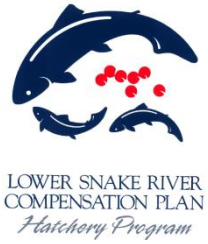
LOWER SNAKE RIVER COMPENSATION PLAN:
Oregon Summer Steelhead Evaluation Studies
2017 Annual Progress Report

Oregon Department of Fish and Wildlife
Fish Research and Development, NE Region

Michael W. Flesher
Debra L. Eddy
Joseph W. Feldhaus
James R. Ruzycki



This report is available at: http://www.fws.gov/lsnakecomplan/Reports/ODFWreports.html

Front cover photo: Jack Woods (retired) delivering steelhead smolts to the Big Canyon Facility in February 2017.

ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies

CONTRACT NUMBER: F16AC00030

PROJECT PERIOD: January 1, 2017 through December 31, 2017

Prepared By: Michael W. Flesher
Debra L. Eddy
Joseph W. Feldhaus
James Ruzycki

December 2019

Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive SE
Salem, OR 97302

This project was financed by the U.S. Fish and Wildlife Service under
the Lower Snake River Compensation Plan.

PREFACE

The purpose of this progress report is to provide summary information for Lower Snake River Compensation Plan (LSRCP) summer steelhead (*Oncorhynchus mykiss*) programs operated by ODFW in the Grande Ronde and Imnaha river basins during 2017. These ongoing monitoring programs provide technical, logistical, and biological information to managers charged with maintaining viable salmon and steelhead populations and associated fisheries in northeast Oregon. This report is organized into fish culture monitoring for juveniles, adults, experimental group recoveries (coded-wire tags and PBT assignments), and estimates for total escapement. During the period covered in this report, steelhead from the 2012-2014 broods returned to spawn, and steelhead from the 2016 brood were released as smolts. Adult steelhead that returned to spawn were used to create the 2017 brood.

ACKNOWLEDGMENTS

We would like to thank hatchery managers Ron Harrod of Wallowa Fish Hatchery and Diane Deal of Irrigon Fish Hatchery, as well as Terry Blessing, Chad Aschenbrenner, and the many other hatchery personnel who exhibited great dedication and provided essential assistance. Numerous personnel from the Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation provided enthusiastic support. We also thank Chris Starr, Mark Robertson, Julie Collins, and Rod Engle, who provided administrative and technical support. This project was funded by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan, contract number F16AC00030, a cooperative agreement with the Oregon Department of Fish and Wildlife.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (continued)

EXECUTIVE SUMMARY

Objectives

1. Document summer steelhead 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 summer steelhead smolts.

3. Document summer steelhead adult returns by stock to each LSRCP broodstock collection facility.

4. Determine if the total production of summer steelhead adults meets mitigation goals, and index annual smolt survival and adult returns to Lower Granite Dam for production groups.

5. Participate in planning activities associated with anadromous fish production and management in the Grande Ronde and Imnaha river basins, and participate in ESA permitting, consultation, and rearing activities.

6. Monitor natural spawning of summer steelhead in selected areas within the Grande Ronde basin.

7. Determine the number of summer steelhead harvested annually and angler effort in recreational fisheries on the Grande Ronde, Wallowa, and Imnaha rivers.

Accomplishments and Findings

We accomplished each of our objectives for 2017. In this report, we present data and results for objectives 1, 2, 3, 4, and 6. To accomplish objective 5, project staff participated in planning and coordination with co-managers to develop and write the annual operation plan (available at: www.fws.gov/lsnakecomplan/Reports/AOPreports.html), and staff consulted with the National Marine Fisheries Service on drafting the Lower Snake River Steelhead Hatchery Program Hatchery Program Biological Opinion. Data and results for objective 7 are published in separate annual creel survey reports (*e.g., Flesher et al. 2018).*

The production goal of 800,000 Wallowa stock smolts was achieved in 2017, with 834,888 smolts released (includes 39,857 smolts from Lyons Ferry Hatchery, WA). The Imnaha stock production goal of 215,000 smolts was also reached with 216,930 smolts released.

In 2017, 1,515 and 2,031 Wallowa stock hatchery steelhead returned to Wallowa Fish Hatchery and the Big Canyon Facility, respectively. We trapped 10 natural steelhead at Wallowa Fish Hatchery and 46 natural steelhead at the Big Canyon Facility, which were released to spawn naturally. At the Little Sheep Creek Facility, we trapped 708 Imnaha stock hatchery and 51 natural steelhead adults. Of these, a total of 164 hatchery and 45 natural steelhead were released above the weir, and 91 hatchery steelhead were outplanted to Big Sheep Creek. During

spawning in the spring of 2017, we collected 738,800 Wallowa stock production eggs, 636,100 Wallowa fall broodstock eggs, and 391,800 Imnaha stock eggs.

In the 2016-17 run year, compensation area goals were not reached for either the Wallowa stock (9,184 adults) or the Imnaha stock (2,000 adults) above Lower Granite Dam. We have met the Wallowa stock compensation area goal thirteen times in our program history, and the Imnaha stock compensation area goal fifteen times. We estimate that 5,983 Wallowa stock hatchery steelhead (65.1% of goal), and 1,243 Imnaha stock hatchery steelhead (62.2% of goal) returned to the LSRCP compensation area in 2017.

INTRODUCTION

The objectives of this report are to document fish culture practices, describe adult returns, and assess progress toward meeting LSRCP goals for Grande Ronde and Imnaha steelhead *(Oncorhynchus mykiss)*. We report on juvenile steelhead rearing and release activities for the 2016 brood year (BY) released in 2017. Included are collection, spawning, and adult characteristics for the 2017 returns, returns from experimental releases, supplementation in Little Sheep Creek, and success toward achieving compensation goals.

The Grande Ronde and Imnaha river steelhead hatchery programs were initiated in 1976 and 1982 in response to the rapid decline in Snake River steelhead abundance. Annual adult mitigation, brood year specific smolt-to-adult return, total smolt-to-adult survival rates, and annual smolt production goals were established to compensate for the estimated annual loss of 48% of adult production. Adaptive management has resulted in current interim smolt production goals of 800,000 (ODFW Wallowa stock released into the Grande Ronde) and 215,000 (Imnaha stock) smolts; less than the original goals of 1,350,000 and 330,000 smolts. Based on original smolt production goals it was assumed that 27,552 Wallowa stock and 6,000 Imnaha stock adults would be produced annually. Furthermore, 66.7% of these fish were expected to be harvested below the compensation area, defined as the watershed above Lower Granite Dam, resulting in compensation area adult return goals of 9,184 Wallowa stock and 2,000 Imnaha stock.

In general, the data in this report were derived from hatchery inventories and standard databases (e.g., Pacific States Marine Fisheries Commission Regional Mark Information System (RMIS), ODFW mark recovery) or through standard measuring techniques. As such, specific protocols are usually not described. In cases where expansions of data or unique methodologies were used, protocols are described in more detail. Additional descriptions of protocols can be found in our work statements (Carmichael et al. 2012, Carmichael et al. 2013). Coded-wire tag (CWT) data collected from 2017 adult returns were used to evaluate smolt-to-adult survival rates in experimental rearing and release groups. In 2017, the only experimental treatments from which fish returned were the third generation progeny from early returning (fall-collected) broodstock. In 2015, smolts were released at Wallowa Hatchery that were third generation progeny of early returning (fall-collected) broodstock for an experimental comparison with progeny of standard production broodstock. Methods for the fall broodstock experiment are described in Warren et al. (2011a). In addition, 2015 was the first year of an experimental evaluation of Irrigon Hatchery-reared Wallowa stock smolts released at the Washington

Department of Fish and Wildlife's Cottonwood Acclimation Facility on the lower Grande Ronde River. Acclimation at the Cottonwood Facility is at low densities in a semi-natural pond, and these factors could translate to better post-release performance. Final adult returns to hatchery facilities from this study will occur in 2021, with analysis of survival and straying to be completed and presented in separate reports, journal articles, or conference presentations once all datasets are complete. Twibell et al. (2018) reports on results of smolt physiology monitoring during this study. In addition, much of the data that we discuss in this report will be used in separate and specific evaluations of ongoing supplementation programs for steelhead in the Imnaha River basin. We began culture evaluations in 1983 and have dramatically 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; 1988a; 1999; 2004; 2005a; 2005b; Clarke et al. 2014; 2015; 2017; Flesher et al. 2005a; 2009a; Gee et al. 2007; 2008; Messmer et al. 1989; 1990; 1991; 1992; 1993; Jonasson et al. 1994; 1995; 1996; Ruzycki et al. 2003; Stanton et al. 2018, Warren et al. 2009; 2010; 2011a; 2011b; 2012; 2013;Whitesel et al. 1993), annual creel survey reports (Carmichael et al. 1988b; 1989; 1990; Flesher et al. 1991; 1992; 1993; 1994; 1995; 1996; 1997; 1999; 2000; 2001; 2004a; 2004b; 2005b; 2007; 2008a; 2008b; 2009b; 2010; 2011; 2012; 2013; 2014; 2015; 2016; 2017, 2018), a United States vs. Oregon production report (Carmichael et al. 1986b), a five-year study plan (Carmichael 1989), and journal articles (Clarke et al. 2010; 2011; 2014; 2017).

RESULTS AND DISCUSSION

Juveniles

Wallowa stock egg-to-eyed embryo survival for the 2016 BY was 90.5%, within the range of recent brood years (1993-2015 BY range = 71.8-93.8%), and embryo-to-smolt survival was 89.1%, within the range of recent brood years (1993-2015 BY range = 65.0-98.3%; Table 1). Imnaha stock egg-to-embryo survival for the 2016 BY was 92.9%, slightly above the range of recent brood years (1993-2015 BY range = 76.7-92.2%), and embryo-to-smolt survival was 75.5%, within the range of recent brood years (1993-2015 BY range = 61.0-98.5%; Table 1). We released 834,888 Wallowa stock smolts in 2017, exceeding our production goal of 800,000 smolts. For the Imnaha stock, we released 216,930 Imnaha stock smolts, exceeding our production goal of 215,000 smolts (Tables 1 and 3) in spite of higher than average losses (see below). Hatchery managers attempt to meet production goals every year; however, variation in mortality at various stages of rearing, from fertilized eggs to acclimated smolts, results in fewer or more fish being released in any given year. Managers periodically adjust the number of eggs collected based on recent hatchery performance.

Imnaha stock BY 2016 juveniles exhibited higher than normal loss - 21,938 fish - while rearing in raceways at Irrigon Fish Hatchery, with the majority (96.2%) of losses occurring in September 2016. Mean loss of all Imnaha stock juveniles after tagging at Irrigon (September through the subsequent February) is generally less than 1,000 fish. The BY 2016 Imnaha juveniles were affected by both gram negative septicemia and cold-water disease (S. Gee, personal communication). After antibiotic treatment, losses decreased from 21,101 in September 2016 to 457 in October 2016, and stayed low through transfer to acclimation in February 2017.

Beginning with BY 2013 releases, a programmatic decision was made to eliminate ventral fin clipping of steelhead for purposes of identifying the presence of coded-wire tags. Electronic scanning is now used to detect wire in hatchery fish harvested in fisheries and recovered at hatchery traps. However, one raceway of coded-wire tagged Wallowa production stock continue to be left ventral fin clipped (AdLV and CWT) to assess the effect that ventral clips have on smolt-to-adult survival, and Wallowa fall broodstock continue to be right ventral clipped so that returning adults may be visually identified at hatchery weirs and collected for broodstock. Hatchery fish continue to be adipose fin clipped. To evaluate different rearing and release strategies, we tagged and released five groups of Wallowa stock steelhead and one group of Imnaha stock steelhead smolts with adipose clips and coded-wire tags (Ad and CWT), one group of Wallowa stock with adipose-left ventral clips and coded-wire tags (AdLV and CWT), and four groups of Wallowa fall broodstock with adipose-right ventral clips and coded-wire tags (AdRV and CWT; Table 2). We marked 99.0 and 100.0% of Wallowa and Imnaha stock smolts with an adipose fin clip, which was within the range of recent brood years for Wallowa stock (1993-2015 BY range = 95.6-99.9%) and within the range of recent brood years for Imnaha stock (1993-2015 BY range = 96.1-100.0). Fin clip quality and tag retention for release groups averaged 99.6% for Wallowa stock, slightly above the range of recent years (1993-2015 BY range = 89.1-99.3%) and 100.0% for Imnaha stock, also above the range of recent years (1993-2015 BY range = 84.7-99.6%). Details of experimental and production releases for the 2016 BY, including the number of fish implanted with passive integrated transponder (PIT) tags, are shown in Table 3.

Densities of residual hatchery steelhead averaged 8.0 fish/100m^2 at index sites in the Grande Ronde basin in 2017 (Table 4), whereas wild *O. mykiss* averaged 18.4 fish/100m^2. In the Imnaha basin, densities of residual hatchery steelhead and wild *O. mykiss* were 11.5 and 1.5 fish/100m^2. Since sampling for residual hatchery steelhead began in 1996, we have observed a clear pattern of higher densities of residual hatchery steelhead than wild *O. mykiss* in the Imnaha basin index sites.

PIT tag monitoring of the month-long volitional smolt release from Little Sheep Creek acclimation pond was discontinued during spring 2017 due to stream flow modifications. The stream level at the facility was raised to provide fish passage upstream during summer low flows, which in turn flooded the outflow pipe from the acclimation pond. The outflow pipe previously supported two PIT-tag antennas used to monitor outmigration timing of juveniles leaving the acclimation pond. Therefore, no data were collected for this task, noted in the 2017 Work Statement (Objective 4, Subobjective 4.1, Task 4.1.2).

Adults

Returning PIT-tagged adults from the 2012 to 2014 broods were detected at main-stem dams during the 2016-17 run year. Of the 221 Wallowa stock adults detected at Bonneville Dam on the Columbia River, 156 were detected at Lower Granite Dam on the Snake River. For the Imnaha stock, 91 of the 198 adults detected at Bonneville Dam were detected at Lower Granite Dam (Table 5). Weirs were installed to capture adult steelhead on 16 February at Wallowa Fish Hatchery, 17 February at Big Canyon Facility, and 17 February at Little Sheep Creek Facility (Table 6). Returns to the Little Sheep Creek Facility were predominantly hatchery fish, with 51

(6.7%) natural steelhead. Similar to Little Sheep Creek, most of the adults that returned to the Big Canyon Facility were of hatchery origin, with only 46 (2.2%) natural steelhead. In addition, 10 (0.7%) natural steelhead returned to Wallowa Fish Hatchery. Fifteen percent of hatchery adults that returned to Wallowa Fish Hatchery and Big Canyon Facility spent one year in the ocean (Table 7) and 29% of hatchery fish that returned to Little Sheep Creek Facility spent one year in the ocean before returning. Of the natural origin fish, 27% (14 of 51), 17% (8 of 46), and 30% (3 of 10) of the Little Sheep Creek Facility, Big Canyon Facility, and Wallowa Fish Hatchery, respectively, spent one year in saltwater before returning.

The majority of hatchery adults that returned to Wallowa Fish Hatchery in 2017 were spawned or killed (Table 7). In 2017, Big Canyon Facility hatchery returns were not needed for the Grande Ronde steelhead hatchery program due to the large number of adults returning to Wallowa Fish Hatchery. We outplanted 213 adult hatchery steelhead from Wallowa Fish Hatchery and the Big Canyon Facility to local ponds for harvest opportunities (fish captured at Big Canyon Facility are no longer returned to the Wallowa River for further angling opportunities due to low harvest success). At Big Canyon Facility, 46 natural adults passed above the weir site to spawn in Deer Creek. Thirty-seven live natural adults were trapped and passed, and nine additional carcasses were observed on the weir; these nine fish likely traveled upstream during high water in mid-March, when some weir panels were removed. Additionally, thirty hatchery-origin adult carcasses were intercepted on Deer Creek weir. Hatchery fish are not intentionally passed into Deer Creek, so these adults almost certainly swam past the weir site during the March high-water event. Adults intentionally passed above the weir or whose carcasses were recovered in Deer Creek were incorporated into Big Canyon 2017 adult returns.

We retained 17.7% of the hatchery fish and 9.8% of the natural fish for spawning at Little Sheep Creek Facility and outplanted 106 hatchery adults in Big Sheep Creek to spawn naturally. Sixteen of the 106 outplanted fish (15.1%) were recaptured at least once at the Little Sheep Creek Facility in 2017. Fifteen adults initially outplanted in Big Sheep Creek and recaptured at Little Sheep Creek facility were subsequently euthanized, leaving 91 hatchery adults in Big Sheep Creek. Natural fish comprised 3.8% of the broodstock. Forty-five natural and 164 hatchery adults were released above the weir in Little Sheep Creek to spawn naturally. In addition, 1 natural and 7 hatchery males were spawned and then passed above the weir, resulting in 78.8% of fish above the weir being of hatchery origin. Of the 217 fish passed into Little Sheep Creek, 11 fell back and were recaptured at the weir (Table 8). Length-at-age data for Wallowa and Imnaha stock adults are presented in Figures 1 and 2, respectively.

We usually conduct multiple spawning surveys for steelhead that are passed above Deer Creek weir using protocols described in Gee et al. (2008). However, on March 16 extremely high water necessitated removal of some Deer Creek weir panels. Also on March 16, panels were put in place at the intake (~100 meters upstream of the weir) to prevent fish that escaped into Deer Creek from migrating further upstream. Weir panels were reinstalled on March 23, but during the six-day breach an unknown number of hatchery- and natural-origin steelhead passed the weir site and likely spawned in Deer Creek. Thus, on May 16 and 17 we conducted a single-survey pass from the intake to mile post 10 to map spatial distribution of redds and observe any steelhead carcasses. In lieu of the normal multi-pass redd surveys and weir counts, we used total discharge at Perry gauge in the Upper Grande Ronde River (station #13318960) from March

through May to calculate the fish:redd estimate for 2017. Since Deer Creek's fish:redd ratio in prior years was significantly correlated with total discharge from the Perry gauge, we deemed this regression an appropriate estimator of fish:redd when Deer Creek weir operates below 100% efficiency, as it did in 2017 (Tattam et al. 2017; Table 9).

In 2017, we exceeded our egg take goal of 1,155,000 green eggs for the Wallowa stock with 1,374,900 green eggs collected. Of these, 738,800 were for production and 636,100 were for the fall broodstock evaluation. We collected 357,600 green Imnaha stock eggs, thus we exceeded our goal of 317,000 eggs. Mortality from green egg-to-eyed embryo from six (Wallowa stock) and seven (Imnaha stock) weekly spawns ranged from 2.1-9.7% for Wallowa production stock, 5.0-13.1% for fall broodstock, and from 2.9-21.6% for Imnaha stock (Table 10).

Experimental Group Returns

The number of coded-wire tag (CWT) and adipose-clipped adults that were harvested or returned to collection sites is used to estimate various performance parameters. These numbers allow us to monitor our success toward meeting the LSRCP goals, to estimate stray rates, and to determine the contribution to recreational, tribal, and commercial fisheries. They also provide the basis for evaluating the success of experimental rearing and release strategies. Recoveries for each CWT code were summarized from the CWT recovery database maintained by PSMFC, ODFW's mark recovery database, and from data reported by the Washington Department of Fish and Wildlife and Idaho Department of Fish and Game. Our protocol was to collect and enumerate all fish marked with a CWT when they were spawned, dispatched, or died. A summary of these data is provided in this report. Final analyses, results, and discussion of production and release strategies will be presented in special reports or conference presentations once all adults have returned from the experimental groups.

Commencing with spawn year 2008, ODFW has collected genetic samples from all steelhead broodstock collected at Wallowa Hatchery (Wallowa stock) and Little Sheep Creek Facility (Imnaha stock). Samples were submitted to Eagle Fish Genetics Laboratory for inclusion in the Snake River Parentage-Based Tagging (PBT) genetic baseline. Beginning with one-ocean returns in return year 2016-17, CWT recoveries are incomplete and have been supplemented with harvest estimates based on PBT samples in certain areas, particularly in the Idaho portion of the Snake River and Idaho tributaries, to account for all recoveries. PBT-based estimates of harvest from the Idaho portion of the Snake River and its tributaries provide total harvest estimates by stock and by age without using CWT recoveries. This is especially important, as BY 2012 was the final brood year in which IDFG applied CWTs to steelhead for the purpose of harvest estimation (Warren et al. 2017), leaving little impetus for IDFG to put significant effort into sampling Idaho fisheries for CWTs beyond return year 2016-17. Therefore, beginning with this report we will employ both CWT and PBT methods of estimating adult recoveries, in order to evaluate our success toward meeting LSRCP goals.

Table 15 enumerates actual harvest recoveries (versus estimates) of genetically sampled hatchery adults assigned to Oregon Wallowa or Imnaha steelhead stocks by PBT. Adults were

sampled by Washington Department of Fish and Wildlife (WDFW), Idaho Department of Fish and Game (IDFG), and ODFW from fishery areas in the Columbia and Snake rivers for the 2016-17 run year. Results of this sampling represent some of the first comprehensive attempts to categorize stock composition of the steelhead harvest in the Lower Columbia sport fishery, and will aid in monitoring needs for the U.S. v Oregon Management Agreement (Byrne et al. 2018). Results also represent some of the first evaluations of stock composition of the Columbia River tribal (Zone 6) fishery, and in-state Washington and Idaho recreational fisheries, using PBT.

For the Columbia River, out of 3,341 samples collected from select fisheries, 2,319 fish (69.4%) were assigned back to known hatchery stocks and of those, 226 (9.7%) were Oregon Wallowa stock adults and 26 (1.1%) were Imnaha stock adults. For the Snake River, Washington, out of 542 total samples, 505 (93.2%) were assigned to known hatchery stocks and of those, 73 (14.5%) were Oregon Wallowa stock adults and nine (1.8%) were Imnaha stock adults. For the Snake River and selected tributaries in Idaho, out of 1,216 samples, 808 steelhead (66.4%) were assigned to stock of origin and of those, 55 (6.8%) assigned to Oregon Wallowa stock and 46 (5.7%) assigned to Imnaha stock. Utilization of PBT sampling to provide parental assignments is discussed in Steele et al. (2018).

Adults from BY 2012 to 2014 returned during the 2016-17 run year, including the eleventh year of adult returns from the Wallowa fall broodstock experiment and the first year of adult returning from the Wallowa stock reciprocal experiment with WDFW's Lyons Ferry Hatchery. We had Wallowa stock recoveries from 21 CWT codes (Table 11) and Imnaha stock recoveries from two CWT codes (Table 12). Of approximately 225,000 total coded-wire-tagged fish released for both production and fall brood groups, a total of 511 Wallowa fall brood, 1,108 Wallowa production, and five Wallowa reciprocal study CWT's were recovered (Table 11). It is important to note that reciprocal study CWTs were only applied to steelhead smolts transferred from Oregon to Lyons Ferry Hatchery. No CWTs were applied to steelhead coming into Oregon from Lyons Ferry Hatchery.

We are still tabulating data from the second generation (brood years 2008-2011) of the fall brood experiment; however, preliminary results suggest that adult run timing was more similar between the fall brood and standard production lines during the second generation than they were in the first generation, as were SAS, straying and harvest rates. Long-term management of the fall brood program includes continuing to spawn and tag fall brood and production lines separately to maintain comparisons of performance metrics, return timing, and straying. We will also occasionally 'refresh" the fall brood line with adults collected via angling in the fall Grande Ronde River fishery. We plan to collect early-returning steelhead by hook and line in fall 2020, social distancing guidelines allowing, to augment fall brood spawners in spring 2021. We expect that refreshing the fall brood line will ameliorate the loss of run timing differences observed in the F1 generation, and diversify the genetic makeup of the broodstock (Clarke et al. 2012).

Compensation Area Goals

The LSRCP Compensation Area is defined as the Snake River and its tributaries above the confluence of the Snake and Columbia rivers at Pasco, Washington, for programs within the State of Oregon. Goals for smolt-to-adult return (SAR) rates and the number of adults produced to the compensation area are 0.68% and 9,184 for the Grande Ronde basin (Wallowa stock) and 0.61% and 2,000 for the Imnaha basin (Imnaha stock).

Compensation plan adult return goals in the past have been defined as returns to the watershed above Lower Granite Dam. Beginning with this return year (2016-17), compensation plan adult return goals also include adult returns to the Snake River and its tributaries below Lower Granite Dam. To provide a cumulative summary of disposition for all adults that returned to the compensation area, we expanded CWT recoveries to account for the non-CWT fish that returned. In addition, we included PBT-based estimates of adult recoveries from the Idaho portion of the Snake River and its tributaries because few CWT estimates were available.

In the 2016-17 run year, we estimate that 5,983 hatchery origin Wallowa stock adults returned to the compensation area, representing 65.1% of the compensation area goal (Table 13). In addition, we estimate that 1,243 Imnaha stock adults returned to the compensation area, representing 62.2% of the compensation area goal. Age composition of returning adults is shown in Table 14. Development of the compensation plan goals assumed that twice as many adult steelhead would be harvested in downriver fisheries as return to the compensation area (USACOE 1975); however, that harvest level was not reached for either stock (Table 13).

There are three principal factors that influence success in meeting the compensation goals: number of smolts released for the brood years that produced the adults; SAS rates to the mouth of the Columbia River; and capture of fish below the compensation area in fisheries and as out-of-basin strays. Over the history of the LSRCP project, we have now reached our adult production compensation goal thirteen times (1997-98, 2001-02, 2003-12, and 2014-16 run years) for the Wallowa program, and fifteen times for the Imnaha program (1992-93, 2001-12, and 2013-16 run years; Figure 3). For both the Grande Ronde and Imnaha programs, we have met our smolt production goals in most years. Returns in the 2016-17 run year represent the final returns of the 2012 BY. For the 2012 BY, SAS for the Wallowa and Imnaha stocks were slightly above average at 1.06% and above average at 2.07%, respectively (Figure 4). Smolt-to-adult return to the compensation area above Lower Granite Dam has reached our goal in thirteen of the last 28 brood years for Wallowa and fourteen of the last 28 brood years for Imnaha stocks (Figure 5). This suggests that low SAS rates may be the primary factor for only occasionally achieving our adult compensation goals. However, the SAR compensation area goal has been reached in each of the last fourteen years for Imnaha stock and in twelve of the last fourteen years for Wallowa stock.

The Imnaha steelhead supplementation program allows us to evaluate and compare productivity (adult progeny produced per parent) of hatchery and naturally spawning fish. Hatchery and natural origin fish are used both for hatchery spawning and they are passed above the weir to spawn naturally; therefore, progeny-per-parent ratios include both hatchery and natural origin parents. Progeny-per-parent ratios for naturally spawning fish were below 1.0 for

completed brood years 1987-1994, 1998, and 2001-2011 and above 1.0 for completed brood years 1995-1997, 1999, and 2000 (Figure 6). Progeny-per-parent ratios for fish spawned in the hatchery (weir returns only) have been above 1.0 for all brood years except 1991. Hatchery ratios exceeded natural ratios for all brood years except for the 1991 and 1997 broods. One purpose of the supplementation program is to enhance or stabilize natural fish abundance. Annual abundance of naturally-produced fish has been highly variable and in recent years adult returns have been lower; however, the long-term pattern suggests an increasing trend in natural returns (Figure 7).

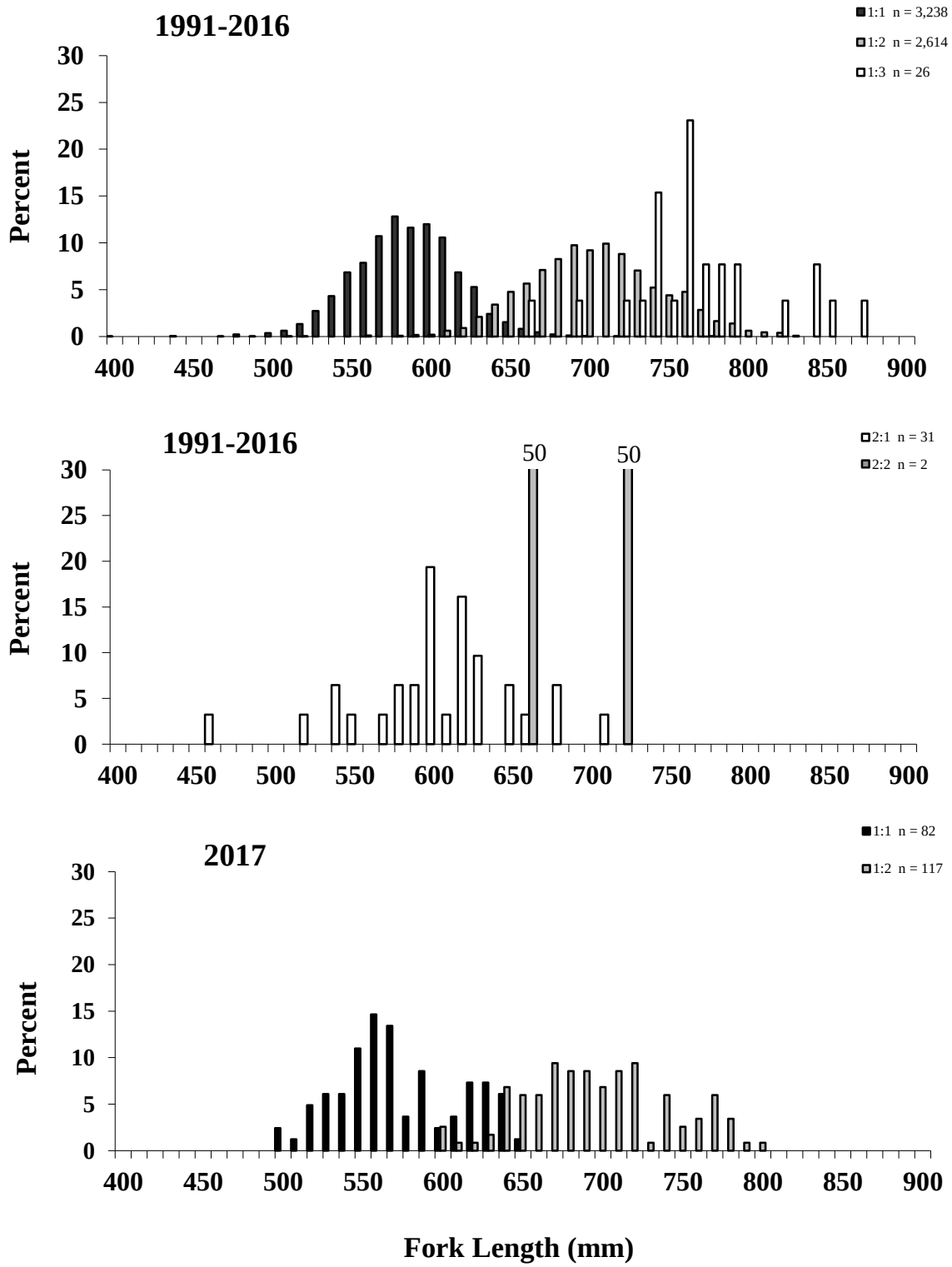


Figure 1. Length-at-age relationships based on scale analysis for hatchery adult returns of one freshwater age (top) and two freshwater age (middle) Wallowa stock summer steelhead from 1991 to 2016, and in 2017 (bottom).

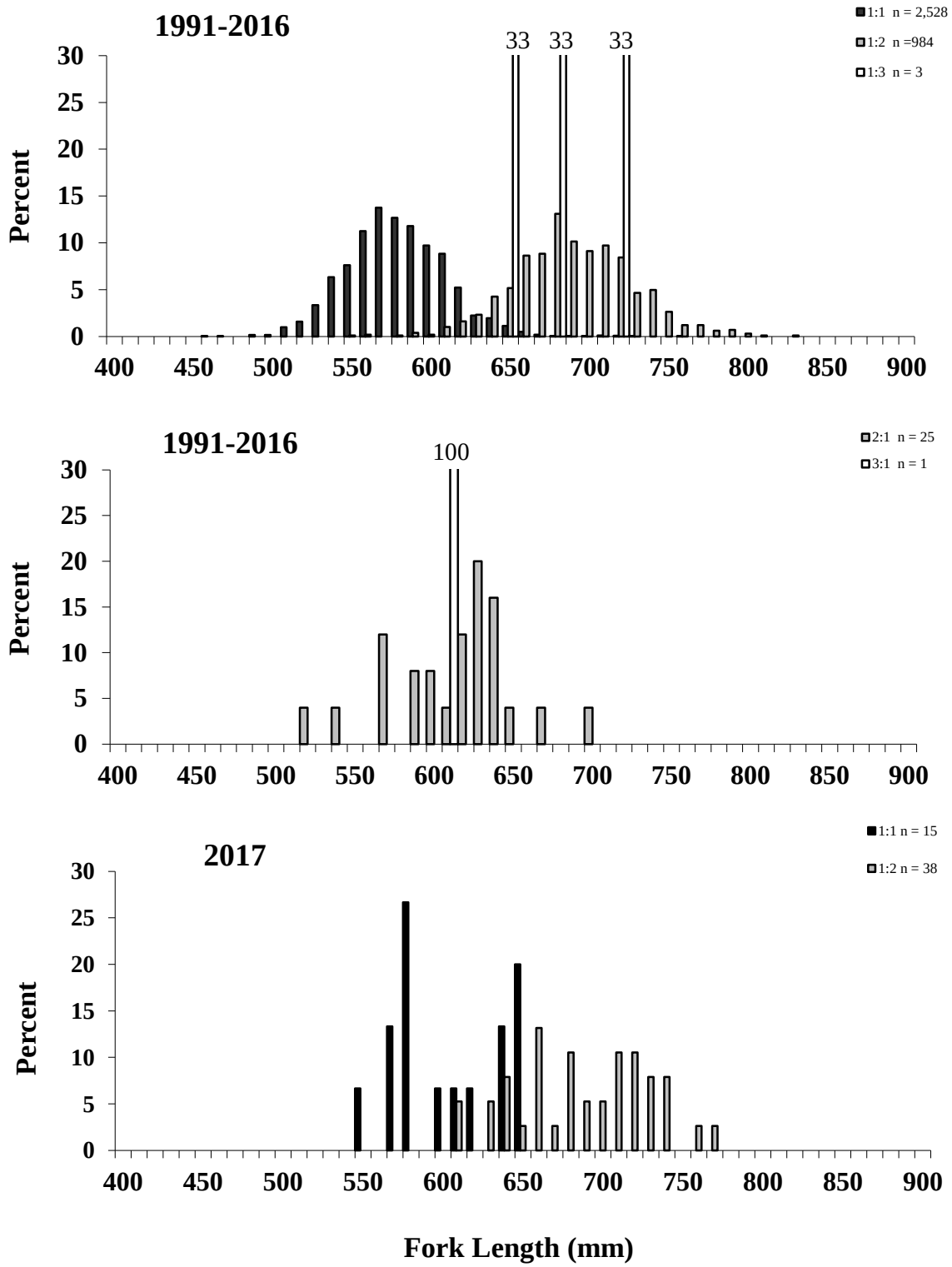


Figure 2. Length-at-age relationships based on scale analysis for hatchery adult returns of one freshwater age (top), and two and three freshwater age (middle) Imnaha stock summer steelhead from 1991 to 2016, and in 2017 (bottom).

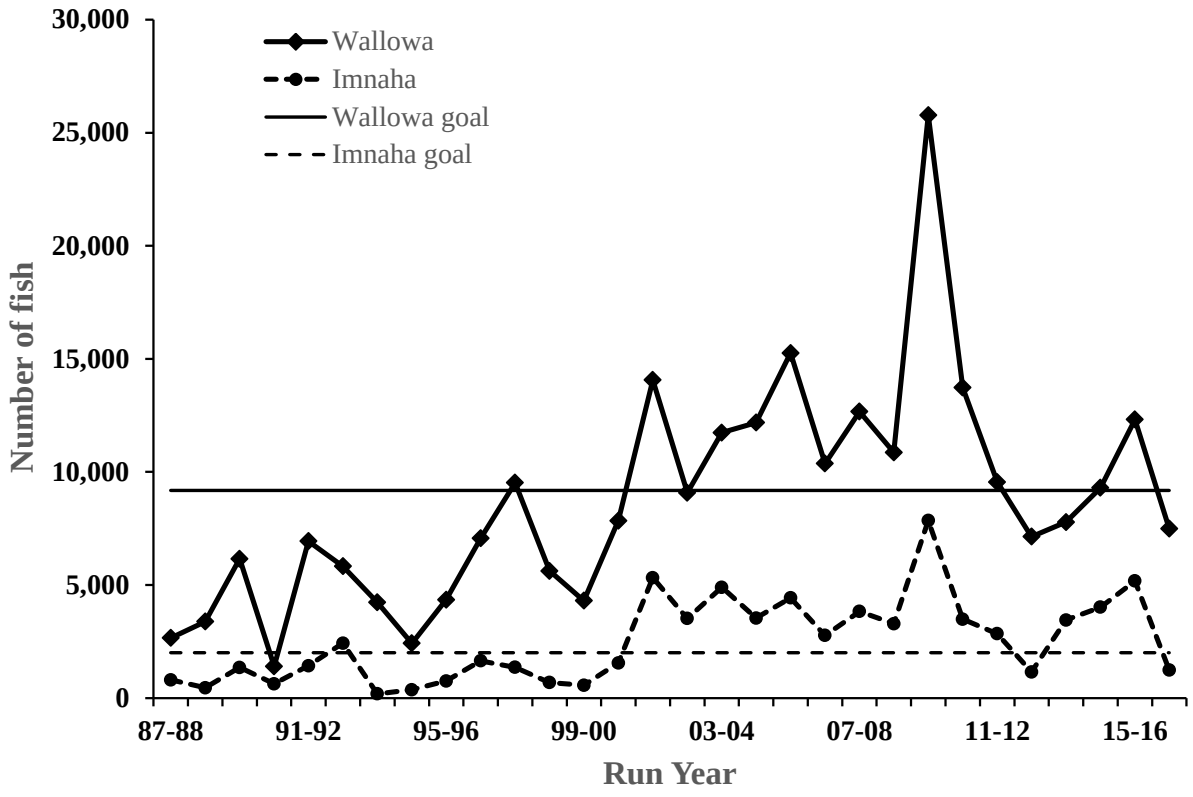


Figure 3. Hatchery returns to the compensation area above the Snake River mouth for Wallowa and Imnaha stock summer steelhead for the 1987-88 to 2016-17 run years. The compensation goal for Wallowa stock is 9,184 adults and the goal for Imnaha stock is 2,000 adults. Data are based on out-of-basin CWT recoveries, in-basin harvest estimates from creel surveys, hatchery rack returns, and harvest estimates from Idaho waters based on parentage-based tagging (PBT) samples and harvest card returns.

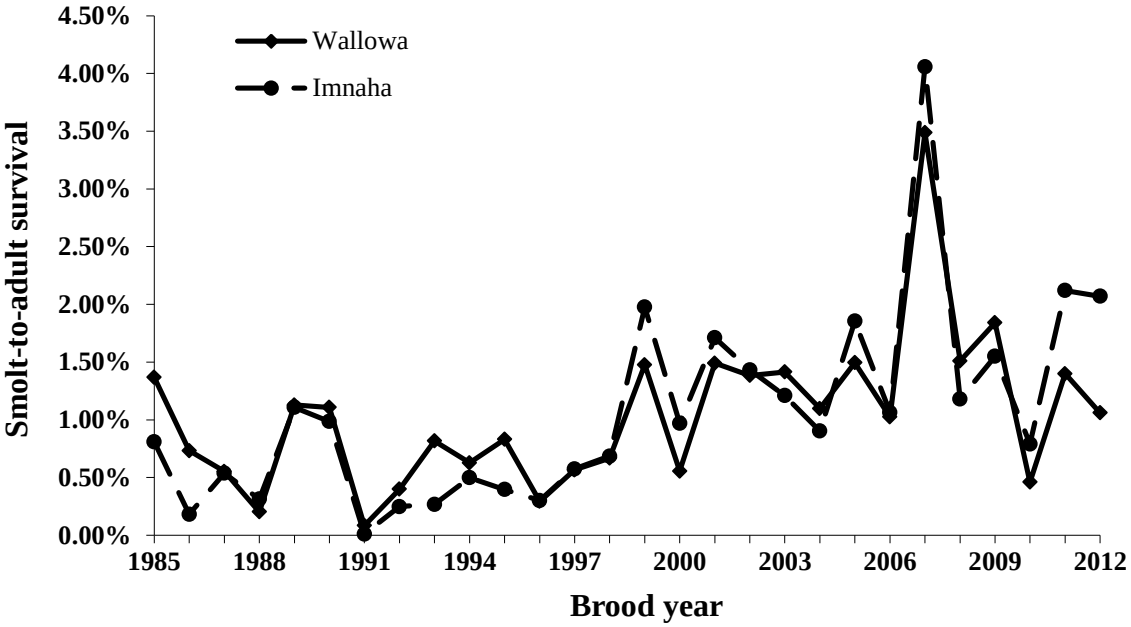


Figure 4. Smolt-to-adult survival (SAS) for Wallowa and Imnaha stock summer steelhead, 1985-2012 brood years. Data is based on CWT recoveries.

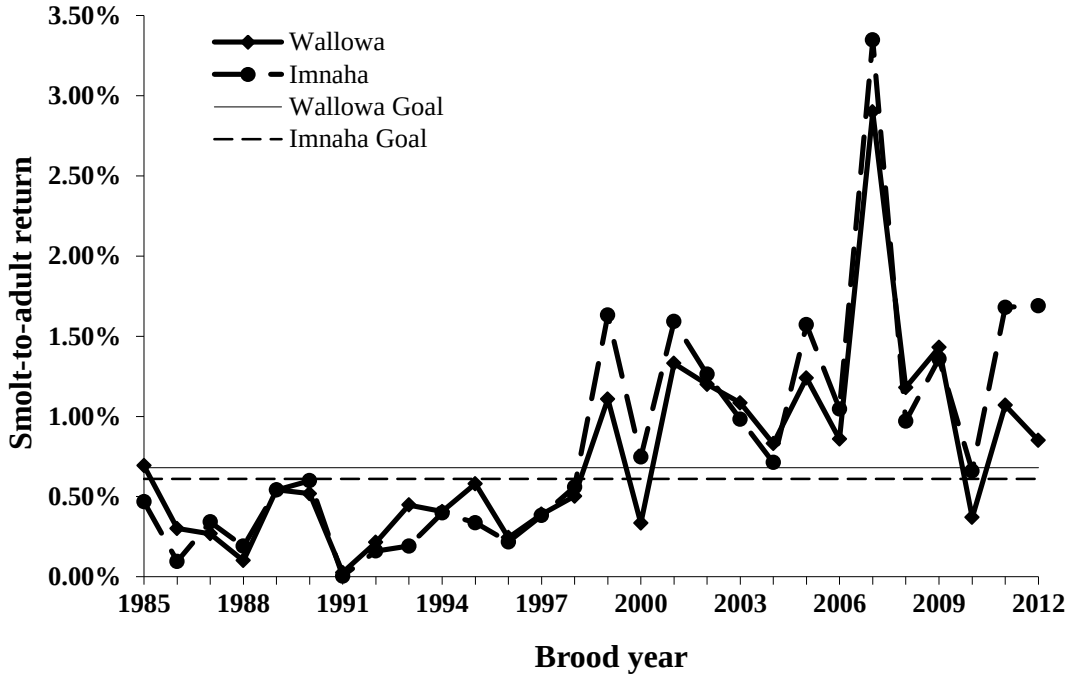


Figure 5. Smolt-to-adult return (SAR) to the compensation area above the Snake River mouth for Wallowa and Imnaha stock summer steelhead, 1985-2012 brood years. The Wallowa stock goal is 0.68% and the Imnaha stock goal is 0.61%. Data is based on CWT recoveries.

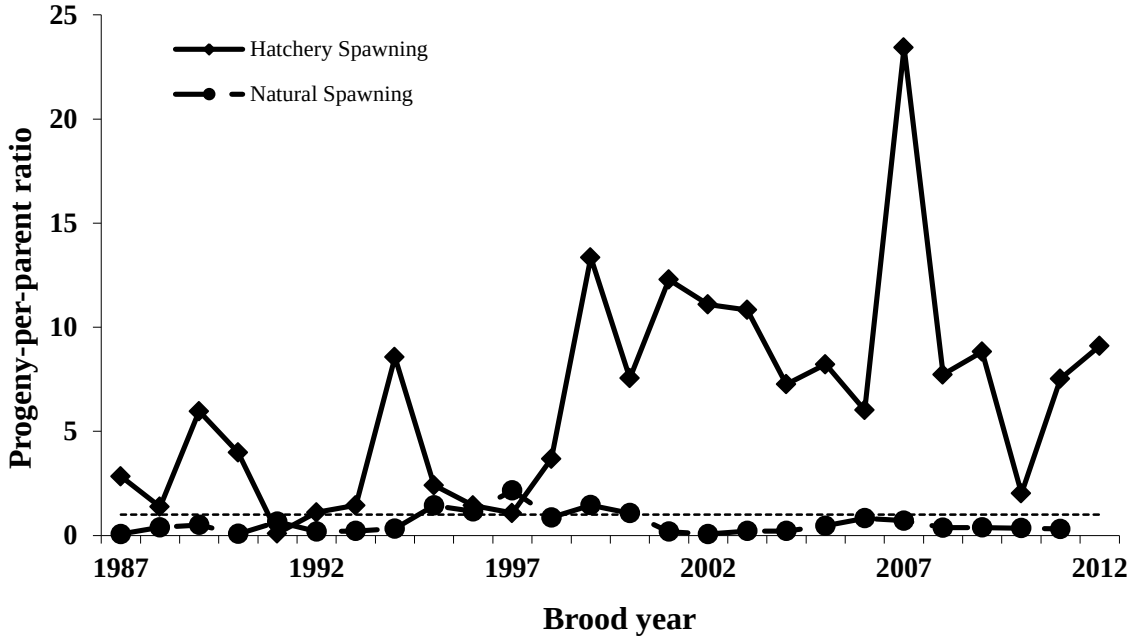


Figure 6. Progeny-to-parent ratios for Little Sheep Creek summer steelhead, 1987-2012 brood years. Both types of spawning include hatchery and natural origin parents. Dotted line represents replacement (P: P ratio = 1.0). Natural origin steelhead data for the 2012 brood year is not yet available.

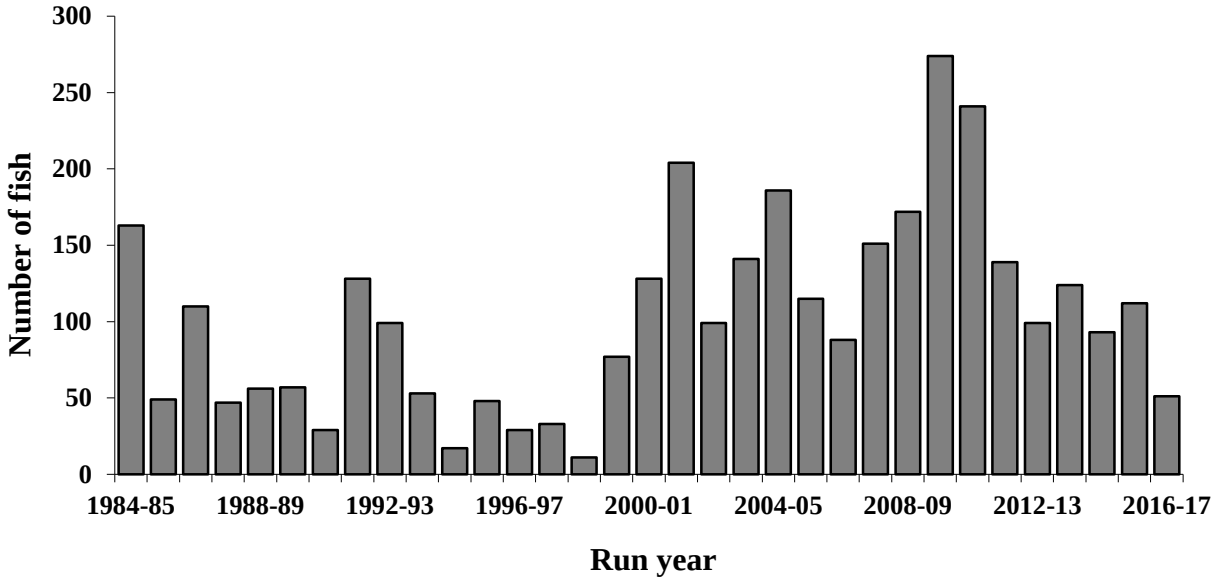


Figure 7. Returns of naturally-produced summer steelhead to Little Sheep Creek, run years 1984-85 to 2016-17.

Table 1. Summary of egg collection and juvenile survival for 2016 brood year summer steelhead released in the Grande Ronde and Imnaha river basins at LSRCP facilities in 2017. This table does not include 40,000 smolts reared at Lyons Ferry Hatchery in Washington and released into Spring Creek. However, this table includes 41,906 smolts reared in pond 14 at Irrigon Fish Hatchery, but released at Cottonwood Creek, Washington.

Stock	Number of eggs taken	Eyed embryos	Total smolts released	Estimated survival rate	
				Egg-to-embryo	Embryo-to-smolt[a]
Wallowa	1,218,250	1,102,600[b]	896,602[c]	90.5	89.1
Imnaha	364,600	338,700[d]	216,930	92.9	75.5

[a] *Embryos that were culled from or not part of production were subtracted from the calculation of embryo-to-smolt survival.*
[b] *Includes 95,200 embryos that were euthanized because they were excess to program needs. Also includes 1,600 embryos that were transferred to the Salmon and Trout Enhancement Program (STEP) Coordinator.*
[c] *Includes a total of 59,808 fish released into Hells Canyon Reservoir as rainbow trout on Oct 26, 2016.*
[d] *Includes 17,200 embryos euthanized because they were excess to program needs.*

Table 2. Estimates of fin clip quality and coded-wire tag retention for 2016 brood year summer steelhead reared at Irrigon Fish Hatchery and released in 2017. Experimental group indicates treatment and rearing raceway number. Wallowa and Imnaha stocks were intended to be 100% adipose fin-clipped. All fall brood (Fall B., progeny of broodstock collected in early fall) released from Wallowa Acclimation Facility were AdRV (adipose + right ventral) fin-clipped. All fall brood released from Big Canyon Acclimation Facility were Ad (adipose only) fin-clipped. Wire-tagged standard production (Prod.) groups were Ad+CWT except for pond 8, which remained AdLV+CWT.

Experimental Group,Raceway	Tag code	No. checked		Percent							
		CWT	Ad[a]	CWT+ Clip[b]	CWT+ noclip	NoCWT + clip	NoCWT +noclip	Ad	No Ad	RV	No RV
Wallowa Stock											
Fall B., 07	091072	506	-	99.8	0.2	0.0	0.0	-	-	91.0	9.0
Fall B., 21	091073	529	-	99.8	0.0	0.2	0.0	-	-	94.4	5.6
Fall B., 15	091081	501	-	99.8	0.0	0.0	0.2	-	-	-	-
Fall B., 23	091080	509	-	99.8	0.0	0.2	0.0	-	-	-	-
Prod., 08	091074	552	-	99.6	0.0	0.0	0.4	-	-	-	-
Prod., 10	091075	541	-	99.8	0.0	0.2	0.0	-	-	-	-
Reciprocal Study, Prod. 14	091078	543	-	98.9	0.0	1.1	0.0	-	-	-	-
Early/Normal Study, Prod. 16	091076	533	-	99.6	0.0	0.2	0.2	-	-	-	-
Prod., 18	091079	503	-	99.2	0.0	0.8	0.0	-	-	-	-
Prod., 22	091077	539	-	99.3	0.0	0.7	0.0	-	-	-	-
Average	-	526		99.6	0.0	0.3	0.1	99.9	0.1	92.6	7.4
Imnaha Stock											
Prod., 28	091071	473	303	100.0	0.0	0.0	0.0	100.0	0.0	-	-
Overall Ave.		521		99.6	0.0	0.3	0.1	99.9	0.1	92.6	7.4

[a] *Adipose fin (Ad) clip quality checks occurred during pre-release sampling at acclimation ponds.*
[b] *A programmatic decision to discontinue ventral fin clipping to indicate the presence of a CWT began with brood year 2013. Fish in pond 8 were left ventral fin clipped (CWT+AdLV) to determine the effect of ventral fin clips on post release survival.*

Table 3. Details of experimental and production groups of 2016 brood year summer steelhead released in the Grande Ronde (Wallowa stock) and Imnaha (Imnaha stock) river basins in 2017. Experimental group indicates release strategy and rearing raceway number(s). All groups were reared at Irrigon Hatchery and acclimated. Target size was 113 g (± SD) for Wallowa stock and 100 g for Imnaha stock. LGD indicates Lower Granite Dam; percent migration includes ±95% confidence intervals. This table does not include 39,857 smolts reared at Lyons Ferry Hatchery in Washington and released into Spring Creek on 2-3 April.

Experimental group, raceway	Transfer date	Release date(s)	Tag code	Fork length (mm)	Weight (g)	Condition factor	Total fish released	PIT tags released[a]	Percent migration to LGD[b]
				Wallowa stock					
Spring Creek									
Production, 8	Jan 13-21	April 2-3	091074	201 (16.1)	95.7 (26.1)	1.13 (0.07)	22,833	2,092	87.3 ± 6.4
Production, 8,10,16	Jan 13-21	April 2-3	-	202 (24.8)	96.1 (30.3)	1.12 (0.07)	48,893	-	-
Production, 10[c]	Jan 13-21	April 2-3	091075	N/A	N/A	N/A	26,581	4,673	77.9 ± 3.4
Production, 16[c]	Feb 15	April 2-3	091076	N/A	N/A	N/A	27,080	1,698	95.1 ± 9.0
Fall Brood, 7[c]	Jan 13-21	April 1-3	091072	N/A	N/A	N/A	24,113	1,993	79.3 ± 6.4
Fall Brood,7,9,11,12	Jan 13-21	April 1-3	-	206 (19.5)	98.4 (29.3)	1.10 (0.06)	140,271	-	-
Production, 22[c]	April 3-4	April 18-30	091077	N/A	N/A	N/A	26,239	-	-
Production, 22, 20	April 3-4	April 18-30	-	211 (20.8)	107.7 (34.5)	1.10 (0.07)	57,150	-	-
Fall Brood, 21[c]	April 3-4	April 18-30	091073	N/A	N/A	N/A	27,028	1,691	77.7 ± 7.0
Fall Brood, 19,21	April 3-4	April 18-30	-	218 (16.6)	111.9 (24.2)	1.08 (0.06)	57,650	-	-
Deer Creek									
Fall Brood, 15[c]	Feb 17-18	March 16[d]	091081	N/A	N/A	N/A	27,746	1,697	76.5 ± 8.8
Fall Brood, 15,17	Feb 17-18	March 16[d]	-	199 (23.8)	85.8 (25.4)	1.08 (0.07)	57,338	-	-
Production, 18[c]	Feb 17-18	March 16[d]	091079	N/A	N/A	N/A	25,659	1,691	77.1 ± 6.8
Production, 13,18	Feb 17-18	March 16[d]	-	201 (20.9)	90.9 (27.1)	1.07 (0.06)	58,413	-	-
Fall Brood, 23[c]	April 17-18	May 1-3	091080	N/A	N/A	N/A	25,931	1,690	104.5 ± 20.1
Fall Brood, 23,25	April 17-18	May 1-3	-	213 (18.7)	103.2 (30.0)	1.04 (0.08)	58,630	-	-
Production, 24,26	April 17-18	May 2-3	-	216 (20.7)	107.5 (26.5)	1.01 (0.06)	83,476	1,694	81.7 ± 12.5
Total released							795,031	18,919	
Cottonwood Creek, WA									
Cottonwood, 14	Feb 10	April 10	091078	N/A	N/A	N/A	26,830	3,997	93.5 ± 5.1
Cottonwood, 14	Feb 10	April 10	-	182 (27.5)	65.5 (25.0)	1.11 (0.07)	15,076	-	-
Total released							41,906	3,997	
				Imnaha stock					
Little Sheep									
Production, 28	Feb 21-22	April 1-28	091071	N/A	N/A	N/A	24,324	5,955	75.5 ± 3.7
Production, 27-32[e]	Feb 21-22	April 1-28	-	203 (23.8)	92.4 (31.2)	1.06 (0.06)	192,606	8,938	80.8 ± 3.3
Total released							216,930	14,923	

[a] *Actual number of PIT tags released at Cottonwood were likely fewer than 3,997 due to un-scanned mortalities in the acclimation pond.*

[b] *Percent of PIT tag release groups that migrated to Lower Granite Dam are Cormack-Jolly-Seber estimated survival probabilities. Values exceeding 100% occur when true survival is close to 100% and/or when PIT tag detection variability is high (Smith et al. 2000). Not shown in table is the number of PIT tags released and percent migration to LGD for the Lyons Ferry release group (N = 3,971, 79.6 ± 4.7).*

[c] *This release group was indistinguishable based on external marks from other groups in the same acclimation pond, therefore unique size measurements could not be taken.*

[d] *There was no volitional release period for these release groups in 2017. Smolts were forced out early (16 March 2017) due to flood conditions in Deer Creek.*

[e] *Percent migration to LGD was calculated from PIT tags in raceways 30 and 32..*

Table 4. Density (±95% confidence interval) and mean fork length (standard deviation in parentheses) of residual hatchery steelhead, wild rainbow trout/juvenile steelhead, and juvenile Chinook salmon from index sites on Deer (Grande Ronde basin) and Little Sheep (Imnaha basin) creeks in 2017. Hatchery steelhead were classified as residuals after 20 June. HSTS indicates residual hatchery steelhead, WSTS indicates wild rainbow trout/juvenile steelhead for ages one and older, and WChS indicates juvenile (age 0+) spring Chinook salmon.

Location[a]	Date	Species	Area (m^2)	Size of fish (mm)			Density[b] (fish/100m^2)
				N	Fork length	Range	
Grande Ronde basin							
Deer Cr.	26 July	HSTS	326.2	22	192.0 (24.6)	148-234	8.0 ± 0.9
Deer Cr.	26 July	WSTS	326.2	46	100.7 (23.1)	68-150	18.4 ± 4.4
Deer Cr.	26 July	WChS	326.2	6	79.6 (5.2)	74-86	na
Imnaha basin							
Little Sheep Cr.	25 July	HSTS	511.9	54	146.7 (35.0)	94-237	11.5 ± 0.3
Little Sheep Cr.	25 July	WSTS	511.9	12	113.3 (11.0)	91-134	1.5 ± 1.1

[a] *Index sites located on Deer Creek (Rkm 0.1) at Big Canyon Facility and on Little Sheep Creek (Rkm 8.0) at Little Sheep Creek Facility. Two adjacent sites were sampled at each location and each site typically included both riffle and pool habitat.*

[b] *Density (±95% confidence interval) was determined using a multiple pass removal method (Zippen 1958) with a backpack electrofisher (Smith-Root Model 12) and block seines.*

Table 5. Number of PIT tags released and unique adult PIT tag detections at Bonneville and Lower Granite dams during the 2016-17 run year by stock and brood year.

Brood year	PIT tags released	Age at return	Adult Detections	
			Bonneville Dam	Lower Granite Dam
Wallowa Stock				
2012	21,875	5	0	0
2013	22,224	4	181	126
2014	26,619	3	40	30
Total	70,718		221	156
Imnaha Stock				
2012	21,882	5	1	0
2013	21,897	4	129	73
2014	14,899	3	68	18
Total	58,678		198	91

Table 6. Timing of adult steelhead returns to LSRCP facilities in 2017 by location and origin.

Period	Week of the year	Number of fish trapped[a]					
		Wallowa		Big Canyon		Little Sheep	
		Hatchery	Natural	Hatchery	Natural	Hatchery	Natural
Jan 22-28	4	-	-	-	-	-	-
Jan 29-Feb 04	5	-	-	-	-	-	-
Feb 05-11	6	-	-	-	-	-	-
Feb 12-18	7	0	0	0	0	0	0
Feb 19-25	8	50	0	284	3	0	0
Feb 26-Mar 04	9	38	0	87	0	5	0
Mar 05-11	10	191	4	474	3	19	0
Mar 12-18	11	340	0	498	4	111	2
Mar 19-25	12	311	2	215	5	157	8
Mar 26-Ap 01	13	202	1	7	8	89	8
Apr 02-Apr 08	14	165	0	186	5	94	12
Apr 09-15	15	128	0	83	3	75	4
Apr 16-22	16	57	1	74	2	83	4
Apr 23-29	17	20	0	68	1	21	3
Apr 30-May 06	18	8	1	25	2	38	5
May 07-13	19	7	1	0	1	11	2
May 14-20	20	0	0	0	0	2	2
May 21-27	21	0	0	0	0	3	1
May 28-June 03	22	-	-	-	-	0	0
Jun 04-10	23	-	-	-	-	-	-
Jun 11-17	24	-	-	-	-	-	-
June 18-24	25	-	-	-	-	-	-
Total		1,517[b]	10	2,001[c]	37[d]	708	51

[a] *The ladder was opened on 16 February at Wallowa Fish Hatchery, and weirs were installed 17 February at Big Canyon Facility (Deer Creek) and 17 February at Little Sheep Creek Facility. Adult collections ended 22 May at Wallowa Fish Hatchery, 23 May at Big Canyon Facility, and 1 June at Little Sheep Creek Facility.*

[b] *An additional 11 fish were taken from the Grande Ronde River by angling the week of 15 October, 2016, for the Fall Brood program.*

[c] *Does not include 30 hatchery-origin steelhead collected dead on Deer Creek weir. On March 16, extremely high water necessitated removal of some Deer Creek weir panels. Also on March 16, panels were put in place at the intake (~100 meters upstream of the weir) to prevent fish that escaped into the creek from migrating further upstream. Weir panels were reinstalled on March 23. During the six-day breach of the weir an unknown number of hatchery steelhead passed the weir site and likely spawned in Deer Creek. After these fish expired, their carcasses floated downstream and were intercepted on the weir.*

[d] *Does not include nine natural-origin steelhead collected dead on Deer Creek weir. On March 16, extremely high water necessitated removal of some Deer Creek weir panels. Also on March 16, panels were put in place at the intake (~100 meters upstream of the weir) to prevent fish that escaped into the creek from migrating further upstream. Weir panels were reinstalled on March 23. During the six-day breach of the weir an unknown number of natural steelhead passed the weir site and likely spawned in Deer Creek. After these fish expired, their carcasses floated downstream and were intercepted on the weir.*

Table 7. Number, disposition, and mean fork length (mm) of adult steelhead that returned to LSRCP facilities in 2017 by stock, origin, estimated age (freshwater:saltwater), and gender. M indicates male and F indicates female.

Facility, stock, disposition	Hatchery[a]									Natural[b]											Grand total
	1:1		1:2		2:1		1:3			2:1		2:2		2:3		3:1		3:2			
	M	F	M	F	M	F	M	F	Total	M	F	M	F	M	F	M	F	M	F	Total	
Wallowa Hatchery (Wallowa Stock-Production)																					
Trapped	119	71	334	522	1	0	0	0	1,047	0	2	1	4	0	0	0	1	1	1	10	1,057
Passed	0	0	0	0	0	0	0	0	0	0	2	1	4	0	0	0	1	1	1	10	10
Outplanted	9	4	20	16	0	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	49
Kept	110	67	314	506	1	0	0	0	998	0	0	0	0	0	0	0	0	0	0	0	998
Mortality	2	0	4	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	6
Spawned	5	0	108	116	0	0	0	0	229	0	0	0	0	0	0	0	0	0	0	0	229
Killed[c]	103	67	202	390	1	0	0	0	763	0	0	0	0	0	0	0	0	0	0	0	763
Wallowa Hatchery (Wallowa Stock-Fallbrood)																					
Trapped	84	49	120	211	2	0	2	0	468	0	0	0	0	0	0	0	0	0	0	0	468
Passed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outplanted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kept	84	49	120	211	2	0	2	0	468	0	0	0	0	0	0	0	0	0	0	0	468
Mortality	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Spawned	38	10	79	105	0	0	1	0	233	0	0	0	0	0	0	0	0	0	0	0	233
Killed[c]	46	39	39	106	2	0	1	0	233	0	0	0	0	0	0	0	0	0	0	0	233
Wallowa Hatchery (Total Returns)																					
Trapped	203	120	454	733	3	0	2	0	1,515	0	2	1	4	0	0	0	1	1	1	10	1,525
Fork length (mm)	574	569	704	675	-	-	-	-		-	-	-	-	-	-	-	-	-	-		
Standard deviation	39	39	43	36	-	-	-	-		-	-	-	-	-	-	-	-	-	-		
Sample size	40	32	47	60	-	-	-	-		-	-	-	-	-	-	-	-	-	-		
Wallowa Hatchery (Fall Broodstock)																					
Transferred to WFH	3	1	2	5	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	11
Passed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outplanted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kept	3	1	2	5	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	11
Mortality	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Spawned	3	1	2	4	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
Killed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7. Continued.

Facility, stock, Disposition	Hatchery[a] 1:1 M	1:1 F	1:2 M	1:2 F	2:1 M	2:1 F	1:3 M	1:3 F	Total	Natural[b] 2:1 M	2:1 F	2:2 M	2:2 F	3:1 M	3:1 F	3:2 M	3:2 F	4:1 M	4:1 F	Total	Grand Total
Big Canyon Facility (Wallowa stock)																					
Trapped[d]	116	98	544	1,269	2	0	2	0	2,031	0	3	11	15	3	2	5	7	0	0	46	2,077
Passed[d]	6	5	22	43	0	0	0	0	76	0	3	11	15	3	2	5	7	0	0	46	122
Outplanted	9	8	48	99	0	0	0	0	164	0	0	0	0	0	0	0	0	0	0	0	164
Kept	101	85	474	1,127	2	0	2	0	1,791	0	0	0	0	0	0	0	0	0	0	0	1,791
Mortality	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawned	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Killed[c]	101	85	474	1,127	2	0	2	0	1,791	0	0	0	0	0	0	0	0	0	0	0	1,791
Fork length (mm)	581	551	773	630	-	-	-	-		-	-	703	692	550	-	-	-	-	-		
Standard deviation	36	21	15	8	-	-	-	-		-	-	41	25	-	-	-	-	-	-		
Sample size	3	7	8	2	-	-	-	-		-	-	2	2	1	-	-	-	-	-		
Little Sheep Creek Facility (Imnaha stock)																					
Trapped	106	99	98	405	0	0	0	0	708	4	10	4	31	0	0	0	2	0	0	51	759
Passed[e]	30	29	23	82	0	0	0	0	164	4	7	3	29	0	0	0	2	0	0	45	209
Outplanted	12	13	10	56	0	0	0	0	91	0	0	0	0	0	0	0	0	0	0	0	91
Kept	64	57	65	267	0	0	0	0	453	0	3	1	2	0	0	0	0	0	0	6	459
Mortality	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
Spawned[f]	30	3	33	59	0	0	0	0	125	0	3	1	1	0	0	0	0	0	0	5	130
Killed[c g]	34	54	32	208	0	0	0	0	328	0	0	0	0	0	0	0	0	0	0	0	328
Fork length (mm)	587	622	696	678	-	-	-	-		537	588	708	669	-	-	-	701	-	-		
Standard deviation	35	15	47	36	-	-	-	-		104	72	30	33	-	-	-	-	-	-		
Sample size	9	3	14	24	-	-	-	-		3	3	2	22	-	-	-	1	-	-		

[a] *Wallowa and Imnaha stock ages apportioned using CWT data and 179 (Wallowa stock) and 50 (Imnaha stock) scale samples collected in 2017. Mean fork lengths are from fish with scale samples collected in 2017.*

[b] *Ages of natural steelhead from the Wallowa basin were apportioned using historical data (246 samples) and 2017 data (5 samples); Little Sheep Creek Facility natural steelhead ages apportioned using 2016 data (91 samples) and 2017 data (31 samples). Mean fork lengths are from fish with scale samples collected in 2017.*

[c] *For Wallowa stock steelhead, 1,395 fish (254 from Wallowa Hatchery and 1,141 from Big Canyon Facility) were euthanized and donated to local food banks, 150 fish (89 from Wallowa and 61 from Big Canyon) were euthanized and used for educational purposes. An additional 297 fish were used for stream enrichment: 73 from Wallowa and 224 from Big Canyon. Of the 73 Wallowa fish, 45 had been spawned prior to use for enrichment. For Imnaha stock steelhead, 166 fish from Little Sheep Creek Facility were euthanized and donated to local food banks, and 273 fish were used for stream enrichment, including 122 fish that had been spawned prior to use for enrichment.*

[d] *Includes 76 hatchery and 10 natural steelhead sampled as fallbacks, or fish that passed above the weir without being trapped, spawned naturally in Deer Creek, and died.*

[e] *Includes one 439 mm hatchery male which most likely did not migrate to the ocean; as no scales were taken to provide evidence either way, so is included here as an anadromous adult.*

[f] *Includes 7 hatchery males and 1 natural male that were live-spawned and passed above the weir. Also, 6 hatchery males were live-spawned, then spawned again at a later date.*

[g] *Includes 3 hatchery males and 12 hatchery females that were initially outplanted to Big Sheep Creek. These 15 fish were subsequently recaptured at the weir and euthanized. One of these males was spawned prior to being euthanized.*

Table 8. Number of adult summer steelhead trapped at the Little Sheep Creek Facility weir that were either outplanted to Big Sheep Creek or passed above the weir, and were subsequently recaptured, 1999-2017.

	Big Sheep Creek			Little Sheep Creek		
	Number of fish		%	Number of fish		%
Year	Outplanted	Recaptured[a]	Recaptured[b]	Passed[c]	Recaptured[a]	Recaptured[b]
1999	42	6	14.3	80	1	1.3
2000	138	17	12.3	200	9	4.5
2001	354	48	13.6	784	89	11.4
2002	2,030	907	44.7	1,198	269	22.5
2003	1,403	439	31.3	387	36	9.3
2004	1,719	244	14.2	823	138	16.8
2005	1,555	109	7.0	461	37	8.0
2006	1,934	703	36.3	356	53	14.9
2007	1,315	168	12.8	241	14	5.8
2008	1,365	382	28.0	291	23	7.9
2009	869	394	45.3	281	15	5.3
2010	1,450	166	11.4	346	6	1.7
2011	401	154	38.4	306	2	0.7
2012	350	175	50.0	241	13	5.4
2013	58	5	8.6	245	20	8.2
2014	232	29	12.5	270	1	0.4
2015	362	10	2.8	147	1	0.7
2016	515	21	4.1	260	1	0.4
2017	106	16	15.1	217	11	5.1
Mean	-	-	21.2	-	-	6.8

[a] *Total number of recaptures, including multiple recaptures. For 1999-2002, recaptures were opercle punched at the weir and second and third time recaptures recorded.*

[b] *Total recaptured divided by total outplanted.*

[c] *Includes natural males that were live-spawned and passed above the weir.*

Table 9. Summary of summer steelhead spawning surveys in Deer Creek above the Big Canyon Facility weir, 2002-2017. Note that data for 2005 has been updated to reflect an adjusted number of fish passed above the weir. The abbreviation "na" indicates incomplete counts so data are not available.

Year	Passed			Redds counted	Fish per redd	Females per redd	% Redds counted[a]	Redds per mile[b]
	Females	Males	Total					
2002	120	89	209	84	2.49	1.43	70	8.4
2003	92	48	140	64	2.19	1.44	70	6.4
2004	47	20	67	46	1.46	1.02	98	4.6
2005	42	35	76	35	2.20	1.20	83	3.5
2006[c]	55	41	96	58	1.66	0.95	105	5.8
2007	27	21	48	41	1.17	0.66	152	4.1
2008	23	38	61	15	4.07	1.53	65	1.5
2009	42	38	80	21	3.81	2.00	50	2.1
2010	85	49	134	84	1.60	1.01	99	8.4
2011	75	58	133	28	4.75	2.68	37	2.8
2012	34	34	69	22	3.09	1.54	65	2.2
2013	41	22	63	33	1.91	1.24	80	3.3
2014[d]	18	30	48	18	2.67	1.00	100	1.8
2015[e]	34	32	66	49	1.35	0.69	144	4.9
2016	53	29	82	63	1.30	0.84	119	6.3
2017[f]	22	14	36	na	3.51[g]	na	na	na

[a] *Calculated as number of redds counted ÷ number of females passed x 100. Assumes each female built one redd.*

[b] *Twelve miles of stream were surveyed in 2002, 2003, 2007-2010, and in 2012-2015 Ten miles of stream were surveyed in 2004-06 and in 2011. Redds per mile are based on the lower ten miles, since redds have not been observed between RM 10-12.*

[c] *Includes an estimated seven additional hatchery steelhead (4 females and 3 males) that escaped above the weir prior to weir installation, based on marked and unmarked fallbacks at weir.*

[d] *Includes an estimated 3 additional hatchery steelhead (1 female and 2 males) that escaped above the weir prior to weir installation. However, the total passed column does not include 3 steelhead passed above the weir after May 16, 2014 because stream surveys were discontinued prior to that date.*

[e] *Estimate includes 9 additional steelhead (5 males, 4 females) that escaped above the weir prior to installation in February, based on marked and unmarked fallbacks recovered at the weir.*

[f] *Deer Creek weir was installed on 17 February, 2017. On March 16, extremely high water necessitated removal of some weir panels. Also on March 16, panels were placed at the intake (~100 meters upstream of the weir) to prevent fish that escaped into Deer Creek from migrating further upstream. Weir panels were reinstalled on March 23. During the six-day breach of the weir an unknown number of hatchery and wild steelhead passed above the weir and likely spawned in Deer Creek.*

[g] *In lieu of the normal multi-pass redd surveys and weir counts, we used total discharge at Perry gauge in the Upper Grande Ronde River (station #13318960) from March through May to calculate the fish:redd estimate for 2017. Since Deer Creek's fish:redd ratio in prior years was significantly correlated with total discharge from the Perry gauge, we deemed this regression an appropriate estimator of fish:redd when Deer Creek weir operates below 100% efficiency, as it did in 2017.*

Table 10. Spawning summaries for summer steelhead at LSRCP facilities in 2017. The percent mortality is from green egg to eyed embryo after shocking.

Spawn date, lot number	Parental origin[a]	Number of females spawned[b]	Number of eggs	Eyed embryos[c]	% mortality
		Wallowa Hatchery (Wallowa stock)			
3/1, WA540	Production	0	0	0	-
	Fall Broodstock	13	65,400	56,800	13.1
3/8, WA541	Production	16	93,100	91,100	2.1
	Fall Broodstock	29	150,800	140,100	7.1
3/15, WA542	Production	22	134,800	130,000	3.6
	Fall Broodstock	32	141,000	127,100	9.9
3/22, WA543	Production	26	173,900	166,300	4.4
	Fall Broodstock	33	180,800	171,800	5.0
3/29, WA544	Production	22	151,700	143,200	5.6
	Fall Broodstock	10	67,600	57,600	14.8
4/5, WA545	Production	18	119,100	107,500	9.7
	Fall Broodstock	5	30,500	27,900	8.5
4/12, WA546	Production	10	66,200	63,200	4.5
	Fall Broodstock	0	0	0	-
Subtotal	Production	114	738,800	701,300	5.1
	Fall Broodstock	122	636,100	581,300	8.6
Total		236	1,374,900	1,282,600	6.7
		Little Sheep Creek Facility (Imnaha stock)[d]			
3/21, LI640	Hatchery	5	26,700	25,300	5.2
	Mixed		0		
3/28, LI641	Hatchery	5	31,400	30,500	2.9
	Mixed		0		
4/04, LI642	Hatchery	7	37,371	37,100	14.9
	Mixed		6,229		
4/11, LI643	Hatchery	15	83,253	81,700	8.4
	Mixed		5,947		
4/18, LI644	Hatchery	14	81,300	78,000	4.1
	Mixed		0		
4/25, LI645	Hatchery	15	69,360	78,600	9.3
	Mixed		17,340		
5/2, LI646	Hatchery	5	32,900	25,800	21.6
	Mixed		0		
Subtotal	Hatchery	66	362,284	357,000	8.9
	Mixed		29,516		
Total		66	391,800	357,000	8.9

[a] *In general, family groups were one male x one female for Wallowa stock and were matrix spawned (three males x three females) for Imnaha stock.*

[b] *Number of males spawned equals the number of females spawned in most cases. Imnaha stock numbers of males and females spawned may differ due to the use of matrix spawning.*

[c] *Includes 1,200 Wallowa production stock eyed embryos that were transferred to the Salmon and Trout Enhancement Program (STEP). Also includes 199,000 eyed embryos from Wallowa Production, 75,900 eyed embryos from Wallowa Fall Broodstock, and 43,200 eyed embryos from Little Sheep (Imnaha stock) that were euthanized because they were excess to program needs.*

[d] *Hatchery and Mixed refer to ancestry of viable eggs. "Mixed" eggs include both natural and hatchery parents. Number of females spawned is listed on "Hatchery" row, regardless of origin.*

.

Table 11. Summary of anadromous adult recoveries of coded-wire tagged (CWT) Wallowa stock summer steelhead for the 2016-17 run year. All CWT fish were of hatchery origin and were released into Deer Creek (at Big Canyon Facility), Spring Creek (at Wallowa Hatchery), or Cottonwood Creek, WA (at the Cottonwood Acclimation Pond) for the reciprocal study with WDFW's Lyons Ferry Hatchery. Beginning with the 2016-17 run year, CWT sampling in many Idaho fisheries was reduced; thus, harvest estimates for Wallowa stock steelhead were based on Parentage Based Tagging (PBT) samples and Idaho harvest card returns (Chuck Warren, personal communication). Data were summarized as available through August 2019.

Brood year, release site	Experimental group[a]	CWT code	Recoveries at weirs[b]	Other in-basin recoveries[c]	Out-of-basin recoveries[d]	Total recoveries
2012						
Spring Cr.	Fallbrood, April	090557	1	0	0	1
2013						
Deer Cr.	Production, April	092745	154	13	52	219
	Fallbrood, April	090779	66	6	32	104
	Production, May	090780	163	9	34	206
Spring Cr.	Production, April	090772	70	9	66	145
	Production, April	090775	69	9	68	146
	Production, April	090777	82	11	59	152
	Production, May	090776	81	10	71	162
	Fallbrood, April	090771	37	1	44	82
	Fallbrood, April	090774	39	7	64	110
	Fallbrood, May	090773	32	0	60	92
2014						
Deer Cr.	Production, April	090814	12	0	0	12
	Fallbrood, April	090813	24	11	9	44
	Fallbrood, May	090815	6	0	0	6
Spring Cr.	Production, April	090808	13	0	1	14
	Production, April	090809	9	0	18	27
	Production, April	090810	11	0	0	11
	Production, May	090811	4	5	5	14
	Fallbrood, April	090806	20	5	39	64
	Fallbrood, May	090807	6	0	2	8
	Total recoveries		899	96	624	1,619
2014						
Cottonwood Cr., WA	Reciprocal, April	090812	0	0	5	5
	Total recoveries		0	0	5	5

[a] *Experimental groups include the release strategy. All releases were targeted for four fish per pound (113 g/fish). All fish were acclimated. April releases were forced (over a 24-hour period) and May releases were volitional (1-3 weeks) unless otherwise noted.*

[b] *Actual number of CWT fish that were released into Spring Creek and recovered at the Wallowa Hatchery weir or released into Deer Creek and recovered at the Big Canyon Facility weir. The protocol was to collect all CWT fish at the weirs for sampling at the hatchery during spawning. Recoveries of CWT fish at the Cottonwood Creek, WA weir are incomplete at time of printing this report.*

[c] *Estimated number (from creel surveys and harvest card returns) of CWT fish that were harvested in the Grande Ronde River basin fisheries, and in-basin stray recoveries.*

[d] *Estimated number (from PSMFC and ODFW databases) of CWT fish that were recovered in the ocean, mainstem Columbia, Deschutes or Snake river fisheries, or in tributaries outside the Grande Ronde River basin. Unexpanded data were used when CWT expansion factors were 25 or greater due to low sampling rates.*

Table 12. Summary of anadromous adult recoveries of coded-wire tagged (CWT) Imnaha stock summer steelhead for the 2016-17 run year. All CWT fish were of hatchery origin and were released into Little Sheep Creek at the Little Sheep Creek Facility. Beginning with the 2016-17 run year, CWT sampling in many Idaho fisheries was reduced; thus, harvest estimates for Wallowa stock steelhead were based on Parentage Based Tagging (PBT) samples and Idaho harvest card returns (Chuck Warren, personal communication). Data were summarized as available through August 2019.

Brood year, release site	Experimental group[a]	CWT code	Recoveries at weirs[b]	Other in-basin recoveries[c]	Out-of-basin recoveries[d]	Total recoveries
2013						
Little Sheep	Production, April	090770	32	0	27	59
2014						
Little Sheep	Production, April	090805	11	0	4	15
	Total recoveries		43	0	31	74

[a] *Experimental groups include the release strategy. All Little Sheep fish were acclimated and volitionally released over a four-week period.*

[b] *Estimated number of CWT fish recovered at the Little Sheep Creek Facility weir based on actual number recovered at the weir and estimated number either passed above the weir to Little Sheep Creek or outplanted to Big Sheep Creek to spawn naturally.*

[c] *Estimated number (from creel surveys and harvest card returns) of CWT fish that were harvested in the Imnaha River basin fishery.*

[d] *Estimated number (from PSMFC and ODFW databases) of CWT fish that were recovered in the ocean, mainstem Columbia, Deschutes or Snake river fisheries, or in tributaries outside the Imnaha River basin. Unexpanded data were used when CWT expansion factors were 25 or greater due to low sampling rates.*

Table 13. Harvest and escapement distribution of adult summer steelhead by recovery location for the 2016-17 run year using the PSMFC and ODFW mark recovery databases, and Parentage-Based Tagging (PBT) harvest estimates from Idaho fisheries. Beginning with the 2016-17 run year, harvest estimates from Idaho waters were based on Idaho harvest card returns and PBT creel samples rather than CWT recoveries (Chuck Warren, personal communication). "C and S" indicates ceremonial and subsistence tribal fisheries. Data were summarized as available through August 2019. "-" indicates not sampled or undefined.

	Wallowa Stock			Imnaha Stock		
Location	Estimated CWT recoveries	Total return	Percent of total return	Estimated CWT recoveries	Total return	Percent of total return
Ocean harvest	0	0	0.0	0	0	0.0
Columbia River harvest						
Treaty net	204	676	9.0	19	179	12.0
C and S	0	0	0.0	0	0	0.0
Sport	139	421	5.6	7	70	4.7
Test	0	0	0.0	0	0	0.0
Tributary sport	73	286	3.8	0	0	0.0
Deschutes River harvest						
Sport	27	97	1.3	0	0	0.0
C and S	0	0	0.0	0	0	0.0
Strays						
Outside Snake R. basin	12	32	0.5	0	0	0.0
Within Snake R. basin*	0	0	0.0	0	0	0.0
Snake River sport, tribs. harvest*	169	538	7.2	5	47	3.2
Idaho harvest from PBT samples*	-	1,192	15.9	-	446	29.9
Oregon tributary harvest* [a]	96	706	9.4	0	42	2.8
Hatchery weir* [b]	899	3,546	47.3	43	708	47.4
Total estimated return	1,619	7,494	100	74	1,492	100
Return to compensation area		5,983			1,243	
Percent of compensation goal		65.1			62.2	

** Indicates areas defining the compensation area. The compensation goal for Wallowa stock is 9,184 adults and the goal for Imnaha stock is 2,000 adults.*

[a] Harvest in Oregon tributaries are estimates based on angler surveys and harvest card returns.

[b] Total returns to the hatchery weir are actual numbers, except for the Imnaha stock where we estimated the number of CWT fish recovered at the Little Sheep Creek Facility weir. This estimate is based on the actual number of CWT fish recovered at the weir and estimated number either passed above the weir to Little Sheep Creek or outplanted to Big Sheep Creek to spawn naturally.

Table 14. Harvest and escapement distribution of adult summer steelhead by age and recovery location for the 2016-17 run year using the PSMFC and ODFW mark recovery databases, and Parentage-Based Tagging (PBT) harvest estimates from Idaho fisheries. Beginning with the 2016-17 run year, harvest estimates from Idaho waters were based on Idaho harvest card returns and PBT creel samples rather than CWT recoveries (Chuck Warren, personal communication). "C and S" indicates ceremonial and subsistence tribal fisheries. Data were summarized as available through August 2019.

	Total returns by age							
	Wallowa Stock				Imnaha Stock			
Location	Age 3	Age 4	Age 5	Total	Age 3	Age 4	Age 5	Total
Ocean harvest	0	0	0	0	0	0	0	0
Columbia River harvest								
Treaty net	70	606	0	676	0	179	0	179
C and S	0	0	0	0	0	0	0	0
Sport	67	354	0	421	42	28	0	70
Test	0	0	0	0	0	0	0	0
Tributary sport	121	165	0	286	0	0	0	0
Deschutes River harvest								
Sport	26	71	0	97	0	0	0	0
C and S	0	0	0	0	0	0	0	0
Strays								
Outside Snake R. basin	2	30	0	32	0	0	0	0
Within Snake R. basin*	0	0	0	0	0	0	0	0
Snake River sport, tribs. harvest*	45	493	0	538	0	47	0	47
Idaho harvest from PBT samples*	186	1,006	0	1,192	72	374	0	446
Oregon tributary harvest*[a]	94	612	0	706	15	27	0	42
Hatchery weir* [b]	537	3,005	4	3,546	205	503	0	708
Total estimated return	1,148	6,342	4	7,494	334	1,158	0	1,492

** Indicates areas defining the compensation area. The compensation goal for Wallowa stock is 9,184 adults and the goal for Imnaha stock is 2,000 adults.*

[a] *Total returns to Oregon tributaries are harvest estimates based on angler surveys and harvest card returns.*

[b] *Total returns to the hatchery weir are actual numbers, except for the Imnaha stock where we estimated the number of CWT fish recovered at the Little Sheep Creek Facility weir. This estimate is based on the actual number of CWT fish recovered at the weir and estimated number either passed above the weir to Little Sheep Creek or outplanted to Big Sheep Creek to spawn naturally.*

Table 15. Distribution of parentage-based tagging (PBT) genetic samples assigned to NE Oregon steelhead during the 2016-17 run year by stock, river, sample collection location, and fishery. Also shown are the total number of samples in pertinent major sample collections, and of these samples, the number that assigned back to any steelhead stock. Data provided by Jesse McCane, Eagle Fish Genetics Laboratory, and summarized as available through August 2019.

	Wallowa Stock[a]		Imnaha Stock		Samples Taken	
River and sample collection location	Fishery	Number	Fishery	Number	Total	Assigned
Columbia River						
Below Bonneville (WN Sec 1-10)	Sport	61	Sport	8	-	-
Bonneville Pool	Sport	1	Sport	0	-	-
Wind River	Sport	1	Sport	0	-	-
Drano Lake/Little White Salmon	Sport	67	Sport	6	-	-
Lake Wallula	Sport	7	Sport	0	-	-
Total Columbia River Sport	Sport	137	Sport	14	1,452	1,012
Total Columbia River Tribal (Zone 6)[b]	Tribal	89	Tribal	12	1,889	1,307
Total Columbia River, All Fisheries	All	226	All	26	3,341	2,319
Total Mouth of Deschutes Sport[c]	Sport	9	Sport	1	69	63
Snake River, Washington*						
Mouth to ID/WA border*	Sport	25	Sport	5	-	-
Grande Ronde River Sport (WA)*	Sport	3	Sport	0	-	-
ID/WA border to WA/OR border*	Sport	45	Sport	4	-	-
Total Snake River Sport, Washington*	Sport	73	Sport	9	542	505
Snake River, Idaho*						
Clearwater River*	Sport	16	Sport	11	524	228
Salmon River*	Sport	2	Sport	2	332	296
ID/WA border to Hells Canyon*	Sport	37	Sport	33	360	284
Total Snake River Sport, Idaho*	Sport	55	Sport	46	1,216	808
Total NE Oregon-origin samples		363		82	5,168	3,695
Samples from Compensation area*		128		55	1,758	1,313

** Indicates areas defining the compensation area.*

[a] *"Wallowa Stock" as used in this table refers only to Wallowa stock steelhead produced in NE Oregon, and does not include Wallowa stock steelhead from the Lyons Ferry complex, Washington.*

[b] *Zone 6 encompasses the Columbia River from Bonneville to McNary.*

[c] *All "Mouth of Deschutes" samples were collected by Oregon samplers; Columbia River samples were collected by Washington samplers and thus, are treated as separate sample collections.*

REFERENCES

Byrne, A., J. Hymer, S. Ellis, R. Dick II, K. Keller, C. A. Steele, M. Begay, and T. Miller. 2018. A genetic analysis of the summer steelhead stock composition in the Columbia River and Snake River tribal and sport fisheries from June 2016 to March 31, 2017. Idaho Department of Fish and Game, Report 18-108, Boise.

Carmichael, R. W. 1989. Lower Snake River Compensation Plan - Oregon evaluation studies, five-year study plan. Oregon Department of Fish and Wildlife, Fish Research Project, Portland.

Carmichael, R. W., and E. J. Wagner. 1983. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Oregon Department of Fish and Wildlife, Fish Research Project 14-16-0001-83269, Annual Progress Report, Portland.

Carmichael, R. W., and R. T. Messmer. 1985. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Oregon Department of Fish and Wildlife, Fish Research Project FRI/LSR-86-35, Annual Progress Report, Portland.

Carmichael, R. W., B. A. Miller, and R. T. Messmer. 1986a. Lower Snake River Compensation Plan - Oregon evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Project FRI/LSR-86-35, Annual Progress Report, Portland.

Carmichael, R. W., R. Boyce, and J. Johnson. 1986b. Grande Ronde River Spring Chinook Production Report (U.S. v. Oregon). Oregon Department of Fish and Wildlife, Portland.

Carmichael, R. W., R. T. Messmer, and B. A. Miller. 1987. Lower Snake River Compensation Plan - Oregon evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Project FRI/LSR-88-16. Annual Progress Report, Portland.

Carmichael, R. W., R. T. Messmer, and B. A. Miller. 1988a. Lower Snake River Compensation Plan - Oregon evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Project AFFI/LSR-90-17. Annual Progress Report, Portland.

Carmichael, R. W., B. A. Miller, and R. T. Messmer. 1988b. Summer steelhead creel surveys in the Grande Ronde, Wallowa, and Imnaha rivers for the 1987-88 run year. Oregon Department of Fish and Wildlife, Fish Research Project AFFI-LSR-89-02. Annual Progress Report, Portland.

Carmichael, R. W., M. W. Flesher, and R. T. Messmer. 1989. Summer steelhead creel surveys in the Grande Ronde, Wallowa, and Imnaha rivers for the 1988-89 run year. Oregon Department of Fish and Wildlife, Fish Research Project AFFI-LSR-90-12. Annual Progress Report, Portland.

Carmichael, R. W., M. W. Flesher, and R. T. Messmer. 1990. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1989-90 run year. Oregon Department of Fish and Wildlife, Fish Research Project AFFI-LSR-91-12. Annual Progress Report, Portland.

Carmichael, R. W., D. L. Eddy, M. W. Flesher, M. Keefe, P. J. Keniry, S. J. Parker, and T .A. Whitesel. 1999. Lower Snake River Compensation Plan: Oregon evaluation studies. Oregon Department of Fish and Wildlife, 1994 Annual Progress Report, Portland.

Carmichael, R. W., D. L. Eddy, M. W. Flesher, T. L. Hoffnagle, P. J. Keniry, and J.R. Ruzycki. 2004. Lower Snake River Compensation Plan: Oregon evaluation studies. Oregon Department of Fish and Wildlife, 1995 and 1996 Bi-Annual Progress Report, Portland.

Carmichael, R. W., D .L. Eddy, M. W. Flesher, G. C. Grant, J. R. Ruzycki, and G. R. Vonderohe. 2005a. Lower Snake River Compensation Plan: Oregon summer steelhead evaluation studies. Oregon Department of Fish and Wildlife, 1997 and 1998 Bi-Annual Progress Report, Portland.

Carmichael, R .W., D. L. Eddy, M. W. Flesher, G. C. Grant, J. R. Ruzycki and G. R. Vonderohe. 2005b. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 1999 and 2000 Bi-Annual Progress Report, Portland.

Carmichael, R. W., and T. L. Hoffnagle. 2012. Lower Snake River Compensation Plan: Oregon evaluation studies. Work Statement submitted to the U.S. Fish and Wildlife Service, Contract Number F13AC00034. Lower Snake River Compensation Plan Office, Boise, ID.

Carmichael, R. W., T. L. Hoffnagle, and L .R. Clarke. 2013. Lower Snake River Compensation Plan: Oregon evaluation studies. Work Statement submitted to the U.S. Fish and Wildlife Service, Contract Number F14AC00042. Lower Snake River Compensation Plan Office, Boise, ID.

Clarke, L. R., M. W. Flesher, T. A. Whitesel, G. R. Vonderohe, and R. W. Carmichael. 2010. Post-release performance of acclimated and direct-released hatchery summer steelhead into Oregon tributaries of the Snake River. North American Journal of Fisheries Management 30:1098-1109.

Clarke, L. R., M. W. Flesher, S. M. Warren, and R. W. Carmichael. 2011. Survival and straying of hatchery steelhead following forced or volitional release. North American Journal of Fisheries Management 31:116-123.

Clarke, L. R., M. W. Flesher, S. M. Warren, and R. W. Carmichael. 2012. Performance of a new steelhead line derived from hatchery parents collected in autumn in the Grande Ronde River. Oregon Department of Fish and Wildlife, 203 Badgley Hall, Eastern Oregon University, La Grande, Oregon.

Clarke, L. R., M. W. Flesher, and R. W. Carmichael. 2014. Hatchery steelhead smolt release size effects on adult production and straying. North American Journal of Aquaculture 76:39-44.

Clarke, L R., M.W. Flesher, S.M. Warren, D. L. Eddy, and R.W. Carmichael. 2014. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2012 Annual Progress Report, Salem.

Clarke, L. R., M. W. Flesher, H. M. Stanton, D. L. Eddy, and R.W. Carmichael. 2015. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2013 Annual Progress Report, Salem.

Clarke, L. R., M. W. Flesher, W. J. Knox, and R. W. Carmichael. 2017. Increased harvest of anadromous hatchery steelhead *Oncorhynchus mykiss* (Walbaum) through return timing manipulation. Fisheries Management and Ecology 24: 274-282.

Clarke, L .R., H. M. Stanton, M. W. Flesher, D. L. Eddy, and R. W. Carmichael. 2017. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2015 Annual Progress Report, Salem.

Flesher, M. W., R.W. Carmichael, and R. T. Messmer. 1991. Summer steelhead creel surveys in the Grande Ronde, Wallowa, and Imnaha rivers for the 1990-91 run year. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-92-09. Annual Progress Report, Portland.

Flesher, M. W., M. A. Buckman, R.W. Carmichael, R. T. Messmer, and T .A. Whitesel. 1992. Summer steelhead creel surveys in the Grande Ronde, Wallowa, and Imnaha rivers for the 1991-92 run year. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-LSR-94-07. Annual Progress Report, Portland.

Flesher, M. W., M .A. Buckman, R.W. Carmichael, R. T. Messmer, and T .A. Whitesel. 1993. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1992-93 run year. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-LSR-94-14. Annual Progress Report, Portland.

Flesher, M. W., M. A. Buckman, R.W. Carmichael, R .T. Messmer, and T .A. Whitesel. 1994. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1993-94 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R.W. Carmichael, and T.A. Whitesel. 1995. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1994-95 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R. W. Carmichael, and T. A. Whitesel. 1996. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1995-96 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R. W. Carmichael, and T. A. Whitesel. 1997. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1996-97 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R. W. Carmichael, and T. A. Whitesel. 1999. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1997-98 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R. W. Carmichael, T. A. Whitesel, and J. R. Ruzycki. 2000. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1998-99 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R. W. Carmichael, and J. R. Ruzycki. 2001. Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 1999-2000 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R. W. Carmichael, and J. R. Ruzycki. 2004a. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2000-01 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., R.W. Carmichael, and J. R. Ruzycki. 2004b. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2001-02 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Flesher, M. W., G. R. Vonderohe, G. C. Grant, D. L. Eddy, and R. W. Carmichael. 2005a. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2001 and 2002 Bi-Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and G. C. Grant. 2005b. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2002-03 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and G. C. Grant. 2007. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2003-04 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, G. C. Grant, and L. R. Clarke. 2008a. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2004-05 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, G. C. Grant, and L. R. Clarke. 2008b. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2005-06 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., S. M. Warren, D. L. Eddy, L. R. Clarke, and R. W. Carmichael. 2009a. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2005 Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and L. R. Clarke. 2009b. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2006-07 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and L. R. Clarke. 2010. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2007-08 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and L. R. Clarke. 2011. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2008-09 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and L. R. Clarke. 2012. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2009-10 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., S. M. Warren, R. W. Carmichael, and L. R. Clarke. 2013. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2010-11 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., S. M. Warren, R. W. Carmichael, and L. R. Clarke. 2014. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2011-12 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M.W., R.W. Carmichael, and L.R. Clarke. 2015. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2012-13 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and L. R. Clarke. 2016. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2013-14 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., R. W. Carmichael, and L. R. Clarke. 2017. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2014-15 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Flesher, M. W., and L .R. Clarke. 2018. Lower Snake River Compensation Plan: Summer steelhead creel surveys on the Grande Ronde, Wallowa, and Imnaha rivers for the 2015-16 run year. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Salem.

Gee, S. A., G. R. Vonderohe, M. W. Flesher, D. L. Eddy, G. C. Grant, and R. W. Carmichael. 2007. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2003 Annual Progress Report, Salem.

Gee, S. A., M. W. Flesher, D. L. Eddy, L. R. Clarke, J. R. Ruzycki, and R. W. Carmichael. 2008. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2004 Annual Progress Report, Salem.

Jonasson, B. C., R. W. Carmichael, and T. A. Whitesel. 1994. Residual hatchery steelhead: Characteristics and potential interactions with spring Chinook salmon in northeast Oregon. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Jonasson, B. C., R. W. Carmichael, and T. A. Whitesel. 1995. Residual hatchery steelhead: Characteristics and potential interactions with spring Chinook salmon in northeast Oregon. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Jonasson, B. C., R. W. Carmichael, and T. A. Whitesel. 1996. Residual hatchery steelhead: Characteristics and potential interactions with spring Chinook salmon in northeast Oregon. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Messmer, R. T., R. W. Carmichael, and M. W. Flesher. 1989. Lower Snake River Compensation Plan: Oregon evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-LSR-91-1. Annual Progress Report, Portland.

Messmer, R. T., R. W. Carmichael, and M. W. Flesher. 1990. Lower Snake River Compensation Plan: Oregon evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-LSR-91-1. Annual Progress Report, Portland.

Messmer, R. T., R. W. Carmichael, M. W. Flesher, and T. A. Whitesel. 1991. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-LSR-92-10. Annual Progress Report, Portland.

Messmer, R. T., R. W. Carmichael, M. W. Flesher, and T. A. Whitesel. 1992. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Oregon Department of Fish and Wildlife, Fish Research Project, AFF1-LSR-94-06. Annual Progress Report, Portland.

Messmer, R. T., R. W. Carmichael, M. W. Flesher, and T. A. Whitesel. 1993. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Ruzycki, J. R., M. W. Flesher, R. W. Carmichael, and D. L. Eddy. 2003. Lower Snake River Compensation Plan: Oregon evaluation studies – steelhead life history, genetics, and kelt reconditioning. Oregon Department of Fish and Wildlife, Fish Research and Development. 1997-2001 Progress Report, Portland.

Stanton, H. M., M. W. Flesher, D. L. Eddy, and L. R. Clarke. 2018. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2016 Annual Progress Report, Salem.

Steele, C. A., J. McCane, J. Powell, N. Vu, and M. Campbell. 2018. Parentage-Based Tagging of Snake River hatchery steelhead and Chinook Salmon. 2017 Annual Progress Report. Idaho Department of Fish and Game, Report Number 18-04, Boise.

Tattam, S. K., C. D. Horn, D. Negru, K. L. Bleisner, E. R. Sedell, and J. R. Ruzycki. 2017. Steelhead escapement monitoring in the upper Grande Ronde River and Joseph Creek basins. Annual Technical Report. Oregon Dept. of Fish and Wildlife, La Grande, Oregon.

Twibell, R., C. Smith, K. Hanson, R. Glenn, J. Von Bargen, J. Bumgarner, and L. Clarke. 2018. Determination of gill Na+, K+ -ATPase enzyme activity and gene expression from juvenile steelhead reared at Lyons Ferry and Irrigon Fish Hatcheries. Abernathy Fish Technology Center Report. 9 pages.

USACOE (U.S. Army Corps of Engineers). 1975. Special report to the Lower Snake River Compensation Plan: Lower Snake River, Washington and Idaho. U.S. Army Engineer District, Walla Walla, Washington.

Warren, C., S. Rosenberger, and F. Bohlen. 2017. 2015 Calendar Year Hatchery Steelhead Report: IPC and LSRCP Monitoring and Evaluation Programs for the State of Idaho. Idaho Department of Fish and Game, Report Number 17-05.

Warren, S. M., M. W. Flesher, D. L. Eddy, L. R. Clarke, and R.W. Carmichael. 2009. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2006 Annual Progress Report, Salem.

Warren, S. M., M. W. Flesher, D. L. Eddy, L. R. Clarke, and R. W. Carmichael. 2010. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2007 Annual Progress Report, Salem.

Warren, S. M., M.W. Flesher, D. L. Eddy, L. R. Clarke, and R. W. Carmichael. 2011a. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2008 Annual Progress Report, Salem.

Warren, S. M., M. W. Flesher, D. L. Eddy, L. R. Clarke, and R. W. Carmichael. 2011b. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2009 Annual Progress Report, Salem.

Warren, S.M., M.W. Flesher, D.L. Eddy, L.R. Clarke, and R.W. Carmichael. 2012. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2010 Annual Progress Report, Salem.

Warren, S.M., M.W. Flesher, D.L. Eddy, L.R. Clarke, and R.W. Carmichael. 2013. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. Oregon Department of Fish and Wildlife, 2011 Annual Progress Report, Salem.

Whitesel, T.A., B.C. Jonasson and R.W. Carmichael. 1993. Residual hatchery steelhead: Characteristics and potential interactions with spring Chinook salmon in northeast Oregon. Oregon Department of Fish and Wildlife, Fish Research Project. Annual Progress Report, Portland.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.