 2011 Imnaha River Chinook Salmon released in 2013 was 79.4% (84.8% green egg-to-eyed egg; 93.8% eyed egg-to-smolt; Table 1). Green egg-to-smolt survival rate for Catherine Creek CHP salmon was 89.5% (93.4% green egg-to-eyed egg; 95.8% eyed egg-to-smolt). For the Upper Grande Ronde River, the green egg-to-smolt survival rate was 81.6% (86.5% green egg-to-eyed egg; 94.4% eyed egg-to-smolt) for CHP offspring. The green egg-to-smolt survival rate for the Upper Grande Ronde River CBS salmon was 72.8% (92.8% green egg-to-eyed egg; 84.5% eyed egg-to-smolt). For Lookingglass Creek CHP salmon, the green egg-to-smolt survival rate was 84.6% (91.6% green egg-to-eyed egg; 92.3% eyed egg-to-smolt). For Lostine River CHP salmon, the green egg-to-smolt survival rate was 87.6% (91.9% green egg-to-eyed egg; 95.4% eyed egg-to-smolt).

Eggs from females with high enzyme-linked immunosorbent assay (ELISA) optical density values were culled in an effort to reduce the incidence of BKD in their offspring. No eggs were culled from females spawned for BY 2011 Upper Grande Ronde River CBS production and no females were spawned for the Catherine Creek or Lostine River CBS production (Gee et al. 2012). For CHP females, the Fish Health recommendation was that eggs from females with ELISA levels ≥ 0.2 should be culled. We culled 3,588 eggs (1 female) from the Imnaha River CHP production but no eggs were culled for BKD prevention in any other stocks.

The number of eggs collected for the Upper Grande Ronde River CBS program exceeded production needs. Therefore, b7etween 27 October and 12 November, 200,250 Upper Grande Ronde River CBS eyed eggs were placed in small batches, as they eyed-up, into Meadow Creek, a tributary to the Upper Grande Ronde River near Vey Meadows.

2011 Brood Year Production and Tagging

The release of 390,703 Imnaha River BY 2011 smolts in 2013 was below the long-term juvenile production goal of 490,000, but above the specific annual production goal of 360,000[*] for this BY (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. From BY 2011 Catherine Creek production, we released 134,520 CHP smolts into Catherine Creek in 2013, achieving 89.7% of the juvenile production goal. From the Upper Grande Ronde River

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

BY 2011 production, we released 135,557 CHP and 155,264 CBS smolts in 2013, 116.3% of the juvenile production goal. In Lookingglass Creek, we released 273,097 smolts from the Lookingglass Creek CHP, achieving 109.2% of the juvenile production goal. In the Lostine River, we released 265,039 CHP smolts from BY 2011, 106.0% 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 2011 smolts released in 2013 for coded-wire-tag (CWT) and mark application success from 6-9 February 2012, 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 (ad) fin clip quality (Table 2). Target numers of parr to be tagged and marked differed among stocks.

We attempted to mark 100% of the Imnaha River smolts in four of seven raceways with both an adipose fin clip and a CWT (Table 2). Smolts in the remaining three raceways were to receive only adipose fin clips (100%). For the portion of smolts receiving both an adipose fin clip and a CWT, we estimated that 97.0% were successfully marked with both marks, 1.5% received an adipose fin clip but no CWT, 1.3% had a CWT but no adipose fin clip, and 0.2% were released without a adipose fin clip or a CWT. Fin clip application success was estimated at 99.2% for the portion receiving just addipose clips.

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 94.5% of the CHP smolts received both an adipose fin clip and a CWT, 2.7% received an adipose fin clip but no CWT, 2.2% had a CWT but no adipose fin clip, and 0.6% of the smolts released had no identifiable mark or CWT. Fin clip application success was estimated at 98.0% for the portion to receive just adipose fin clips.

For Upper Grande Ronde River smolts, we attempted to mark100% the CHP 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 AD/CWT, we estimated that 92.5% were successfully marked with both marks, 6.0% were only marked with an adipose clip, 1.4% were only marked with a CWT, and 0.1% were released unmarked. For the two raceways marked with only a CWT, 94.5% were successfully tagged and 5.5% were released untagged.

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 AD/CWT, we estimated that 98.1% of the smolts received both marks, 1.3% were only marked with an ad clip, 0.6% had a CWT but no ad clip, and 0% of the smolts released had no identifiable mark. For the one raceway that was only marked with an adipose fin clip, we estimated that 99.1% were successfully marked and 0.9% were released unmarked.

We reared four raceways of Lostine River CHP smolts and attempted to mark 100% of the smolts in two of four raceways (Table 2). The remaining two raceways were marked with only an adipose fin clip. For the raceways receiving both marks, we estimated that 97.3% received both marks, 0.9% were only marked with an adipose fin clip, 1.6% were only marked with a CWT, and 0.2% were released unmarked. For the two raceways marked with only an adipose fin clips, we estimated that 97.9% of the smolts were successfully marked and 2.1% were released unmarked.

2011 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 2011 Imnaha River Chinook Salmon smolts were transported to the Imnaha River Acclimation and Trapping Facility from 20-21 March 2013 (Table 3). Three raceways were released directly into the Imnaha River at the Imnaha River Acclimation Facility on 30 March 2013, when volitional release of the acclimated smolts began. All remaining smolts in the acclimated group were forced out on 5 April 2013. Mean survival rate to LGD for Imnaha River smolts released in 2013 was 72%; 70% for those directly released into the Imnaha River at the acclimation facility and 73% for those that were acclimated.

Three raceways of Catherine Creek CHP smolts were transferred to the Catherine Creek Acclimation Facility on 19 March 2013 (Table 3). Volitional release began on 21 March 2013 and smolts were forced out on 15 April 2013. Mean survival rate to LGD for CHP smolts released into Catherine Creek was 22%.

Two raceways of smolts produced from the Upper Grande Ronde River CBS were transferred to the Upper Grande Ronde River Acclimation Facility on 18 March 2013 and two raceways of Upper Grande Ronde CHP smolts were transferred on 4 April 2013 (Table 3). Volitional release of CBS smolts began on 20 March 2013, with force-out occurring on 1 April 2013. Volitional release of CHP smolts began on 6 April 2015, with force-out occurring on 15 April 2015. The mean survival rate to LGD for smolts released from the Upper Grande Ronde River Acclimation facility was 40%. Mean survival rates were 37% and 44% for CBS (early release) and CHP smolts (late release), respectively.

Smolts produced from the Lookingglass Creek CHP were volitionally released into Lookingglass Creek directly from rearing ponds at Lookingglass Fish Hatchery starting on 14 March 2013, with force-out occurring on 12 April 2013 (Table 3). Mean survival rate to LGD for CHP smolts released into Lookingglass Creek was 57%.

Two raceways of Lostine River CHP smolts were transported to the Lostine River Acclimation Facility on 11 March 2013 (Table 3). This group was volitionally released beginning on 21 March 2013, with force-out occurring on 1 April 2013. The two remaining raceways of Lostine River CHP smolts were transferred to the acclimation facility on 3 April 2013. Volitional release was initiated on 12 April 2013 and smolts were forced out on 22 April 2013. Mean survival rate to LGD for CHP smolts released into the Lostine River was 61% (0.63% for early release and 0.60% for late release), the highest mean survival rate for smolts released in the Grande Ronde Basin.

2012 Brood Year Parr at Lookingglass Fish Hatchery

From 20–28 August 2013, the brood year 2012 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. The Lookingglass Creek parr were marked/tagged from 17–19 July at Irrigon Fish Hatchery and transferred to Lookingglass Fish Hatchery on 24 September 2013.

Marking and tagging rates varied among stocks and were based on management and monitoring requirements. Imnaha River parr were reared in 6 raceways and we attempted to mark 100% of the parr in two raceways with only an adipose fin clip and mark/tag 100% of the parr in 4 of 6 raceways with both an adipose fin clip and a CWT (Table 4). We attempted to mark/tag 100% of the Catherine Creek parr in two of three raceways with both an adipose fin clip and a CWT and 100% of the parr in the remaining raceway with only an adipose fin clip. The goal was to mark/tag 100% of the parr in two of the four Upper Grande Ronde River raceways with both an adipose fin clip and a CWT and 100% of the parr in the two remaining raceways with only a CWT. Two of four raceways containing Lookingglass Creek parr were 100% marked/tagged with both an adipose fin clip and a CWT and the two remaining raceways were marked with only an adipose fin clip. We attempted to mark 100% of the parr in the four Lostine River raceways with an adipose fin clip and 50% of the parr in each raceway with an adipose fin clip and a CWT. Mark and tag retention checks will be conducted in February 2014, 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 2013. We estimated that 20,816 Imnaha River, 20,772 Catherine Creek, 1,988 Upper Grande Ronde River, 2,961 Lookingglasss Creek, and 3,972 Lostine River parr were successfully PIT-tagged (Table 4). PIT tags were distributed approximately evenly across all raceways for each population.

2013 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 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 and will classify small age 4 Chinook Salmon as jacks and large jacks 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). One way to reduce the number of salmon without a known age is to release more CWT-marked hatchery salmon or to collect scales on all salmon passed above the weirs.

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 and increases the number of hatchery Chinook Salmon from an equivalent age.

Imnaha River

The Imnaha River weir was installed by ODFW Lookingglass Fish Hatchery personnel on 5 July 2013 and operated until 13 September 2013 (Table 5). After adjusting for unclipped returns, we estimated that 890 hatchery and 180 natural origin mature salmon were captured (Table 6). We retained 183 hatchery and 42 natural mature salmon for broodstock. To limit the number of hatchery salmon on spawning grounds, one hatchery salmon was outplanted to Big Sheep Creek and 401 were distributed to Oregon or Nez Perce Tribal food banks. To provide additional harvest opportunities, 232 hatchery salmon were returned to the river below the weir. There were seven hatchery and zero natural origin trap morts in 2013. The remaining salmon collected at the weir were released above the weir to spawn naturally (68 hatchery, 135 natural). Of the hatchery salmon captured at the weir, 76.2% were age 3, 19.7% were age 4, and 4.1% were age 5. Natural origin returns captured at the weir were comprised of 73.6% age 3, 20.7% age 4, and 5.7% age 5.

Catherine Creek

The Catherine Creek weir was operated by CTUIR from 21 February to 31 July 2013 (Table 5). The first Chinook was captured on 27 May 2013 and the last new (i.e., not a recapture) salmon was captured on 24 July 2013. A total of 462 hatchery and 339 naturally-produced salmon were captured (Table 6). CTUIR retained 46 hatchery and 53 natural origin salmon for broodstock. There were zero hatchery and one natural origin trap morts. To reduce the number of hatchery salmon on the spawning ground, 194 hatchery jacks were killed for tribal foodbanks and zero were outplanted. The remaining 220 hatchery and 285 natural mature salmon, were passed above the weir to spawn naturally. Age structure of hatchery salmon captured at the weir was 42.4% age 3, 53.1% age 4, and 4.5% age 5 and 28.3% age 3, 59.3% age 4, and 12.4% age 5 for natural-origin salmon.

This is the eighth complete BY of mature Catherine Creek hatchery salmon returns from both the CBS and CHP production (BYs 2001-2008). As juveniles, all CBS and CHP smolts from BY 2008 (age 5) were marked with an adipose fin clip and CWT and CHP smolts were additionally marked with a blue visual implant elastomer. Mature Chinook Salmon smolts from BY 2009 (age 4) CBS program were marked with an adipose fin clip and a CWT and BY 2009 CHP smolts were marked with an adipose fin clip, CWT, and green visual implant elastomer. All smolts released into Catherine Creek from BY 2010 (age 3 returns) were from the CHP program and were marked with either an adipose fin clip (38.4%) or an adipose fin clip and CWT (61.6%). The age structure of mature CBS salmon handled at the weir was 0% age 3 (no CBS smolts were released from BY 2010), 95.7% age 4, and 4.3% age 5. Age structure of mature CHP weir captures was 77.8% age 3; 17.4% age 4, and 4.8% age 5.

Upper Grande Ronde River

The Upper Grande Ronde River weir was operated by CTUIR from 6 March to 18 June 2013 (Table 5). Between 29 March and 17 June 2013, 122 hatchery and 52 natural salmon were captured (Table 6). The CTUIR retained 68 hatchery and 28 natural salmon for broodstock, 32 hatchery salmon were sent to a foodbank, and 22 hatchery and 28 natural mature Chinook

Salmon were released above the weir to spawn naturally. The age structure of hatchery salmon captured at the weir was 34.4% age 3, 59.0% age 4, and 6.6% age 5, 11.5% age 3, 73.0% age 4, and 15.5% age 5 for natural salmon

This is the eighth year of complete brood year returns of mature Upper Grande Ronde River hatchery salmon from both the CBS and CHP production (BYs 2001 – 2008). All CBS program smolts from BYs 2008 (age 5) and 2009 (age 4) were marked with both an adipose fin clip and a CWT and all were released to spawn in nature. No CBS salmon from BY 2010 were capture, as none were released. The CHP salmon from BYs 2008 – 2009 were marked with only a CWT. 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%). Age structure of CBS returns handled at the weir was 0% age 3 (no CBS smolts were released from BY 2010), 66.7% age 4, and 33.3% age 5. Age structure of the CHP weir captures was 40.4% age 3, 57.7% age 4, and 1.9% age 5.

Lookingglass Creek

The Lookingglass Creek weir was operated by Lookingglass Fish Hatchery (ODFW) personnel from 1 March to 11 September 2013 (Table 5). The ODFW had unique captures of 775 hatchery and 123 natural mature salmon (Table 6). The trap total includes 56 assumed strays from the Upper Grande Ronde CHP program based the absence of an adipose fin clip and the presence of a CWT. Forty-two of the assumed Upper Grande Ronde River strays were kept for the Grande Ronde River CHP program, two jacks were recycled downstream, and 12 jacks were killed.

A total of 129 hatchery and 94 natural origin Chinook were passed above the weir to spawn naturally; 88 hatchery salmon were released below the weir, 404 hatchery salmon were killed (foodbank or landfill), and 112 hatchery and 29 natural mature salmon were kept for the Lookingglass Creek CHP program broodstock. Hatchery salmon captured at the weir (includes strays) were comprised of 68.1% age 3, 28.7% age 4, and 3.2% age 5. Natural origin returns captured at the weir were comprised of 51.2% age 3, 39.8% age 4, and 9.0% age 5.

Lostine River

The Lostine River weir was operated by NPT from 15 February to 27 September 2013 (Table 5). The NPT had unique captures of 557 hatchery and 247 natural mature salmon at the weir, of which 89 hatchery and 56 natural origin mature salmon were retained for broodstock (Table 6). To reduce the number of hatchery salmon on the spawning grounds, 417 hatchery salmon were sent to Wallowa Fish Hatchery for distribution to Oregon or Nez Perce Tribal foodbanks and 31 hatchery salmon were released into Bear Creek, a tributary of the Wallowa River. One hatchery salmon was released below the weir and one natural salmon was kept by the Nez Perce Tribe for ceremonial purposes. The remaining salmon were passed above the weir to spawn naturally (19 hatchery, 190 natural). Of the hatchery salmon captured at the weir, 84.0% were age 3, 12.9% were age 4, and 3.1% were age 5. Natural origin returns captured at the weir were comprised of 43.3% age 3, 42.5% age 4, and 14.2% age 5.

This is the ninth year we had a complete BY return of mature Lostine River hatchery salmon from both the CBS and CHP programs (BYs 2000-2008). Mature salmon used as broodstock in BY 2013 were both natural and hatchery origin. The only Chinook Salmon smolts released into the Lostine River from BY 2010 were from the CHP program and these smolts were marked with an adipose fin clip and CWT. The CBS and CHP salmon from BY 2009 (age 4) were only marked with a CWT. As juveniles, all CBS smolts released from BY 2008 (age 5)

were marked with only a CWT and CHP smolts were marked with an adipose fin clip and CWT. Additionally, 66,820 parr marked with only an adipose fin clip (12,654 CBS and 54,166 CHP parr) from BY 2008 were released into the Lostine River (Gee et al. 2010, 2011, Feldhaus et al. 2012b).

The release of adipose-only clipped CBS and CHP parr into the Lostine River from BY 2008 is problematic because when these salmon return to the Lostine River, we have no way of identifying the program from which the salmon were produced. Therefore, we assume that, based on length-at-age relationships, all age 5 hatchery returns handled at the Lostine River weir in 2013 that were only marked with an adipose fin clip were from BY 2008 parr releases. We also assume that CBS and CHP parr releases had equal parr-to-smolt survival and SAR rates. Therefore, we used the proportions of CBS and CHP parr released into the Lostine River to portion the age 5 year hatchery returns that were only marked with an adipose fin clip into the SAR calculations for the CBS and CHP programs. The potential consequence of this assumption is that BY 2008 CBS and CHP program SAR calculations will increase slightly because we are including assumed returns of mature Chinook Salmon from the CBS and CHP parr release. We assume that survival to maturation of the parr release was low. Alternatively, we could estimate the number of parr releases that returned as mature adults and remove them from the SAR calculations, but since we do not know if these returns were indeed from parr releases, we could be negatively biasing our CBS and CHP SAR calculations. Another potential consequence of releasing CBS parr that are not identifiable is that they could be utilized in the broodstock when they return, which is counter to the CBS protocol.

For the 2013 return year, based on length-at-age, we estimated that 17 age 5 hatchery salmon were handled at the weir, 16 of these were kept for broodstock, and one age 5 CBS program salmon was passed above the weir. Based on the presence of an intact adipose fin and a CWT (the mark applied to BY 2008 captive smolts), we estimated that eight of 17 age 5 salmon trapped at the weir were from the CBS program. Based on CWT recoveries at Lookingglass Fish Hatchery, four of the age 5 adults spawned for the Lostine River CHP program were from the CBS program. The only identifiable CBS salmon handled at the Lostine River weir in 2013 were the eight age 5 adults previously discussed. The age structure of the CHP salmon captured at the weir was 85.4% age 3, 13.0% age 4, and 1.6% 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. Consequently, to reduce numbers of hatchery salmon on the spawning grounds, it has been necessary to outplant salmon to other tributary streams (e.g., Bear Creek, Big Sheep Creek, Lick Creek, and Wallowa River) and to coordinate distribution of surplus hatchery salmon to local and tribal foodbanks. Chinook Salmon that are distributed to local/tribal food banks are either distributed directly from the weir or sent to Wallowa Hatchery for distribution. 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 accidently get 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.

Because these Chinook Salmon are not uniquely marked and some die prior to food distribution, it is difficult to reconcile the number of salmon sent to foodbanks with the trapping records.

One unique challenge with counting returns to Lookingglass Creek that occurred in 2012, but not 2013, was 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 where 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. However, length distributions overlap between adjacent ages, so these discrepancies are impossible to eliminate. Marking all hatchery releases with an adipose fin clip or a CWT would help reduce errors associated with differentiating hatchery and natural returns.

2013 Brood Year Hatchery Spawning

Imnaha River

We spawned 68 hatchery and 19 natural females with 82 unique hatchery and 20 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 390,184 green eggs which were incubated at Lookingglass Fish Hatchery where mortality rate to shocking was 8.0%, resulting in 359,106 eyed eggs.

Catherine Creek

Mature salmon used as broodstock to create the Catherine Creek 2013 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 23 hatchery and 26 natural females with 15 unique hatchery and 22 unique natural male parents (Table 7). Jacks were use the same as adult males

and some adult males were spawned more than once. We collected 186,125 green eggs and mortality rate to shocking was 16.4%, resulting in 155,649 eyed eggs.

Upper Grande Ronde River

Mature salmon used as broodstock to create the Upper Grande Ronde River 2013 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 53 hatchery and 13 natural females with 38 unique hatchery and 8 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 251,184 green eggs and mortality rate to shocking was 8.3%, resulting in 230,290 eyed eggs.

Lookingglass Creek

We spawned 52 hatchery and 15 natural females with 40 unique hatchery and 13 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 249,742 green eggs and morality rate to shocking was 19.2%, resulting in 201,754 eyed eggs.

Lostine River

We spawned 39 hatchery and 30 natural females with 39 unique hatchery and 16 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 294,759 green eggs and morality rate to shocking was 10.7%, resulting in 263,330 eyed eggs.

Egg Weight

For all stocks, a greater number of eggs were collected from age 4 than age 5 salmon (Table 8). Mean egg weight for all stocks was greater for age 5 than age 4 females ($P < 0.001$). Mean egg weight for natural origin salmon was not significantly different from hatchery salmon ($P \geq 0.082$). The largest mean egg weight (0.281 g) was from the Imnaha River natural females and the smallest mean egg weight (0.212 g) was from the Catherine Creek and Upper Grande Ronde River hatchery 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.

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 Creeks, 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, we summed all estimated escapement (harvest, removed at the weir, strays, and all salmon remaining in nature) for the 2013 return year above LGD.

Imnaha River

Coded-wire tag recoveries

We recovered 522 hatchery-reared Imnaha River Chinook Salmon with a CWT from BYs 2008–2010: 300 CWT from BY 2010 (age 3), 184 from BY 2009 (age 4), and 38 from BY 2008 (age 5; Table 9). From these CWT recoveries, we estimate that three Imnaha River salmon were harvested in ocean fisheries, 332 were harvested in the Columbia River, 86 were harvested in Snake River sport fisheries, and zero were harvested in Snake River tribal fisheries. The Columbia River harvest consisted of an estimated 42 salmon harvested in treaty net fisheries, 40 in non-tribal net fisheries, and 250 in sport fisheries. Below LGD, 17 stray CWT-marked salmon were recovered in the Deschutes River and we estimated that this represented 32 stray Imnaha River Chinook Salmon. Above LGD, the four CWT-marked jack salmon caught in the Rapid River trap in Idaho were estimated to represent five stray Imnaha River Chinook Salmon.

Within the Imnaha River Basin, we recovered 333 CWT-marked salmon (Table 9). ODFW estimated that 61 Chinook Salmon were caught in the Imnaha River sport fishery (Yanke et al. 2013). No CWTs were collected from the tribal fishers, but the NPT and CTUIR reported a

total harvest of 232 hatchery salmon (Joe Oatman, NPT, personal communication, 22 November 2013; Preston Bronson, CTUIR, personal communication, 20 November 2013). We estimated that 701 mature hatchery salmon were on the spawning grounds above the weir, 351 were below the weir, and 594 mature salmon were collected at the Imnaha River trapping facility.

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).

We estimated that 2,030 mature Imnaha River hatchery Chinook Salmon returned to the LSRCP compensation area in 2013, 63.2% of the hatchery production goal for the Imnaha River stock (Table 9). Of the total escapement above Lower Granite Dam, we estimated that 293 mature hatchery salmon were harvested in fisheries, 9.1% of the compensation area mitigation goal. We estimated 335 mature Imnaha River hatchery Chinook Salmon were harvested in fisheries below Lower Granite Dam, 2.6% of the downstream harvest mitigation goal.

Return to the River

We estimated that 1,939 hatchery and 521 natural origin salmon returned to the Imnaha River in 2013. The estimated total return to the river of hatchery salmon was comprised of 952 age 3, 748 age 4, and 239 age 5 returns. For natural salmon, we estimated that 239 age 3, 169 age 4, and 113 age 5 returned.

Estimated total return to the river includes 31 hatchery jacks and 30 hatchery adults harvested by sport anglers. The estimated incidental mortality of hooked and released Chinook (estimated at 10% mortality) was two unmarked jacks and one unmarked 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 5–19 July 2013 (Yanke et al. 2013). Additionally, NPT reported that 130 hatchery jacks, 84 hatchery adults, zero natural jacks, and two natural adults were harvested (Joe Oatman, NPT, personal communication, 22 November 2013). CTUIR reported harvest of 13 hatchery jacks, five hatchery adults, zero natural jacks, and one natural adult (Preston Bronson, CTUIR, personal communication, 20 November 2013). The combined sport and tribal harvest of 293 hatchery salmon represents 15.0% of the estimated total return to the Imnaha River.

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

The recruits-per-spawner (R:S) ratios reported here include jacks and were adjusted for estimates of pre-spawn mortality in the parent spawner population. The R:S ratio for BY 2008 was 0.4 for naturally spawning (any origin) Imnaha River salmon and 18.9 for those spawned in the hatchery (any origin). The BY 2008 smolt-to-adult return rate (SAR) for hatchery salmon that returned to the mouth of the Imnaha River was 1.155% (Table 10).

Grande Ronde Basin

Catherine Creek coded-wire tag recoveries

We recovered 187 hatchery-reared Catherine Creek Chinook Salmon with a CWT from BYs 2008–2010: 105 from BY 2010 (age 3), 67 from BY 2009 (age 4), and 15 from BY 2008 (age 5; Table 11). From these recoveries we estimated that zero Catherine Creek Chinook Salmon were recovered in ocean fisheries, 24 were caught in the Columbia River, and 22 were caught in the Snake River sport fishery. Of the Columbia River harvest, we estimated that one salmon was caught in tribal net fisheries, eight were caught in in non-tribal net fisheries, and fifteen we caught in sport fisheries. Below LGD, we recovered two CWTs from stray salmon at the Pelton Dam fish trap in the Deschutes River. Above LGD, zero CWTs were recovered outside the Grande Ronde Basin.

Within the Grande Ronde Basin, two CWT-marked Catherine Creek salmon were recovered in the Lostine River (one on the spawning ground and one from the salmon trap), one was recovered from the Minam River, and 17 were recovered in Lookingglass Creek (one on the spawning grounds and 16 in the hatchery trap; Table 11). We estimated that these 20 CWT-marked salmon represented 51 strays. No salmon from Catherine Creek were outplanted into Lookingglass Creek in 2013. Within Catherine Creek, 148 CWT-marked salmon were recovered. We estimated that 225 mature hatchery salmon were on the spawning grounds above the weir, zero were below the weir, and 242 were collected at the Catherine Creek salmon trap.

Upper Grande Ronde River coded-wire tag recoveries

We recovered 249 hatchery-reared Upper Grande Ronde River Chinook Salmon with a CWT from BYs 2008–2010: 109 from BY 2010 (age 3), 132 from BY 2009 (age 4), and eight from BY 2008 (age 5; Table 12). From these recoveries, we estimated that zero were caught in ocean fisheries, seven were caught in the Columbia River, and eight were caught in the Snake River. Below Lower Granite Dam, the one CWT-marked salmon recovered at the Pelton Dam fish trap in the Deschutes River was estimated to represent one salmon. Above LGD, no CWT-marked salmon were recovered outside the Grande Ronde Basin.

Within the Grande Ronde Basin, 66 CWT-marked salmon were recovered as in-basin strays (11 from the spawning grounds, 54 from the salmon trap, and one from the sport fishery). These 66 CWT-marked salmon strays were estimated to represent 90 salmon. We recovered 174 CWT-marked salmon from the Upper Grande Ronde River. We estimated that 730 mature hatchery salmon were on the spawning grounds above the weir, zero were below the weir, and 100 were collected at the Upper Grande Ronde River salmon trap.

The limited number of CWT recoveries outside the Upper Grande Ronde River is probably because only 26.2% of the 2010, 21.1% of BY 2009, and 76.6% of BY 2008 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 rate 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 337 hatchery-reared Chinook Salmon released into Lookingglass Creek with a CWT from the BYs 2008–2010: 194 from the BY 2010 (age 3), from BY 2009 brood year (age 4), and 12 from BY 2008 (age 5; Table 13). Zero Lookingglass Creek salmon were caught in ocean fisheries. We estimated that 63 mature salmon were recovered in the Columbia River: five in treaty net fisheries, 24 in non-tribal net fisheries, and 34 in sport fisheries. We estimated that 17 mature hatchery salmon were harvested in Snake River sport fisheries and zero were harvested in Snake River tribal fisheries. Below LGD, six CWT-marked salmon, which expanded to seven salmon, were recovered. Five CWTs were recovered in the Deschutes River and one CWT was recovered at Bonneville Fish Hatchery. No stray Lookingglass Creek salmon were recovered outside the Grande Ronde Basin.

Above LGD and within the Grande Ronde basin, eight CWT-marked salmon were recovered in the Wenaha River, one in the Minam River, one on the Catherine Creek spawning grounds, three in the Upper Grande Ronde River salmon trap, and two in the Lostine River salmon trap (Table 13). These 15 CWT recoveries expanded to 54 salmon. Within Lookingglass Creek, 294 CWT-marked salmon were recovered. We recovered 13 CWTs from the sport fishery and ODFW estimated that 132 jack salmon were harvested in the sport fishery (Yanke et al. 2013). No CWTs were collected from the tribal fishers, but the NPT and CTUIR reported a total harvest of 189 hatchery salmon (Joe Oatman, NPT, personal communication, 22 November 2013; Preston Bronson, CTUIR, personal communication, 20 November 2013). We estimated that 142 mature hatchery salmon were on the spawning grounds above the weir, 324 were below the weir, and 516 Lookingglass Creek CHP salmon were collected at the Lookingglass Creek salmon trap.

Lostine River coded-wire tag recoveries

We recovered 231 hatchery-reared Chinook Salmon released into the Lostine River with a CWT from BYs 2008–2010: 138 CWT from BY 2010 (age 3), 70 from BY 2009 (age 4), and 23 from BY 2008 (age 5; (Table 14). We estimated that two mature Lostine River Chinook Salmon were caught in ocean fisheries. In the Columbia River we estimated that seven were recovered in tribal net fisheries, four in non-tribal net fisheries, and 107 in sport fisheries. Below LGD, three CWT-marked salmon were recovered in the Deschutes River and one was recovered at the Kalama Falls Hatchery for an estimate of four salmon. Within the Snake River, no CWT-marked salmon were recovered from either sport or tribal fisheries. Above LGD, one Lostine River salmon was recovered at the Imnaha River adult trap.

Within the Grande Ronde Basin, six CWT-marked Lostine River salmon were recovered in Lookinglass Creek, two were recovered in the Upper Grande Ronde River salmon trap, one in the Wenaha River, and two in the Wallowa River (Table 14). These 11 CWT recoveries were expanded to represent 42 in-basin stray salmon. Within the Lostine River, 190 CWT-marked salmon were recovered. We estimated that 429 mature hatchery salmon were on the spawning grounds above the weir, 250 were below the weir, and 537 were collected at the Lostine River salmon trap.

Return to Compensation Area

The annual total production goal for Grande Ronde Basin hatchery Chinook Salmon is 29,300 (Corps of Engineers 1975). 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 215 Grande Ronde Basin hatchery salmon were harvested in fisheries below Lower Granite Dam, 0.9% of the downstream mitigation goal (Tables 11-14). Harvest below Lower Granite Dam was comprised of 24 Catherine Creek, eight Upper Grande Ronde River, 63 Lookingglass Creek, and 120 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 540 Catherine Creek, 928 Upper Grande Ronde River, 1,374 Lookingglass Creek, and 1,279 Lostine River mature hatchery Chinook Salmon returned to the compensation area, a combined return of 4,121, 70.3% of the compensation goal (Tables 11-14). Of the total escapement above Lower Granite Dam, we estimated that 321 hatchery salmon were harvested in fisheries, 5.5% of the compensation area return. No hatchery salmon were harvested in Catherine Creek, the Upper Grande Ronde River, or the Wallowa and Lostine rivers, but 321 were harvested in Lookingglass Creek.

Returns of Grande Ronde Basin hatchery Chinook Salmon in 2013 did not meet the mitigation goals for either returns to the compensation area or harvest mitigation. Harvest of hatchery salmon in the Grande Ronde Basin is hindered by the paucity of natural salmon and the threat of endangering them further from 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 migration survival (<50%) of 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 197 age 3, 249 age 4, and 21 age 5 hatchery salmon and 96 age 3, 205 age 4, and 42 age 5 natural salmon returned to Catherine Creek in 2013 (Table 11). There was no sport fishery in Catherine Creek and tribal fishers reported zero catch in Catherine Creek.

We estimated that 225 age 3, 541 age 4, and 64 age 5 hatchery salmon and 33 age 3, 288 age 4, and 61 age 5 natural salmon returned to the Upper Grande Ronde River in 2013 (Table 12). There were no sport or tribal fisheries in the Upper Grande Ronde River.

We estimated that 914 age 3, 349 age 4, and 40 age 5 hatchery salmon released as smolts into Lookingglass Creek and 90 age 3, 73 age 4, and 18 age 5 natural salmon returned to Lookingglass Creek in 2013 (Table 13). CTUIR tribal harvest estimates were 25 hatchery jacks, three hatchery adults, one natural origin jack, and one natural origin adult (Preston Bronson, CTUIR, personal communication, 20 November 2013). NPT tribal harvest estimates were 107 hatchery jacks, 54 hatchery adults, zero natural jacks, and three natural adults (Joe Oatman, NPT, personal communication, 22 Nov 2013). The ODFW sport fishery was open from 1 June – 21 June 2013. The area open to anglers extended from the confluence of Lookingglass Creek and the Grande Ronde River upstream 3.2 kilometers to the confluence of Jarboe Creek (Yanke et al. 2013). The sport fishery harvest estimates were 132 hatchery jacks and zero hatchery adults. Additionally, ODFW estimated that seven natural origin jacks and 16 natural origin adults were released by sport anglers for an estimated (7.5% hooking mortality) take of 1 natural origin adult.

Unlike 2012, there were no mature Chinook Salmon from Catherine Creek released into Lookingglass Creek for harvest augmentation in 2013.

We estimated that 1,006 age 3, 162 age 4, and 48 age 5 hatchery and 174 age 3, 231 age 4, and 92 age 5 natural salmon returned to the Lostine River in 2013 (Table 14). There were no sport or tribal fisheries in the Lostine River.

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

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 these 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 hatchery and natural origin salmon, ages 3-5, that spawned naturally in the river, adjusted for pre-spawn mortality of the parents.

In Catherine Creek, the R:S ratio for BY 2008 was 17.4 for the hatchery CHP component and 2.2 for the natural component. The BY 2008 SAR rates to the mouth of Catherine Creek were 0.718% and 0.900% 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 2008 brood year were 20.4 and 0.9, respectively. The BY 2008 SAR rates to the Upper Grande Ronde River were 0.405% and 1.222% for CBS and CHP programs, respectively (Table 16).

In Lookingglass Creek, the R:S ratios for the hatchery and natural component from BY 2008 were 19.7 and 1.1, respectively. The SAR rate to the mouth of Lookingglass Creek for BY 2008 returns of CHP smolts released into Lookingglass Creek was 1.117% (Table 17).

In the Lostine River, the R:S ratios for BY 2008 were 18.6 and 0.7 for hatchery CHP and natural returns, respectively. The SAR rates to the mouth of the Lostine River for the BY 2008 smolts released into the Lostine River were 1.445% and 0.673% for CBS and CHP returns, respectively (Table 18).

Escapement Monitoring

We surveyed three streams in the Imnaha River Basin and 12 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 2013, we counted 484 redds and recovered 302 carcasses in the Imnaha River Basin (Table 19). The number of redds/river kilometer (rkm) in 2013 (5.8 redds/rkm) was lower than 2012 when 9.6 redds/rkm were observed (Figure 2). We did not recovery any out-of-basin stray hatchery salmon in the Imnaha River Basin (Table 20). With 519 natural salmon returning to the Imnaha River Basin, 2013 is the 13th year since the first year of hatchery returns (1985) with >500 natural origin salmon returning to the Imnaha River (Figure 3). Hatchery salmon comprised 71.3% of known origin carcasses recovered on spawning ground surveys in the Imnaha River Basin. Adult (age 4-5) hatchery salmon returns to the Imnaha River have exceeded natural adult returns for the last ten consecutive years and 14 of the 29 years that

hatchery salmon have returned to the Imnaha River. On two tributary streams to the Imnaha River, Big Sheep Creek and Lick Creek, only one carcass (unknown origin) was recovered (in Big Sheep Creek).

In the Grande Ronde Basin, we counted 709 redds and recovered 561 carcasses. The number of redds/rkm in 2013 (3.2 redds/rkm) was lower than 2012 when 7.9 reds/rkm were observed (Figure 2). Hatchery salmon comprised the majority (56.2%) of known origin carcasses recovered on spawning ground surveys in the Grande Ronde Basin (Table 19). A total of 190 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: 111 were released on 4 June 2013 and 79 were released on 14 August 2013. All 9 redds in Sheep Creek were believed to have been constructed by the SNP outplants. Adult hatchery Chinook Salmon have comprised the majority of returns in 12 of the last 13 return years in Catherine Creek, nine of the last 12 return years in the Upper Grande Ronde River, 11 of the last 13 return years in the Lostine River, and seven of the last 10 years in Lookingglass Creek.

In the Grande Ronde Basin, we recovered 29 in-basin strays: one Lookingglass Creek and one Upper Grande Ronde River salmon in Catherine Creek; 10 Upper Grande Ronde River, one Catherine Creek, and one Lostine River salmon in Lookingglass; one Catherine Creek salmon in the Lostine River; one Catherine Creek and one Lookingglass Creek salmon in the Minam River; two Lostine River salmon in the Wallowa River; and nine Lookingglass Creek, and one Upper Grande Ronde River salmon in the Wenaha River (Table 20).

In 2013, 31 hatchery jacks were collected at the Lostine River weir and released into Bear Creek, a tributary to the Wallowa River in Wallowa, OR. None of these salmon were recovered on spawning ground surveys in Bear Creek. No other salmon were collected at weirs within the Grand Ronde Basin in 2013 and outplanted elsewhere.

In streams with hatchery supplementation programs, returns over the last seven years have been largely comprised of hatchery salmon (Figure 4). The percentage of hatchery salmon recovered on the spawning grounds in 2013 was 54.5%, 74.1% , 85.8%, and 41.6%, for Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and Lostine River, respectively (Table 19, Figures 6-8).

Bacterial Kidney Disease Monitoring

We collected 133 kidney samples from Imnaha River Chinook Salmon in 2013 (Table 21). Of those, 99 came from hatchery-reared salmon and 34 from natural salmon; 87 samples were collected at Lookingglass Fish Hatchery and 46 from carcasses recovered on spawning ground surveys. ELISA OD levels were <0.2 for 100% of hatchery salmon and 93.5% of natural origin salmon.

We collected 369 kidney samples from Grande Ronde Basin salmon in 2013: 218 from hatchery-reared salmon and 151 from natural salmon; 251 from salmon spawned at Lookingglass Fish Hatchery and 118 recovered during spawning ground surveys (Table 21). ELISA OD levels were <0.2 for 90.4% of hatchery salmon and 86.8% of natural origin salmon.

The highest ELISA OD level was measured from a hatchery origin male salmon collected in Lookingglass Creek (2.368; Table 21). In the Minam River, ELISA OD levels were <0.2 for 11 natural salmon and moderate (0.2–0.799 OD units) for six natural origin salmon. Of the two hatchery origin salmon sampled from the Wenaha River, one salmon had low and one had

moderate ELISA OD levels. From the other wilderness stream, the Wenaha River, two of five hatchery and nine of 14 natural origin salmon recovered had ELISA OD levels <0.2.

We found no evidence that the release of hatchery salmon is causing an increase in BKD prevalence in the monitored streams, despite the fact that the CBS Program has released offspring of females with ELISA OD levels >1.0, particularly into the Upper Grande Ronde River. 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 always from females with ELISA OD levels <0.2. It seems likely that any sick salmon that may have been released were either unable to survive in nature or they were able to fight off the infection, leaving only healthy salmon to survive to maturation and return to spawn.

Acknowledgments

Roger Elmore, 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, 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 the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) provided weir data from Catherine Creek and the Upper Grande Ronde River. Additionally, CTUIR provided all the spawning ground survey data summarized from Lookingglass Creek and Indian 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.

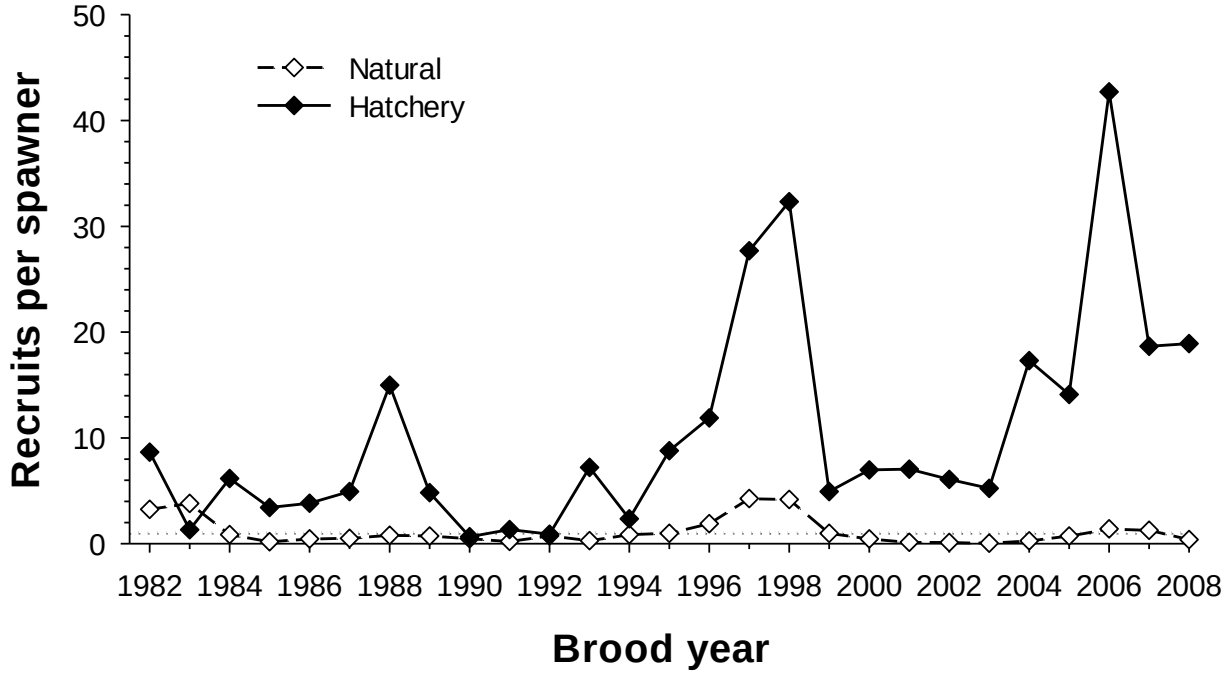

Figure 1. Total (including jacks) recruits-per-spawner ratios for completed brood years of Imnaha River Chinook Salmon, completed BYs 1982–2008. Note: dotted line indicates recruits-per-spawner ratio=1.

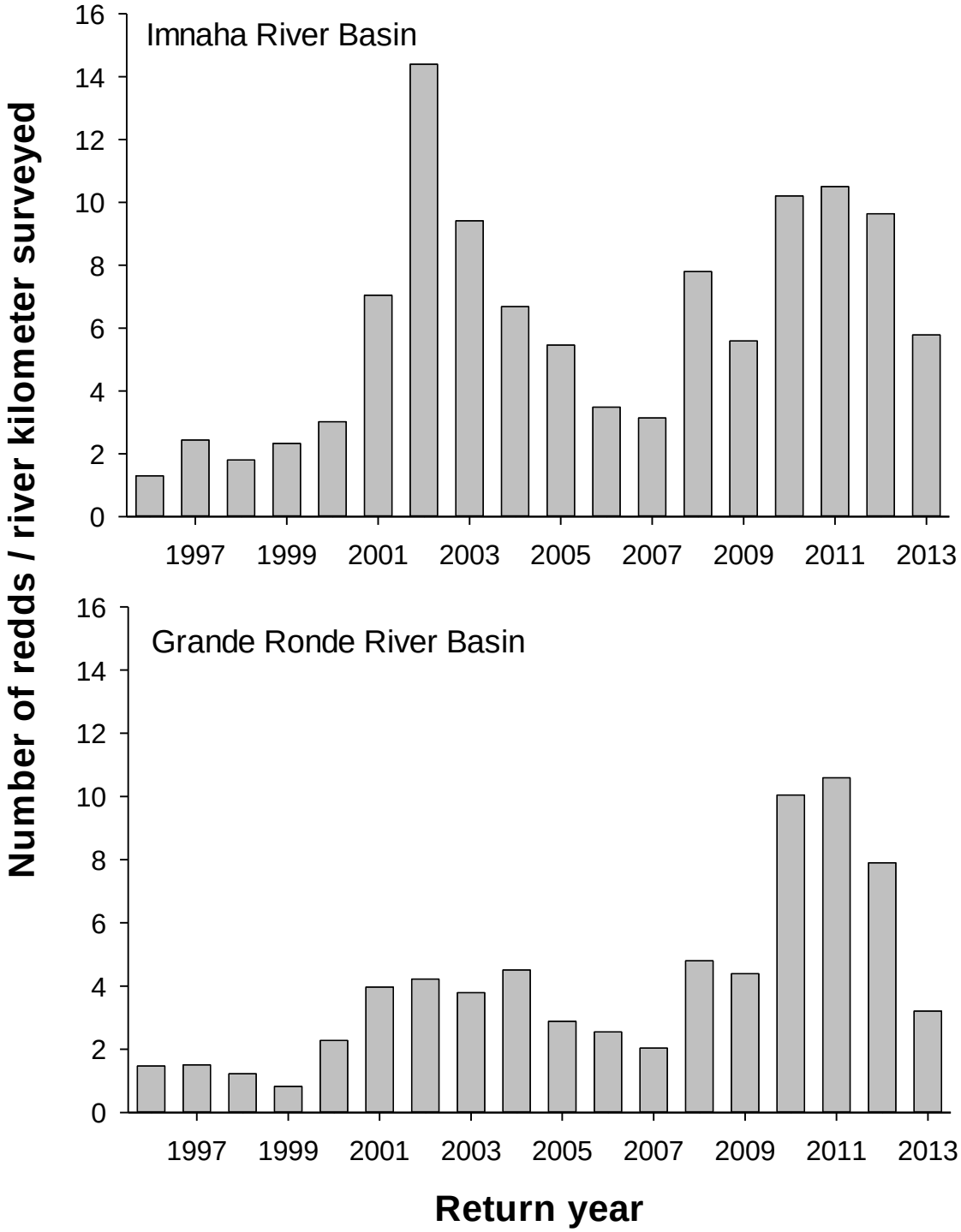

Figure 2. Total redds/river kilometer surveyed in the Imnaha and Grande Ronde river basins, 1996-2013.

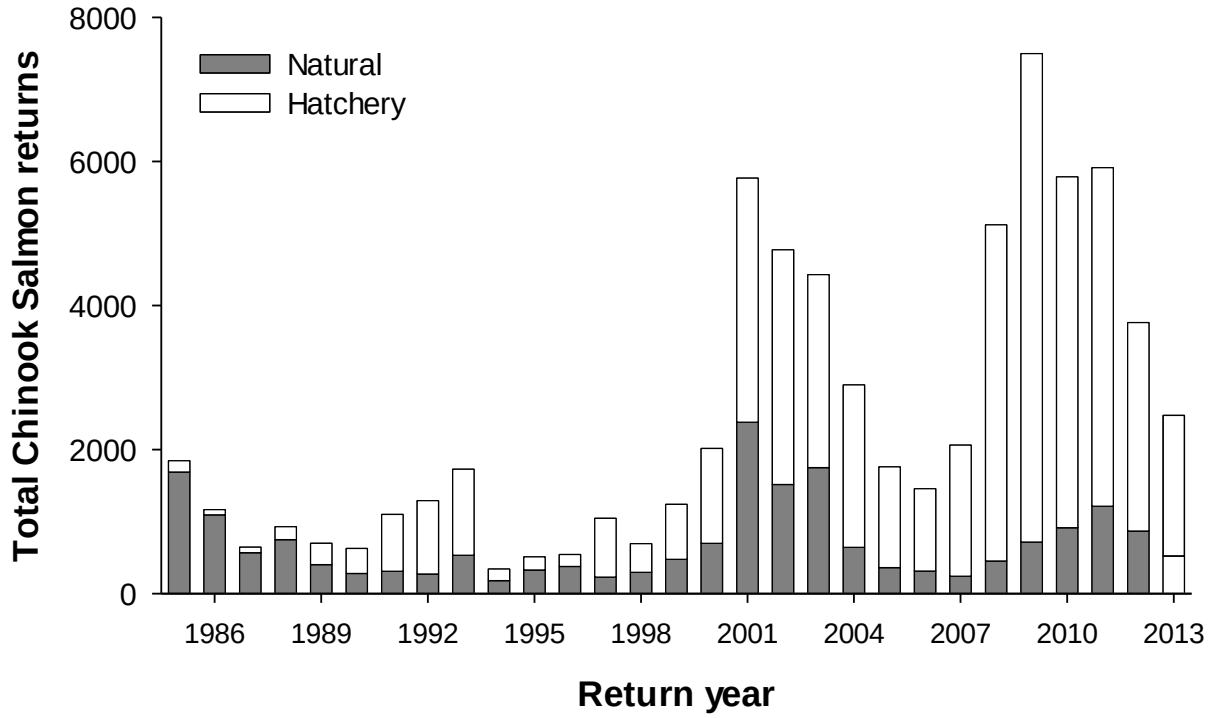

Figure 3. Estimated numbers of mature natural- and hatchery-origin spring/summer Chinook Salmon that retuned to the Imnaha River, 1985-2013.

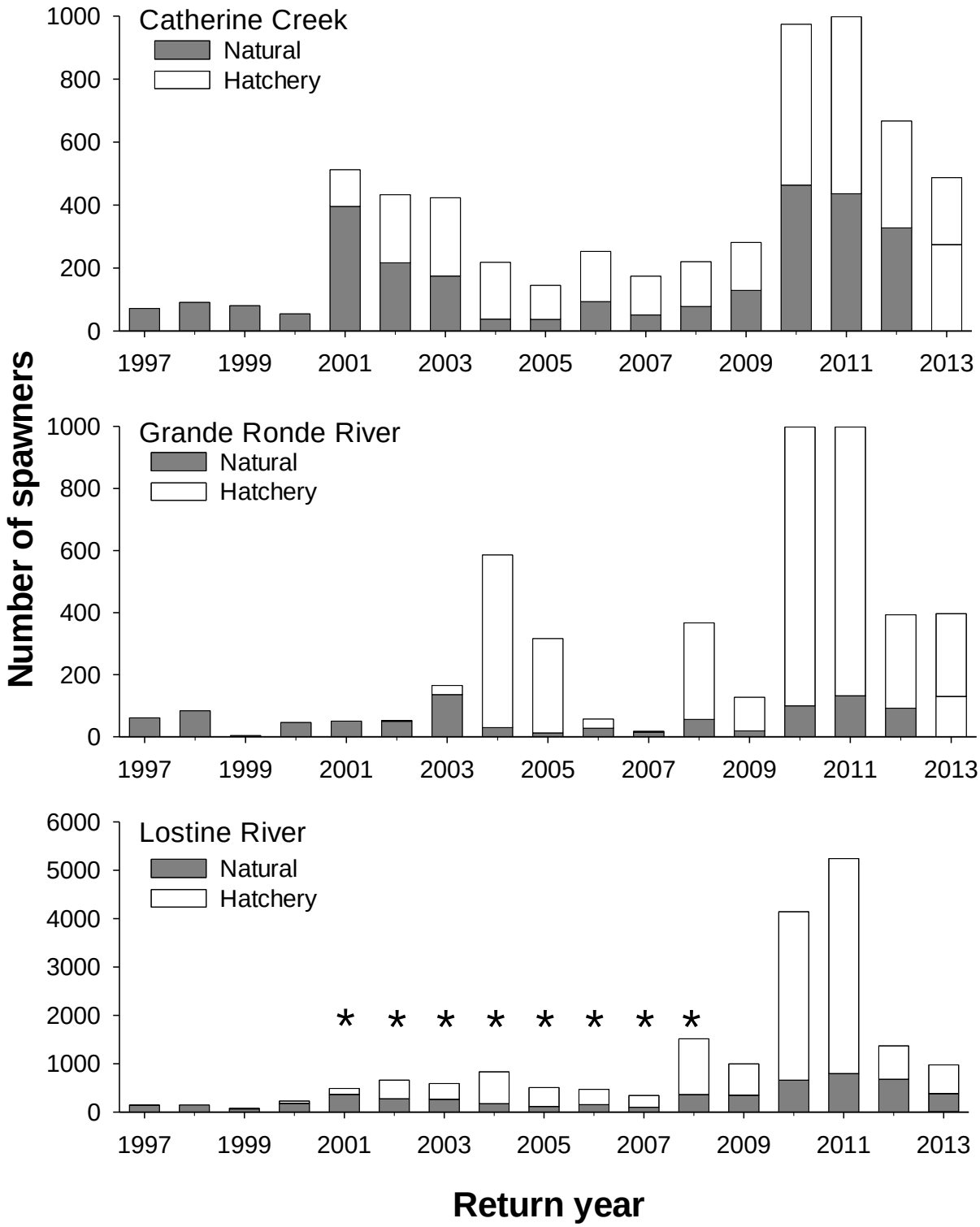

Figure 4. Estimated numbers of mature natural- and hatchery-origin Chinook Salmon that spawned naturally in Catherine Creek, the Upper Grande Ronde River, and Lostine River, 1997-2013. *Lostine River data from 2001–2008 may not be reliable because the Nez Perce Tribe reported that some members of the hatchery production staff falsified weir data.

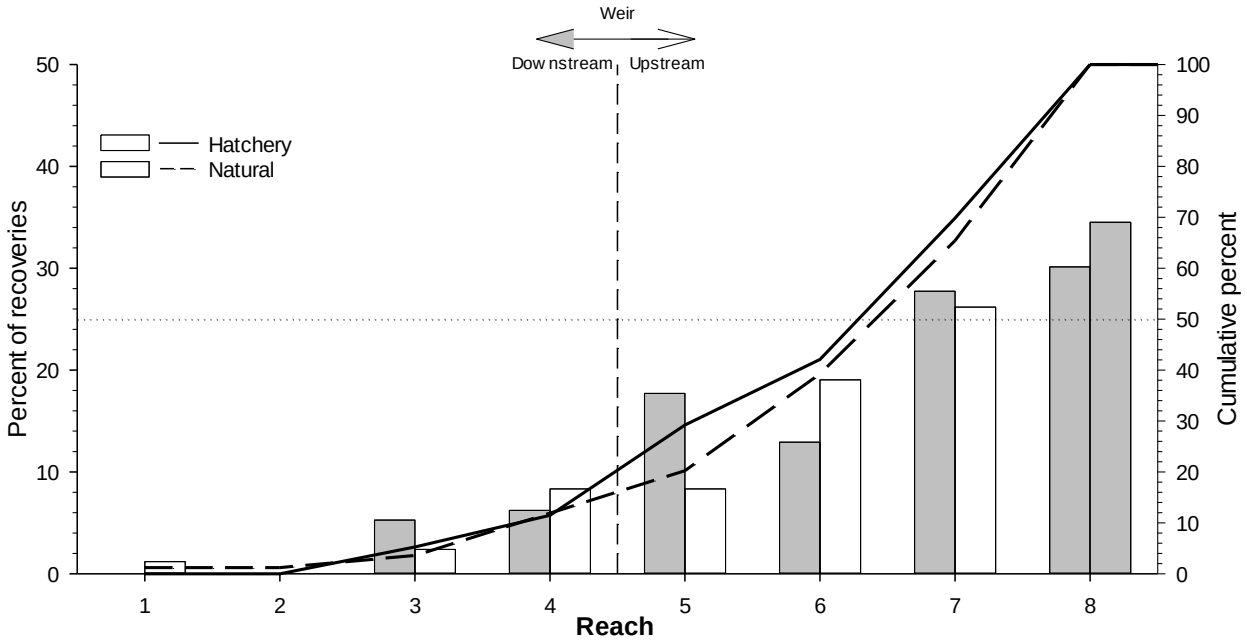

Figure 5. Percent of natural-and hatchery-origin Chinook Salmon carcasses recovered during spawning ground surveys on the Imnaha River, 2013. Reach 1- Gorge to Freezeout Creek, Reach 2-Grouse Creek to the Gorge, Reach 3-Crazyman Creek to Grouse Creek, Reach 4-Weir to Crazyman Creek, Reach 5-Macs Mine to the weir, Reach 6-Log to Macs Mine, Reach 7-Indian Crossing to Log, Reach 8-Blue Hole to Indian Crossing.

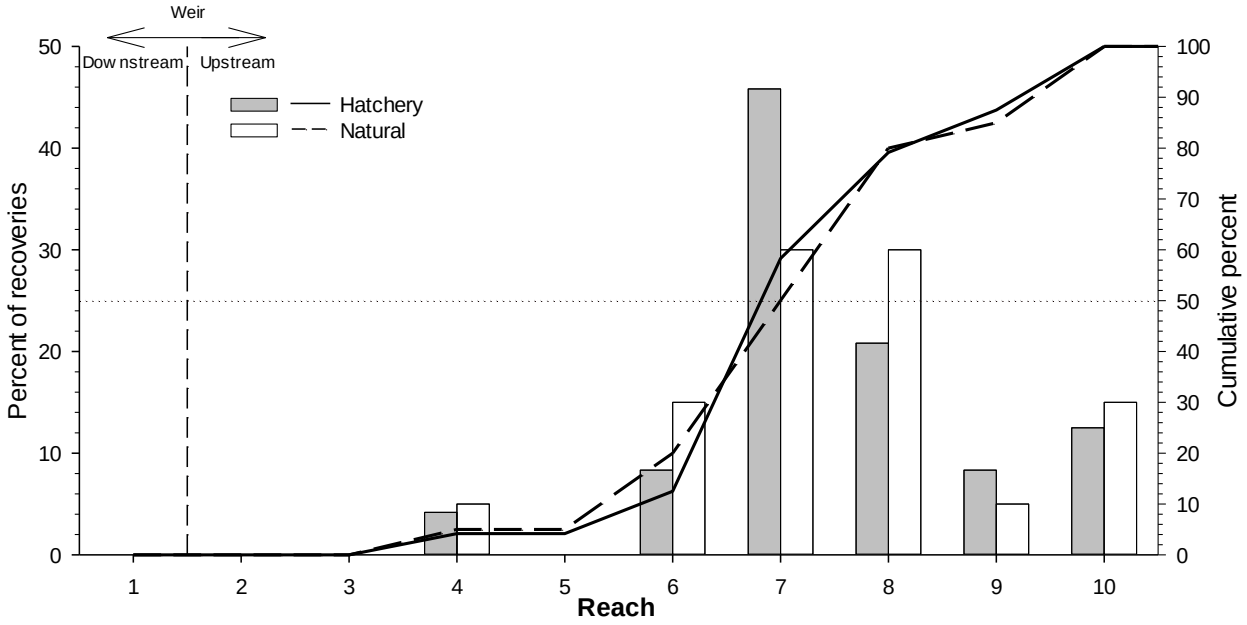

Figure 6. Percent of natural-and hatchery-origin Chinook Salmon carcasses recovered during the spawning ground surveys on Catherine Creek, 2013. Reach 1-Weir to 2nd Union Bridge, Reach 2-Bottom of Southern Cross Ranch to the Weir, Reach 3-Mile Post 5 to top of Southern Cross Ranch, Reach 4-Badger Flat 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.

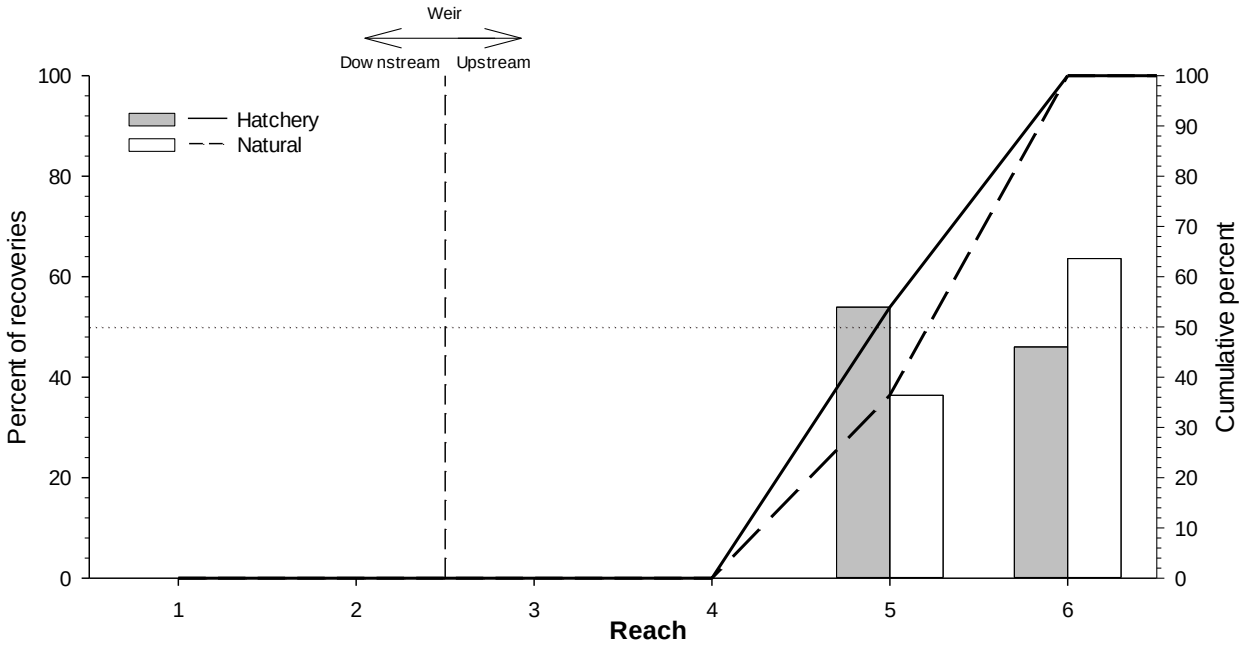

Figure 7. Percent of natural-and hatchery-origin Chinook Salmon carcasses recovered during spawning ground surveys on the Upper Grande Ronde River, 2013. Reach 1-Weir to Starkey Store, Reach 2-Spoolcart Campground to the Weir, Reach 3-Time and a Half Campground to Spoolcart Campground, Reach 4-Forest 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.

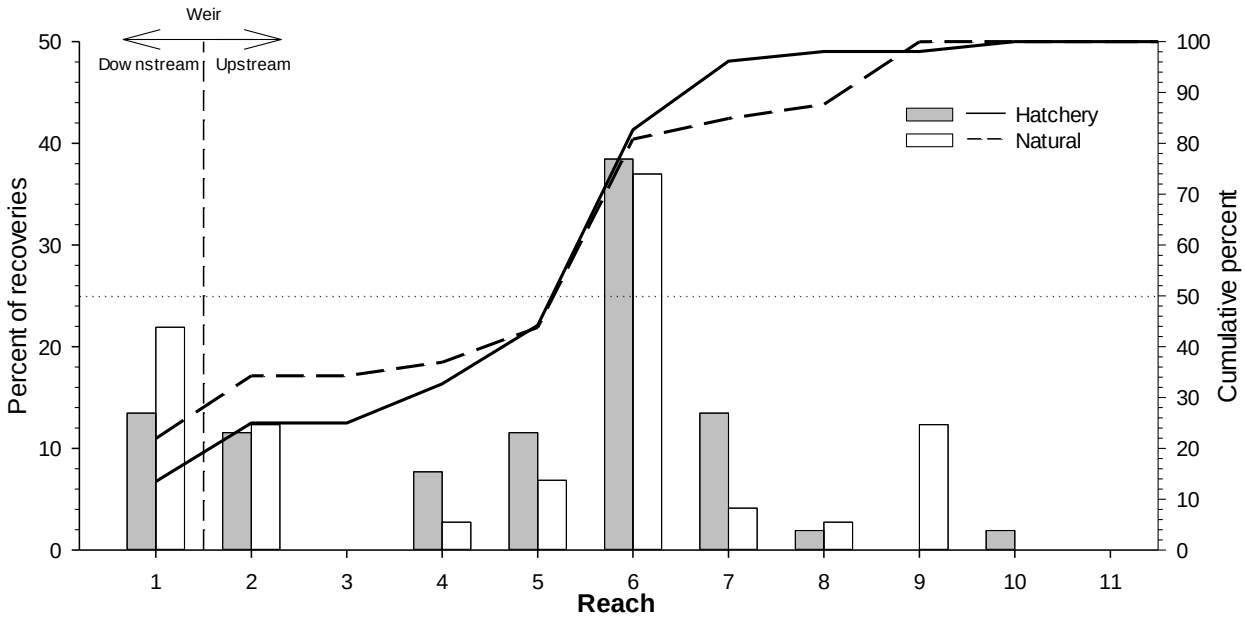

Figure 8. Percent of natural-and hatchery-origin Chinook Salmon carcasses recovered during spawning ground surveys on the Lostine River, 2013. Reach 1-Weir to the Mouth, Reach 2-McLain's Ranch to the Weir, Reach 3-Highway 82 Bridge in Lostine to McLain's Ranch, Reach 4-Westside Ditch to the trout farm, 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 the 2011 brood year of juvenile spring Chinook Salmon from the Captive Broodstock (CBS) and Conventional Hatchery Program (CHP) released into the Imnaha and Grande Ronde river basins, 2013.

Stock	Program	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	CHP	105	495,534	419,970	3,588	0	84.8	93.8	79.4	390,703
Catherine Creek	CHP	39	150,225	140,364	0	0	93.4	95.8	89.5	134,520
Upper Grande	CHP	39	166,042	143,568	0	0	86.5	94.4	81.6	135,557
Ronde River	CBS	153	413,536	383,954	0	200,250[c]	92.8	84.5	72.8	155,264
Lookingglass Creek	CHP	79	322,990	295,912	0	0	91.6	92.3	84.6	273,097
Lostine River	CHP	64	302,422	277,876	0	0	91.9	95.4	87.6	265,039

[a] *Eggs were culled if enzyme-linked immunosorbent assay (ELISA) levels of female broodstock were > 0.2 for CHP production. No eggs were culled from the Upper Grand Ronde River CBS.*

[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.*

[c] *A total of 32,560 eyed eggs were released into Meadow Creek, a tributary to the Upper Grande Ronde River near Starkey, OR, on 22 November 2011. A total of 167,690 eyed eggs were released into Sheep Creek, a tributary to the Upper Grande Ronde River near Vey Meadows in small batches as they eyed-up between 27 October and 17 November 2011.*

Table 2. Estimates of percent adipose fin (Ad) clip and coded-wire tag application success for the 2011 brood year of spring Chinook Salmon smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs reared at Lookingglass Fish Hatchery and released in 2013.

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								
090549	12	CHP	505	97.4	0.2	2.2	0.2	55,931
090550	13	CHP	500	97.4	1.2	1.4	0.0	56,014
090551	14	CHP	501	98.2	0.6	0.8	0.4	56,245
090552	15	CHP	506	94.9	4.1	0.8	0.2	55,780
Total/mean			2,012	97.0	1.5	1.3	0.2	223,970
Ad-only	16-18	CHP	1,518	n/a	99.2	n/a	0.8	166,733
Catherine Creek								
090432	1	CHP	507	94.9	2.7	2.2	0.2	44,919
090540	2	CHP	511	94.1	2.7	2.2	1.0	45,160
Total/mean			1,018	94.5	2.7	2.2	0.6	90,079
Ad-only	3	CHP	501	n/a	98.0	n/a	2.0	44,441
Upper Grande Ronde River								
090545	4	CHP	508	n/a	n/a	94.5	5.5	68,999
090546	5	CHP	504	n/a	n/a	94.4	5.6	66,558
Total/mean			1,012	n/a	n/a	94.5	5.5	135,557
090543	6	CBS	511	92.0	7.2	0.8	0.0	74,765
090544	7	CBS	516	93.0	4.9	1.9	0.2	80,499
Total/mean			1,027	92.5	6.0	1.4	0.1	155,264

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								
090542	AHPC	CHP	505	97.8	1.2	1.0	0.0	65,653
090541	AHPD	CHP	508	98.4	1.4	0.2	0.0	64,627
Total/mean			1,013	98.1	1.3	0.6	0.0	130,280
Ad-only	AHPA,B	CHP	1,012	n/a	99.1	n/a	0.9	142,817
Lostine River								
090547	8	CHP	504	96.8	1.2	1.6	0.4	68,048
090548	9	CHP	507	97.8	0.6	1.6	0.0	66,719
Total/mean			1,011	97.3	0.9	1.6	0.2	134,767
Ad-only	10-11	CHP	1,026	n/a	97.9	n/a	2.1	130,272

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 the 2010 brood year of spring Chinook Salmon smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery Programs (CHP) and released in 2013. Length and weight data were collected at Lookingglass Fish Hatchery, 11-14 February 2013.

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													
090549	12	CHP		30 MAR[a]	116.5	6.6	18.9	3.6	1.2	0.1	55,931	2,976	0.78
090550	13	CHP		30 MAR[a]	115.7	5.8	19.3	3.5	1.2	0.1	56,014	2,986	0.61
090551	14	CHP	30 MAR	5 APR	116.0	7.5	20.4	4.6	1.2	0.1	56,245	2,978	0.66
090552	15	CHP	30 MAR	5 APR	118.9	6.7	20.9	3.5	1.2	0.1	55,780	2,991	0.78
Ad-only	16	CHP	30 MAR	5 APR	118.4	6.9	21.1	4.6	1.2	0.1	55,875	2,985	0.69
Ad-only	17	CHP	30 MAR	5 APR	117.1	6.8	20.7	3.5	1.2	0.2	55,774	2,989	0.80
Ad-only	18	CHP		30 MAR[a]	116.8	5.4	20.2	3.3	1.2	0.1	55,084	2,991	0.71
Total/mean											390,703	20,896	0.72
Catherine Creek													
090432	1	CHP	21 MAR	15 APR	110.3	9.0	16.4	3.9	1.2	0.1	44,919	6,940	0.21
090540	2	CHP	21 MAR	15 APR	111.4	6.9	17.0	3.5	1.2	0.1	45,160	6,918	0.24
Ad-only	3	CHP	21 MAR	15 APR	115.4	5.7	19.1	3.0	1.2	0.1	44,441	6,958	0.22
Total/mean											134,520	20,816	0.22
Upper Grande Ronde River													
090545	4	CHP	6 APR	15 APR	112.1	5.9	16.4	2.9	1.2	0.1	68,999	501	0.45
090546	5	CHP	6 APR	15 APR	116.2	6.4	18.3	2.9	1.2	0.1	66,558	499	0.42
090543	6	CBS	20 MAR	1 APR	113.2	6.1	17.2	2.8	1.2	0.1	74,765	496	0.39
090544	7	CBS	20 MAR	1 APR	110.5	6.0	16.2	2.3	1.2	0.1	80,499	499	0.35
Total/mean											290,821	1,995	0.40

Table 3 continued.

Stock, CWT code	Raceway	Program	Release Date		Fork Length (mm) Mean	Fork Length (mm) SD	Weight (g) Mean	Weight (g) SD	Condition Factor (K) Mean	Condition Factor (K) SD	Total released	Number PIT-tagged	Survival rate to Lower Granite Dam
Lookingglass Creek[b]													
Ad-only	AHPA	CHP	14 MAR	12 APR	109.1	7.0	15.8	3.6	1.2	0.1	77,597	781	0.62
Ad-only	AHPB	CHP	14 MAR	12 APR	110.1	6.4	16.6	2.2	1.2	0.1	65,220	672	0.57
090542	AHPC	CHP	14 MAR	12 APR	110.5	6.3	15.6	2.8	1.2	0.2	65,653	758	0.52
090541	AHPD	CHP	14 MAR	12 APR	111.5	6.9	15.6	3.1	1.1	0.1	64,627	679	0.55
Total/mean											273,097	2,890	0.57
Lostine River													
090547	8	CHP	21 MAR	1 APR	109.9	6.2	17.6	2.5	1.2	0.1	68,048	1,498	0.59
090548	9	CHP	12 APR	22 APR	114.4	6.2	18.0	2.9	1.2	0.1	66,719	1,570	0.66
Ad-only	10	CHP	21 MAR	1 APR	112.7	5.7	18.5	3.6	1.3	0.2	66,370	1,417	0.60
Ad-only	11	CHP	12 APR	22 APR	113.3	5.4	16.8	2.9	1.3	0.2	61,946	1,492	0.60
Total/mean											265,039	5,977	0.61

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

[b] *Reared and coded-wire tagged at Irrigon Fish Hatchery; transferred to rearing ponds at Lookingglass Fish Hatchery on 25 September 2012.*

Table 4. Estimated numbers of brood year 2012 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 also implanted with a passive integrated transponder (PIT) tag, and the estimated number of parr on hand at Lookingglass Fish Hatchery (LFH) on 31 December 2013. Note: tag retention checks will be conducted in February 2014, after which we will calculate estimates of the numbers of parr that were successfully marked/tagged.

	Estimated number of parr marked from July–August 2013				Number PIT-tagged, October 2013	Estimated number of parr at LFH, 31 December 2013
Stock	AD clip with CWT	CWT, no AD clip	AD clip, no CWT	Total marked parr		
Imnaha River	233,696	0	114,939	348,635	20,816	347,413
Catherine Creek	93,870	0	46,336	140,206	20,772	139,106
Upper Grande Ronde River	123,680	118,778	0	242,458	1,988	241,645
Lookingglass Creek[a]	150,614	0	103,017	253,631	2,961	242,210
Lostine River	134,479	0	100,329	234,808	3,972	233,823
Total	736,339	118,778	364,624	1,219,738	50,509	1,204,197

[a] Lookingglass Creek parr were marked/tagged from 17–19 July at Irrigon Fish Hatchery and transferred to Lookingglass Fish Hatchery on 24 August 2013.

Table 5. Number of mature spring Chinook Salmon handled each week at northeast Oregon LSRCP trapping facilities in 2013. The total for each stream excludes recaptured salmon. The total for Lookingglass Creek includes stray hatchery salmon from the Catherine Creek and Upper Grande Ronde River stocks, and excludes outplants from Catherine Creek. These numbers were not adjusted to account for unmarked hatchery returns.

Period	Week of year	Imnaha River[a]		Catherine Creek[b]		Upper Grande Ronde River[b]		Lookingglass Creek[a]		Lostine River[c]	
		Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural
Dates of trap operation:		5 JUL – 13 SEP		21 FEB – 31 JUL		6 MAR – 18 JUN		1 MAR – 11 SEP		15 FEB – 27 SEP	
14 – 27 MAY	20	-	-	-	-	-	-	0	2	-	-
21 – 27 MAY	21	-	-	1	1	-	-	3	2	-	-
28 MAY – 3 JUN	22	-	-	56	86	48	29	58	19	-	-
4 – 10 JUN	23	-	-	219	142	60	14	149	26	-	-
11 – 17 JUN	24	-	-	115	55	14	9	159	21	0	1
18 – 24 JUN	25	0	0	44	24	0	0	84	11	2	0
25 JUN – 1 JUL	26	3	0	17	17	-	-	85	11	23	7
2 – 8 JUL	27	4	1	6	14	-	-	73	12	22	7
9 – 15 JUL	28	108	15	0	2	-	-	26	4	69	20
16 – 22 JUL	29	257	39	0	1	-	-	11	5	214	67
23 – 29 JUL	30	102	19	0	1	-	-	9	0	20	8
30 JUL – 5 AUG	31	77	12	0	0	-	-	3	0	1	0
6 – 12 AUG	32	40	6	0	0	-	-	8	0	8	2
13 – 19 AUG	33	72	16	0	0	-	-	12	2	3	2
20 – 26 AUG	34	64	10	-	-	-	-	33	1	14	18
27 AUG – 2 SEP	35	81	22	-	-	-	-	35	5	109	55
3 – 9 SEP	36	78	36	-	-	-	-	23	2	61	50
10 – 16 SEP	37	4	4	-	-	-	-	4	0	9	10
17 – 23 SEP	38	-	-	-	-	-	-	-	-	1	1
24 – 30 SEP	39	-	-	-	-	-	-	-	-	-	-
Total		890	180	458	343	122	52	775	123	556	248

[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 (NPT).*

Table 6. Number and disposition, by origin, age, and sex of mature spring Chinook Salmon returning to northeast Oregon LSRCP trapping facilities in 2013. The 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 collected may not match the numbers spawned 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	693	0	97	76	19	25	890	135	1	19	11	6	8	180	1,070
Passed above the weir	9	0	34	12	7	6	68	129	0	4	2	0	0	135	203
Released below the weir	231	0	1	0	0	6	232	0	0	0	0	0	0	0	232
Outplanted	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Foodbank/tribal distribution	387	0	10	2	1	1	401	1	0	0	0	0	0	1	402
Trap Morts	7	0	0	0	0	0	7	0	0	0	0	0	0	0	7
Kept for broodstock	45	0	61	55	3	19	183	1	0	16	15	4	6	42	225
Spawned	26	0	53	53	3	17	152	1	0	15	14	4	5	39	191
Killed, not spawned	18	0	5	0	0	0	23	0	0	1	0	0	0	1	24
Pre-spawn mortality	1	0	3	2	0	2	8	0	0	0	1	0	1	2	10
Weir age & sex composition (%)	76.2	0.0	11.9	7.8	1.2	2.9	100	73.6	0.0	11.2	9.5	2.3	3.4	100	
Catherine Creek[a]															
Trapped	196	1	117	127	8	13	462	96	0	97	104	20	22	339	801
Passed above the weir	2	1	103	105	5	4	220	93	0	78	82	15	17	285	505
Outplanted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foodbank/tribal distribution	192	0	4	0	0	0	194	0	0	0	0	0	0	0	194
Trap Morts	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Kept for broodstock[b]	2	0	10	22	3	9	46	2	0	19	22	5	5	53	99
Spawned[c]	2	0	10	15	3	8	38	1	0	17	22	4	4	48	86
Killed, not spawned	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-spawn mortality	0	0	0	7	0	1	8	1	0	2	0	1	1	5	13
Weir age & sex composition (%)	42.2	0.2	25.4	27.7	1.7	2.8	100	28.3	0.0	28.6	30.7	5.9	6.5	100	

Table 6 continued.

	Hatchery							Natural							
	Age 3		Age 4		Age 5			Age 3		Age 4		Age 5			Grand
Stock, Disposition	M	F	M	F	M	F	Total	M	F	M	F	M	F	Total	total
Upper Grande Ronde River (UGR)[a]															
Trapped	41	4	21	51	3	5	122	5	1	19	19	2	6	52	174
Passed above the weir	0	1	4	11	3	3	22	5	1	10	8	0	4	28	50
Foodbank/tribal distribution	32	0	0	0	0	0	32	0	0	0	0	0	0	0	32
Kept for broodstock[b]	9	0	20	34	0	5	68	1	0	10	12	0	5	28	96
Spawned[c]	4	0	17	30	0	5	56	0	0	8	10	0	3	21	77
Killed, not spawned	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Pre-spawn mortality	4	0	3	4	0	0	11	1	0	2	2	0	2	7	18
Weir age & sex composition (%)	33.6	0.8	17.2	41.8	2.5	4.1	100	9.6	1.9	36.5	36.5	3.9	11.6	100	
Lookingglass Creek															
All trapped Chinook[d]	527	1	97	125	7	18	775	63	0	19	30	4	7	123	898
Stray from UGR[e]	25	0	11	20	0	0	56	0	0	0	0	0	0	0	56
Stray from Catherine Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passed above weir	6	1	48	59	5	10	129	63	0	9	18	1	3	94	223
Released below weir	88	0	0	0	0	0	88	0	0	0	0	0	0	0	88
Removed/foodbank	403	0	1	0	0	0	404	0	0	0	0	0	0	0	404
Kept for broodstock[b, f]	30	0	48	66	2	8	154	0	0	10	12	3	4	29	183
Kept for LFH broodstock	19	0	37	46	2	8	112	0	0	10	12	3	4	29	141
Spawned[d]	8	0	30	45	2	7	92	0	0	10	12	3	3	45	154
Killed, not spawned	11	0	6	0	0	0	17	0	0	0	0	0	0	0	17
Pre-spawn mortality	0	0	1	1	0	1	3	0	0	0	0	0	1	0	4
Weir age & sex composition (%)	68.0	0.1	12.5	16.2	0.9	2.3	100	51.2	0.0	15.4	24.4	3.3	5.7	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	468	0	42	30	2	15	557	105	2	59	46	17	18	247	804
Passed above the weir	14	0	2	2	0	1	19	103	2	42	19	16	8	190	209
Released below the weir	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
Tribal distribution/foodbank	412	0	5	0	0	0	417	0	0	0	0	0	1	0	418
Outplanted	31	0	0	0	0	0	0	0	0	0	0	0	0	0	31
Kept for broodstock	11	0	34	28	2	14	89	2	0	17	27	1	9	56	145
Spawned[c]	6	0	31	27	2	12	78	1	0	14	21	1	9	46	124
Killed, not spawned	5	0	0	0	0	0	5	1	0	0	2	0	0	3	8
Pre-spawn mortality	0	0	3	1	0	2	6	0	0	3	4	0	0	7	13
Weir age & sex composition (%)	84.0	0.0	7.5	5.4	0.4	2.7	100	42.5	0.8	23.9	18.6	6.9	7.3	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 56 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 56 assumed strays from the Upper Grande Ronde CHP program, 11 jacks, 11 age 4 females, and 20 age 4 males were kept for the Upper Grande Ronde River broodstock program; two jacks were recycled downstream and 12 jacks were killed.*
[f] *Broodstock collection includes 42 stray Chinook that were kept for the Upper Grande Ronde CHP program.*
[g] *Operated by Nez Perce Tribe (NPT). Data provided by Peter Cleary (NPT).*

Table 7. Spawning summaries of spring Chinook Salmon from the Conventional Hatchery Programs at Lookingglass Fish Hatchery for the Imnaha and Grande Ronde basins, 2013.

	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	68	82[c]	126	19	20	43[c]	390,184	4,484	359,106	8.0
Catherine Creek	23	15	31	26	22	48	186,125	3,798	155,649	16.4
Upper Grande Ronde River	53	38	58	13	8	24	251,184	3,806	230,290	8.3
Lookingglass Creek	52	40	74	15	13	29	249,742	3,727	201,754	19.2
Lostine River	39	39	72	30	16	33	294,759	3,806	263,330	10.7

[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.*

[c] *Six jacks were spawned as one male.*

Table 8. Number of female spring/summer Chinook Salmon and mean egg weight (g) by stock, origin (hatchery or natural), and age, 2013. P-value for t-test comparing hatchery vs. natural salmon mean egg weights for each stock.

		Hatchery			Natural			
Stock		Age 4	Age 5	Total/ mean	Age 4	Age 5	Total/ mean	P-value
Imnaha River	Females	51	17	68	14	5	19	
	Mean egg wt.	0.220	0.269	0.233	0.241	0.281	0.251	0.082
Catherine Creek	Females	15	8	23	22	4	26	
	Mean egg wt.	0.212	0.239	0.221	0.217	0.242	0.221	0.983
Upper Grande Ronde River*	Females	47	5	52	10	3	13	
	Mean egg wt.	0.212	0.265	0.217	0.216	0.254	0.225	0.443
Lookingglass Creek*	Females	44	7	51	11	3	14	
	Mean egg wt.	0.226	0.268	0.232	0.228	0.231	0.229	0.756
Lostine River	Females	27	12	39	21	9	30	
	Mean egg wt.	0.225	0.264	0.238	0.241	0.266	0.248	0.310

** 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 for the 2013 return year of smolts released into the Imnaha River from brood years 2008-2010. Estimated coded-wire tag (CWT) recoveries were summarized through 10 December 2015 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2009)			Age 5 (BY 2008)			
Total Smolts Released	469,807			252,588			390,062			
% Ad + CWT	52.3%			69.9%			49.2%			
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	1	2	3	3
Columbia River										
Tribal	1	2	5	4	19	27	1	5	10	42
Non-tribal net	1	2	3	14	24	34	1	2	3	40
Sport	14	81	151	12	57	81	2	9	18	250
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	2	15	28	4	40	58	0	0	0	86
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	5	5	9	11	15	21	1	1	2	32
Stray above LGD[a,b]	4	4	5	0	0	0	0	0	0	5
Recruitment to river[a]										
Sport Fisheries[c]	3	--	31	2	--	25	2	--	5	61
Tribal Fisheries[c]	0	--	143	0	--	73	0	--	16	232
Above weir estimate[d]	11	--	152	62	--	394	18	--	155	701
Below weir estimate[d]	3	--	189	8	--	130	2	--	32	351
Removed at weir[d]	256	--	437	67	--	126	10	--	31	594
Compensation area return	279	--	985	143	--	806	32	--	239	2,030
Total/Total estimated return	300	--	1,153	184	--	969	38	--	275	2,397

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

[b] *Estimated number of total 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, total returns (age 3-5), and smolt-to-adult return rates (SAR) to Lower Granite Dam and total returns to the Imnaha River for hatchery-reared spring Chinook Salmon released into the Imnaha River, complete brood years 1982-2008. SAR data were updated on 27 June 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	0.310
1985	123,533	207	0.168	206	0.167
1986	199,506	499	0.250	499	0.250
1987	142,320	384	0.270	384	0.270
1988	253,869	2,066	0.814	2,066	0.814
1989	267,670	661	0.247	661	0.247
1990	262,500	99	0.038	99	0.038
1991	157,659	99	0.063	99	0.063
1992	438,617	207	0.047	207	0.047
1993	590,118	1,046	0.177	1,046	0.177
1994	91,240	99	0.109	99	0.109
1995	50,903	528	1.037	528	1.037
1996	93,112	895	0.961	895	0.962
1997	194,958	3,163	1.622	3,161	1.622
1998	179,972	4,405	2.448	4,397	2.443
1999	123,009	1,193	0.970	1,187	0.965
2000	303,717	2,285	0.752	2,256	0.743
2001	268,420	1,777	0.662	1,772	0.660
2002	398,178	1,433	0.360	1,327	0.333
2003	435,187	1,268	0.291	1,268	0.291
2004	441,680	3,394	0.768	3,394	0.768
2005	432,530	3,281	0.759	3,281	0.759
2006	348,909	8,635	2.475	8,587	2.461
2007	293,801	3,567	1.214	3,567	1.214
2008	390,062	4,526	1.160	4,503	1.155
Mean	244,668	1,708	0.697	1,700	0.694

Table 11. Catch and escapement summary for the 2013 return year of Captive Broodstock and Conventional Hatchery program smolts released into Catherine Creek from brood years 2008-2010. Estimated coded-wire tag (CWT) recoveries were summarized through 10 December 2015 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2009)			Age 5 (BY 2008)			
Total Smolts Released	161,373			155,475			144,353			
% Ad + CWT	61.6%			96.3%			93.8%			
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	0	0	0	1	1	1	1
Non-tribal net	2	3	5	2	3	3	0	0	0	8
Sport	0	0	0	5	13	13	1	2	2	15
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	3	8	12	3	10	10	0	0	0	22
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	0	0	0	2	2	2	0	0	0	2
Stray above LGD[a,b]										
Outside GR Basin	0	0	0	0	0	0	0	0	0	0
GR Basin[c]	12	--	32	8	--	19	0	--	0	51
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]	0	--	3	17	--	213	2	--	9	225
Below weir estimate[c]	0	--	0	0	--	0	0	--	0	0
Removed at weir[c]	88	--	194	30	--	36	11	--	12	242
Compensation area return	103	--	241	58	--	278	13	--	21	540
Total/Total estimated return	105	--	246	67	--	296	15	--	24	566

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

[b] *Estimated number of total 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 for the 2013 return year of Captive Broodstock and Conventional Hatchery program smolts released into the Upper Grande Ronde River from brood years 2008-2010. Estimated coded-wire tag (CWT) recoveries were summarized through 10 December 2015 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2009)			Age 5 (BY 2008)			
Total Smolts Released	285,738			242,385			232,349			
% Ad + CWT	46.2%			21.2%			76.6%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	1	1	1	0	0	0	1
Non-tribal net	2	3	3	0	0	0	0	0	0	3
Sport	0	0	0	2	4	4	0	0	0	4
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	1	2	2	2	6	6	0	0	0	8
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	1	1	1	0	0	0	0	0	0	1
Stray above LGD[a,b]										
Outside GR Basin	0	0	0	0	0	0	0	0	0	0
GR Basin[c]	24	--	32	42	--	58	0	--	0	90
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]	20	--	184	36	--	487	3	--	59	730
Below weir estimate[c]	0	--	0	0	--	0	0	--	0	0
Removed at weir[c]	61	--	41	49	--	54	5	--	5	100
Compensation area return	106	--	259	129	--	605	8	--	64	928
Total/Total estimated return	109	--	263	132	--	610	8	--	64	937

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

[b] *Estimated number of total 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 the 2013 return year of smolts released into Lookingglass Creek from brood years (BY) 2008-2010. Estimated coded-wire tag (CWT) recoveries were summarized through 10 December 2015 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2009)			Age 5 (BY 2008)			
Total Smolts Released	228,565			101,343			262,910			
% Ad + CWT	51.2%			98.7%			53.6%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	1	5	5	0	0	0	5
Non-tribal net	4	7	13	6	11	11	0	0	0	24
Sport	1	5	9	6	20	21	1	2	4	34
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	3	8	17	0	0	0	0	0	0	17
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	0	0	0	6	7	7	0	0	0	7
Stray above LGD[a,b]										
Outside GR Basin	0	0	0	0	0	0	0	0	0	0
GR Basin[c]	6	--	17	9	--	37	0	--	0	54
Recruitment to river[a]										
Sport Fisheries	13	--	132	0	--	0	0	--	0	132
Tribal Fisheries	0	--	132	0	--	51	0	--	6	189
Above weir estimate[c]	0	--	7	24	--	121	4	--	14	142
Below weir estimate[c]	2	--	221	16	--	93	1	--	10	324
Removed at weir[c]	165	--	422	63	--	84	6	--	10	516
Compensation area return	189	--	948	112	--	386	11	--	40	1,374
Total/Total estimated return	194	--	970	131	--	430	12	--	44	1,444

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

[b] *Estimated number of total 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) Grande Ronde River (GR) basin hatchery salmon.*

Table 14. Catch and summary distribution for the 2013 return year of Captive Broodstock and Conventional Hatchery program smolts released into the Lostine River from brood years (BY) 2008-2010. Estimated coded-wire tag (CWT) recoveries were summarized through 10 December 2015 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2010)			Age 4 (BY 2009)			Age 5 (BY 2008)			
Total Smolts Released	267,352			62,836			243,663			
% Ad + CWT	52.4%			0.0%			72.5%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	1	2	2	0	0	0	0	0	0	2
Columbia River										
Tribal	0	0	0	1	2	2	1	5	5	7
Non-tribal net	0	0	0	1	2	2	1	2	2	4
Sport	17	101	102	0	0	0	1	5	5	107
Stray	0	0	0	0	0	0	0	0	0	0
Snake River										
Sport[a]	2	20	20	0	0	0	0	0	0	20
Tribal[a]	0	0	0	0	0	0	0	0	0	0
Stray below LGD[b]	2	2	2	1	1	1	1	1	1	4
Stray above LGD[a,b]										
Outside GR Basin	1	1	1	0	0	0	0	0	0	1
										42
GR Basin[c]	6	--	6	4	--	35	1	--	1	
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]	11	--	344	7	--	61	4	--	24	429
Below weir estimate[c]	1	--	208	3	--	34	0	--	8	250
Removed at weir[c]	97	--	454	53	--	67	14	--	16	537
Compensation area return	118	--	1,033	67	--	197	19	--	49	1,279
Total/Total estimated return	138	--	1,139	70	--	202	23	--	62	1,403

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

[b] *Estimated number of total 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 basin hatchery salmon.*

Table 15. Total smolts released, 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 released into Catherine Creek, complete brood years 1998-2008. SAR data were updated on 27 June 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	267	0.195	242	0.177
2000	CBS	180,340	693	0.384	673	0.373
2001	CBS	105,292	132	0.125	112	0.106
2001	CHP	24,392	79	0.324	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	1,503	1.286	1,433	1.226
2007	CHP	138,843	1,034	0.745	940	0.677
2008	CBS	34,111	275	0.806	245	0.718
2008	CHP	110,242	1,074	0.974	992	0.900
Mean	CBS/CHP	80,967	378	0.460	354	0.432

Table 16. Total smolts released, 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 released into the Upper Grande Ronde River, complete brood years 1998-2008. SAR data were updated on 27 June 2016.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
1998	CBS	1,508	5	0.332	5	0.332
1999	CBS	2,559	11	0.430	11	0.430
2000	CBS	151,443	655	0.433	626	0.413
2001	CBS	210,113	325	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	44	0.042	41	0.039
2004	CBS	76	0	0.000	0	0.000
2004	CHP	18,901	92	0.487	82	0.434
2005	CBS	20,620	121	0.587	115	0.558
2005	CHP	118,803	780	0.657	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	543	1.298	511	1.222
Mean	CBS/CHP	80,004	434	0.463	410	0.439

Table 17. Total smolts released, 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 2000-2008. SAR data were updated on 27 June 2016.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
2000	CBS	51,864[a]	79	0.152	66	0.127
2001	CBS	17,880[a]	53	0.296	53	0.296
2002	CBS	53,333	107	0.201	106	0.199
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	CHP	43,219	776	1.796	717	1.660
2007	CBS/CHP[b]	150,478	1,763	1.172	1,438	0.956
2008	CHP	262,910	2,955	1.124	2,937	1.117
Mean	CBS/CHP	89,095	801	0.665	741	0.610

[a] *Parr releases, not smolts.*

[b] *Released 104,450 Catherine Creek CBS smolts and 50,027 Lookingglass Creek CHP smolts. All smolts were marked with an adipose fin clip and a CWT.*

Table 18. Total smolts released, 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 released into the Lostine River, complete brood years 1998-2008. SAR data were updated on 27 June 2016.

Brood Year	Program	Total smolts released	To Lower Granite Dam		To river mouth	
			Total	SAR	Total	SAR
1997	CHP	11,870	238	2.005	234	1.968
1998	CBS	34,986	576	1.646	562	1.606
1999	CBS	133,880	319	0.238	298	0.223
2000	CBS	77,312	658	0.851	626	0.809
2000	CHP	31,464	417	1.325	410	1.302
2001	CBS	141,867	439	0.309	433	0.305
2001	CHP	100,882	668	0.662	648	0.642
2002	CBS	133,729	192	0.144	184	0.137
2002	CHP	116,370	324	0.278	311	0.267
2003	CBS	62,149	114	0.183	113	0.182
2003	CHP	102,556	271	0.264	255	0.249
2004	CBS	40,982	118	0.288	109	0.267
2004	CHP	197,950	1,336	0.675	1,222	0.617
2005	CBS	24,604	213	0.866	201	0.816
2005	CHP	205,407	1,867	0.909	1,844	0.898
2006	CBS	10,470	213	2.025	212	2.024
2006	CHP	194,594	5,529	2.841	5,311	2.729
2007	CBS	61,927	1,323	2.136	1,317	2.126
2007	CHP	185,765	2,829	1.523	2,764	1.488
2008	CBS	60,997	903	1.480	882	1.445
2008	CHP	182,666	2,044	1.119	1,229	0.673
Mean	CBS/CHP	100,592	980	1.037	913	0.989

Table 19. Summary of hatchery and natural spring Chinook Salmon carcasses recovered and number of redds observed by stream during spawning ground surveys in the Imnaha River and Grande Ronde River basins, 2013.

Basin, stream	Carcasses				Number of redds
	Hatchery	Natural	Unknown origin	Percent hatchery[a]	
Imnaha River Basin					
Big Sheep Creek	0	0	1	0.0	5
Imnaha River	209	84	8	71.3	479
Lick Creek	0	0	0	0.0	0
Total	209	84	9	71.3	484
Grande Ronde River Basin					
Bear Creek	0	7	1	0.0	16
Catherine Creek	24	20	3	54.5	110
Upper Grande Ronde River	63	22	9	74.1	41
Hurricane Creek	0	0	0	0.0	10
Limber Jim Creek	0	0	0	0.0	0
Lookingglass Creek[b,c]	121	20	4	85.8	108
Lostine River	52	73	7	41.6	122
Meadow Creek	0	0	0	0	0
Minam River[d]	6	49	2	10.9	141
Sheep Creek[e]	6	0	0	100	9
Wallowa River	7	10	1	41.2	7
Wenaha River	20	32	2	38.5	145
Total	299	233	29	56.2	709

[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 Safety Net Program (UGR SNP) Chinook Salmon which were released to spawn in nature on 4 June and 14 August 2013; all redds were constructed by UGR SNP 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, 2013.

Recovery location	Brood year	CWT code	Number recovered	Release site
Imnaha River Basin				
Imnaha River	2008	094667	7	Imnaha River
		094668	7	Imnaha River
		094669	6	Imnaha River
	2009	090290	17	Imnaha River
		090291	23	Imnaha River
		090292	30	Imnaha River
	2010	090416	5	Imnaha River
		090417	1	Imnaha River
		090418	3	Imnaha River
		090419	5	Imnaha River
Grande Ronde River Basin				
Catherine Creek	2008	094592	2	Catherine Creek
	2009	090288	8	Catherine Creek
		090361	1	Lookingglass Creek
		090378	7	Catherine Creek
		090379	1	Upper Grande Ronde River
Upper Grande Ronde	2008	094596	2	Upper Grande Ronde River
		094597	1	Upper Grande Ronde River
	2009	090285	5	Upper Grande Ronde River
		090286	13	Upper Grande Ronde River
		090287	13	Upper Grande Ronde River
		090379	5	Upper Grande Ronde River
	2010	090396	5	Upper Grande Ronde River
		090397	1	Upper Grande Ronde River
		090398	10	Upper Grande Ronde River
		090399	4	Upper Grande Ronde River
Lookingglass Creek[a]	2008	094593	2	Lookingglass Creek
		094593	3	Lookingglass Creek
	2009	090285	6	Upper Grande Ronde River
		090286	2	Upper Grande Ronde River
		090287	1	Upper Grande Ronde River
		090361	39	Lookingglass Creek
		090378	1	Catherine Creek
		090379	1	Upper Grande Ronde River
	2010	090282	1	Lostine River
		090394	1	Lookingglass Creek
		090395	1	Lookingglass Creek

Table 20 continued.

Recovery location	Brood year	CWT code	Number recovered	Release site
Lostine River	2008	094599	1	Lostine River
		094664	1	Lostine River
	2009	090284	9	Lostine River
		090288	1	Catherine Creek
		094121	1	Lostine River
	2010	090282	4	Lostine River
		090283	8	Lostine River
Minam River[b]	2010	090381	1	Catherine Creek
		090394	1	Lookingglass Creek
Wallowa River[a]	2009	090284	1	Lostine River
		094121	1	Lostine River
Wenaha River	2007	090284	1	Lookingglass Creek
		090286	1	Upper Grande Ronde River
		090361	7	Lookingglass Creek
	2010	090394	1	Lookingglass Creek

[a] *Data provided by CTUIR. Includes Little Lookingglass Creek.*
[b] *Includes the Little Minam River.*

Table 21. 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 ELISA OD levels in each category and the mean ELISA OD level, 2013.

Population, origin	Sample Location	ELISA category (OD units) Low (< 0.2) N	%	Moderate (0.2-0.799) N	%	High (≥ 0.8) N	%	Total N	Mean ELISA OD level
Imnaha River									
Hatchery	LFH	68	100	0	0.0	0	0.0	68	0.087
	SGS	29	93.5	2	6.5	0	0.0	31	0.143
Natural	LFH	19	100	0	0.0	0	0.0	19	0.097
	SGS	14	93.3	1	6.7	0	0.0	15	0.149
Catherine Creek									
Hatchery	LFH	23	100	0	0.0	0	0.0	23	0.084
	SGS	5	62.5	3	37.5	0	0.0	8	0.180
Natural	LFH	26	100	0	0.0	0	0.0	26	0.090
	SGS	4	57.1	2	28.6	1	14.3	7	0.285
Upper Grande Ronde River									
Hatchery	LFH	52	98.1	0	0.0	1	1.9	53	0.128
	SGS	6	50.0	6	50.0	0	0.0	12	0.255
Natural	LFH	13	100	0	0.0	0	0.0	13	0.083
	SGS	6	85.7	1	14.3	0	0.0	7	0.141
Lookingglass Creek									
Hatchery	LFH	51	98.1	1	1.9	0	0.0	52	0.090
	SGS	16	80.0	3	15.0	1	5.0	20	0.313
Natural	LFH	15	100	0	0.0	0	0.0	15	0.084
	SGS	3	60.0	2	40.0	0	0.0	5	0.174
Lostine River									
Hatchery	LFH	38	97.4	1	2.6	0	0.0	39	0.099
	SGS	3	75.0	1	25.0	0	0.0	4	0.141
Natural	LFH	30	100	0	0.0	0	0.0	30	0.109
	SGS	14	82.4	3	17.6	0	0.0	17	0.158
Minam River									
Hatchery	SGS	1	50.0	1	50.0	0	0.0	2	0.195
Natural	SGS	11	64.7	6	35.3	0	0.0	17	0.186
Wenaha River									
Hatchery	SGS	2	33.3	3	60.0	0	0.0	5	0.215
Natural	SGS	9	80.0	5	35.7	0	0.0	14	0.186
Total		458	91.2	41	8.2	3	0.6	502	0.153

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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 the contribution to the population of each brood year. 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 the salmon sent to tribal subsistence distribution, but many of these are hatchery-origin jacks. All natural salmon captured at a weir are either kept for hatchery broodstock or released to spawn in nature. We recover only ~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 because most that are captured are sent to foodbanks.

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. 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, 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

When the spawning season is over, we are left with a sample of the entire population, comprised of two groups of Chinook Salmon: one group with lengths only (un-aged) and the other group 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.

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 approximately 25% (half of that for jacks) of those salmon (as carcasses) 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, we randomly remove one un-aged length datum from the weir data set and replace it with an aged length datum, from the appropriate length bin, from the spawning grounds. E.g., 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. Carcasses without a FL or that have an unknown opercle punch (OP) mark are excluded from all analyses.

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 salmon with an OP-mark by the sum of OP-marked and non-OP-marked adult salmon. 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: the 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. These results are used 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.

Assigning Individual Ages

Length distributions 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 maxima and minima 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, which diminishes precision.

Weighted Age-Length Key (WALK) example

To construct our 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, for each age class, 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).

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 Northeastern Oregon: Imnaha River, Catherine Creek, Lookingglass Creek, the Lostine River, and the Upper Grande Ronde River. 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.

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, adult Chinook Salmon have a fork length >630 mm and jacks are ≤630 mm. In Catherine Creek, the Upper Grande Ronde River, and Lookingglass Creek, adult Chinook Salmon have a fork length >600 mm and jack Chinook are ≤600 mm. Because of differences in recovery rats of jacks and adults, we calculate separate population estimates for each of these size classes.

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.

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 above the weir 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 return can result in a hatchery fraction above the weir that may not accurately represent the ratio of hatchery and natural adults handled and passed above the weir.

Above Weir Adult Chinook Salmon Population Estimates

When a weir is 100% efficient, the number of salmon above the weir does not have to be estimated because the number and origin of salmon released above the weir is known. 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 and look 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 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:

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

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

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

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

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

Below Weir Adult Chinook Salmon Estimates

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

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

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

Estimating Chinook Salmon jack returns

Jack estimates are challenging. First, based on PIT tag detections, the median date of the jack return over Lower Granite Dam is 1-2 weeks later than the median date of the adult return. This differential run timing means that weir efficiency for adults and jacks is likely to be different if a weir is installed after the first salmon arrive at the weir site. Also, sliding scale management agreements 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 some 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 about 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, by origin and age, of salmon trapped at the weir. 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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