FISHERY RESEARCH

WILD ADULT STEELHEAD AND CHINOOK SALMON ABUNDANCE AND COMPOSITION AT LOWER GRANITE DAM, SPAWN YEAR 2019

ANNUAL PROGRESS REPORT

Photo: IDFG

Prepared by:

Katherine M. Lawry, Fisheries Biologist
Carlos A. Camacho, Fisheries Biologist
John S. Hargrove, Fishery Biologist 2
Thomas Delomas, Fisheries Biologist 2
Micah Davison, Supervisory Fisheries Biologist
Marika E. Dobos, Fisheries Biologist
William C. Schrader, Principal Fisheries Biologist
Timothy Copeland, Fisheries Program Coordinator
Matthew R. Campbell, Fisheries Program Coordinator

IDFG Report Number 20-12
May 2020

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2019 Annual Report

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Katherine M. Lawry
Carlos A. Camacho
John S. Hargrove
Thomas Delomas
Micah Davison
Marika E. Dobos
William C. Schrader
Timothy Copeland
Matthew R. Campbell

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

IDFG Report Number 20-12
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ACKNOWLEDGEMENTS

Report Authors:

Katherine M. Lawry (IDFG)

Carlos A. Camacho (IDFG)

John S. Hargrove (IDFG / PSMFC)

Thomas Delomas (IDFG / PSMFC)

Micah Davison (IDFG / PSMFC)

Marika E. Dobos (IDFG)

William C. Schrader (IDFG)

Timothy Copeland (IDFG)

Matthew R. Campbell (IDFG)

Report Contributors: Data, reviews, and other assistance (*alphabetical*)

IDFG

- Matt Belnap
- Alan Byrne
- Lance Hebdon
- Brian Leth
- Chris Sullivan
- Chuck Warren

IDFG / PSMFC

- Amanda Boone
- Julianna Browning
- Paul Bunn
- Mike Eastman
- Karen Gregory
- Audrey Harris
- Brent Haverkamp
- Kelly Heindel
- Elizabeth Jossie
- Kyle King
- Dylan Kovis
- Dalton Lebeda
- Nicole Lawonn
- Jesse McCane
- Laura Redfield
- Leslie Reinhardt
- Lynn Schrader
- Craig Steele
- Patrick Vrablik
- Shelby Wallace
- Tyler Zumwalt

Northwest Fisheries Science Center

- Amber Barenberg
- Allen Bartels
- Ross Gleason
- Tiffani Marsh
- Ken McIntyre
- Darren Ogden

Columbia River Inter-Tribal Fish Commission

- Stephanie Harmon
- Rebekah Horn
- Shawn Narum
- Jeff Stephenson

Ocean Associates Inc.

- Randy Bunce
- Megan Lamb
- Kriston Snyder
- Caroline Whitney
- Lela Work

PSMFC

- Allen Martin
- Jenna Fortier

WDFW

Afton Oakerman

ACKNOWLEDGEMENTS (CONTINUED)

Project Administration: Funding and other assistance (*alphabetical*)

- Biomark, Applied Biological Services

- Bonneville Power Administration (BPA); projects:
    - 1990-055-00 Idaho Steelhead Monitoring and Evaluation Studies
    - 1991-073-00 Idaho Natural Production Monitoring and Evaluation Program
    - 2010-026-00 Chinook and Steelhead Genotyping for Genetic Stock Identification (GSI) at Lower Granite Dam
    - 2010-031-00 Parentage-Based Tagging (PBT) of Snake River Hatchery Steelhead and Chinook Salmon

- Idaho Office of Species Conservation (IOSC)

- Idaho Power Company (IPC)

- National Marine Fisheries Service (NMFS)

- Northwest Power and Conservation Council (NPCC)

- Pacific States Marine Fisheries Commission (PSMFC)

- U. S. Fish and Wildlife Service, Lower Snake River Compensation Program (LSRCP)

Suggested citation:

Lawry, K. M., C. A. Camacho., J. S. Hargrove, T. Delomas, M. Davison, M. E. Dobos, W. C. Schrader, T. Copeland, and M. R. Campbell. 2020. Wild adult steelhead and Chinook Salmon abundance and composition at Lower Granite Dam, spawn year 2019. Annual Report. Idaho Department of Fish and Game Report 20-12.

ABBREVIATIONS AND ACRONYMS

BPA	Bonneville Power Administration
BY	Brood Year
CI	Confidence Interval
CHMBLN	Chamberlain Creek Genetic Stock
CLRWTR	Clearwater River Major Population Group
CWT	Coded Wire Tag
DPS	Distinct Population Segment
EFGL	Eagle Fish Genetics Lab
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FALL	Snake River Fall Chinook Salmon
FL	Fork Length
FPC	Fish Passage Center
GRROND	Grande Ronde River Genetic Stock
GSI	Genetic Stock Identification
GT-seq	Genotyping-in-Thousands by Sequencing
H	Adipose Fin Clipped Hatchery
HELLSC	Hells Canyon Genetic Stock
HNC	Adipose Fin Intact Hatchery
IA	Individual Assignment
ICBTRT	Interior Columbia Basin Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IMNAHA	Imnaha River Genetic Stock
IOSC	Idaho Office of Species Conservation
IPC	Idaho Power Company
LGR	Lower Granite Dam
LOCLWR	Lower Clearwater River Genetic Stock
LOSALM	Lower Salmon River Genetic Stock
LSNAKE	Lower Snake River Genetic Stock
LSRCP	Lower Snake River Compensation Plan
MFSALM	Middle Fork Salmon River Genetic Stock
MM	Mixture Modelling
MPG	Major Population Group
MY	Smolt Migration Year
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWFCS	Northwest Fisheries Science Center
PBT	Parentage Based Tag
PCR	Polymerase Chain Reaction
PIT	Passive Integrated Transponder
PSMFC	Pacific States Marine Fisheries Commission
QCI	Quantitative Consultants, Inc.

SALMON	Salmon River Major Population Group
SAR	Smolt-to-adult return rate
SCOBI	Salmonid Compositional Bootstrap Intervals
SFCLWR	South Fork Clearwater River Genetic Stock
SFSALM	South Fork Salmon River Genetic Stock
SNP	Single Nucleotide Polymorphism
SY	Spawn Year
TAC	Technical Advisory Committee, *U.S. v. Oregon*
TUCANO	Tucannon River Genetic Stock
UPCLWR	Upper Clearwater River Genetic Stock
UPSALM	Upper Salmon River Genetic Stock
USACE	U. S. Army Corps of Engineers
VSP	Viable Salmonid Population
W	Wild
WDFW	Washington Department of Fish and Wildlife

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FOREWORD

Populations of steelhead trout *Oncorhynchus mykiss* and Chinook Salmon *O. tshawytscha* in the Snake River basin declined substantially following the construction of hydroelectric dams in the Snake and Columbia rivers. Raymond (1988) documented a decrease in survival of emigrating steelhead trout and Chinook Salmon from the Snake River following the construction of dams on the lower Snake River during the late 1960s and early 1970s. Abundance rebounded slightly in the early 1980s, but escapements over Lower Granite Dam (LGR) into the Snake River basin declined again (Busby et al. 1996). In recent years, abundances in the Snake River basin have slightly increased. However, the increase has been dominated by hatchery fish, while the returns of naturally produced steelhead trout and Chinook Salmon remain critically low. As a result, Snake River spring-summer Chinook Salmon (hereafter Chinook Salmon) were classified as threatened under the Endangered Species Act (ESA) in 1992 and Snake River steelhead trout (hereafter steelhead) were classified as threatened under the ESA in 1997.

Within the Snake River steelhead distinct population segment (DPS), there are six major population groups (MPGs): Lower Snake River, Grande Ronde River, Imnaha River, Clearwater River, Salmon River, and Hells Canyon Tributaries (Table 1; ICBTRT 2003, 2005, 2009; Ford 2011, 2015; NMFS 2016). The Hells Canyon MPG is considered to have been functionally extirpated. A total of 24 extant populations have been identified in the DPS.

Within the Snake River spring-summer Chinook Salmon evolutionarily significant unit (ESU), there are seven MPGs: Lower Snake River, Grande Ronde/Imnaha Rivers, South Fork Salmon River, Middle Fork Salmon River, Upper Salmon River, Dry Clearwater River, and Wet Clearwater River (Table 1; ICBTRT 2003, 2005, 2009; Ford 2011, 2015; NMFS 2016). The Dry Clearwater River and Wet Clearwater River MPGs are considered to have been extirpated but have been refounded with stocks from other Snake River MPGs. A total of 28 extant populations have been identified in the ESU.

Anadromous fish management programs in the Snake River basin include large-scale hatchery programs – intended to mitigate for the impacts of hydroelectric dam construction and operation in the basin – and recovery planning and implementation efforts aimed at recovering ESA-listed wild steelhead and salmon stocks. The Idaho Department of Fish and Game's anadromous fish program long-range goals, consistent with basinwide mitigation and recovery programs, are to preserve Idaho's salmon and steelhead runs and recover them to provide benefit to all users (IDFG 2019). Management to achieve these goals requires an understanding of how salmonid populations function (McElhany et al. 2000) as well as regular status assessments. The key metrics to assessing viability of salmonid populations are abundance, productivity, spatial structure, and diversity (McElhany et al. 2000).

The aggregate escapement of Snake River steelhead and Chinook Salmon is measured at LGR, with the exception of the Tucannon River, Washington, population downstream of LGR. Some of the wild fish are headed to Washington or Oregon tributaries to spawn, but the majority are destined for Idaho. Age, sex, and stock composition data are important for monitoring recovery of wild fish for both species. Age data collected at LGR are used to assign returning adults to specific brood years, for cohort analysis, and to estimate productivity and survival rates (Camacho et al. 2017; 2018a; 2018b; 2019a; 2019b). In addition, escapement estimates by cohort are used to forecast run sizes in subsequent years, and these forecasts are the basis for preliminary fisheries management plans in the Columbia River basin.

This report contains two chapters. The goal of the first chapter is to summarize the abundance and composition of wild steelhead and spring-summer Chinook Salmon returning to LGR during spawn year (SY) 2019 as defined by the U.S. Army Corps of Engineers (USACE) calendar date designations. We also update the adult-to-adult productivity series smolt-to-adult return (SAR) rates. The goal of the second chapter is to review the recent data series and update the reconstruction of Idaho steelhead populations before formal sampling began at Lower Granite Dam.

Author:

Katherine M. Lawry, Fisheries Biologist

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TABLES

Table 1. Major population groups and independent populations within the Snake River steelhead distinct population segment (DPS) and spring-summer Chinook Salmon evolutionary significant unit (ESU; ICBTRT 2003, 2005, 2009; Ford 2011, 2015; NMFS 2016).

Snake River steelhead DPS	
Major population group	**Population name**
Lower Snake River	1. Tucannon River 2. Asotin Creek
Grande Ronde River	3. Lower Grande Ronde River 4. Joseph Creek 5. Wallowa River 6. Upper Grande Ronde River
Imnaha River	7. Imnaha River
Clearwater River	8. Lower Clearwater River 9. North Fork Clearwater River (extirpated) 10. Lolo Creek 11. Lochsa River 12. Selway River 13. South Fork Clearwater River
Salmon River	14. Little Salmon River 15. Chamberlain Creek 16. South Fork Salmon River 17. Secesh River 18. Panther Creek 19. Lower Middle Fork Salmon River 20. Upper Middle Fork Salmon River 21. North Fork Salmon River 22. Lemhi River 23. Pahsimeroi River 24. East Fork Salmon River 25. Upper Salmon River
Hells Canyon Tributaries (extirpated)	

Table 1. Continued.

Snake River spring-summer Chinook Salmon ESU	
Major population group	**Population name**
Lower Snake River	1. Tucannon River 2. Asotin Creek (extirpated) [a]
Grande Ronde/Imnaha Rivers	3. Wenaha River 4. Lostine River 5. Minam River 6. Catherine Creek 7. Upper Grande Ronde River 8. Imnaha River 9. Big Sheep Creek (extirpated) [a] 10. Lookinglass Creek (extirpated) [a]
South Fork Salmon River	11. Little Salmon River 12. South Fork Salmon River 13. Secesh River 14. East Fork South Fork Salmon River
Middle Fork Salmon River	15. Chamberlain Creek 16. Lower Middle Fork Salmon River 17. Big Creek 18. Camas Creek 19. Loon Creek 20. Upper Middle Fork Salmon River 21. Sulphur Creek 22. Bear Valley Creek 23. Marsh Creek
Upper Salmon River	24. North Fork Salmon River 25. Lemhi River 26. Upper Salmon River Lower Mainstem 27. Pahsimeroi River 28. East Fork Salmon River 29. Yankee Fork Salmon River 30. Valley Creek 31. Upper Salmon River Upper Mainstem 32. Panther Creek (extirpated) [a]
Dry Clearwater River (extirpated) [a]	33. Potlatch River (extirpated) [a] 34. Lapwai Creek (extirpated) [a] 35. Lawyer Creek (extirpated) [a] 36. Upper South Fork Clearwater River (extirpated) [a]
Wet Clearwater River (extirpated) [a]	37. Lower North Fork Clearwater River (extirpated) 38. Upper North Fork Clearwater River (extirpated) 39. Lolo Creek (extirpated) [a] 40. Lochsa River (extirpated) [a] 41. Meadow Creek (extirpated) [a] 42. Moose Creek (extirpated) [a] 43. Upper Selway River (extirpated) [a]

[a] Reintroduced fish exist in extirpated areas except the North Fork Clearwater River.

CHAPTER 1 ─ ABUNDANCE AND COMPOSITION OF WILD ADULT STEELHEAD AND CHINOOK SALMON RETURNING TO LOWER GRANITE DAM IN SPAWN YEAR 2019

ABSTRACT

This chapter summarizes the abundance and composition of wild steelhead and spring-summer Chinook Salmon returning to Lower Granite Dam in spawn year 2019. We used a combination of window counts and systematic biological samples from the fish trap to decompose each species by origin, body size, sex, age, and stock. These metrics were then used to calculate adult-to-adult productivity, expressed as recruits per spawner for each species, and smolt-to-adult return rate for spring-summer Chinook Salmon. The combined window count was 51,818 hatchery and wild steelhead. The estimated wild steelhead escapement was 8,287 (90% CI 7,966–8,611) fish, which comprised 16% of the window count resulting in a decrease for the fourth consecutive year. With the exceptions of the South Fork Clearwater stock, the South Fork Salmon stock, and the Upper Salmon stock, point estimates for wild escapement declined for all genetic stocks in SY2019 for the fourth consecutive year. The Grande Ronde River genetic stock was the most abundant followed by the lower Snake River. Small steelhead (<78 cm, FL) dominated the total wild run and genetic stocks. Wild steelhead were female biased at 66%. Sex ratios for each genetic stock mirrored the aggregate wild run and ranged from 55% female for upper Salmon River to 77% female for the Middle Fork Salmon River. We observed 21 different age classes. Age at spawn ranged from three to nine years, freshwater age ranged from one to four years, and saltwater age ranged from zero to three years with additional fish returning as repeat spawners. Adult-to-adult productivity was completed for brood year 2011 at 0.81 returning recruits per spawner. The Lower Clearwater and Lower Snake River genetic stocks were above replacement, but all others were below replacement. The smolt-to-adult return rate for the aggregate wild steelhead run was 0.56% for smolts crossing Lower Granite Dam in migration year 2015. The combined window count was 29,617 hatchery and wild spring-summer Chinook Salmon. The estimated wild Chinook Salmon escapement was 5,162 fish, which comprised 17% of the window count. Wild abundance decreased for the spring-summer genetic stock from the previous spawn year. The Hells Canyon genetic stock was the most abundant followed by the upper Salmon River. Large Chinook Salmon (≥57 cm, FL) dominated the total wild run and within each genetic stock. Wild Chinook Salmon were male biased at 59%. Sex ratios for each genetic stock mirrored the aggregate wild run and ranged from 54% male for Hells Canyon to 80% male for Chamberlain. Eight different age classes were observed where age at spawn ranged from three to six years, freshwater age ranged from one to two years, and saltwater age ranged from zero (mini-jacks) to three years. Adult-to-adult productivity for brood year 2013 was completed at 0.20 returning recruits per spawner. All spring-summer stocks were below replacement. The smolt-to-adult return rate for the aggregate wild Chinook Salmon run was 0.75% for smolts crossing Lower Granite Dam in migration year 2015.

Authors:

Katherine M. Lawry, Fisheries Biologist

Carlos A. Camacho, Fisheries Biologist

John S. Hargrove, Fishery Biologist 2

Thomas Delomas, Fisheries Biologist 2

Micah Davison, Supervisory Fisheries Biologist

Marika E. Dobos, Fisheries Biologist

William C. Schrader, Principal Fisheries Biologist

Timothy Copeland, Fisheries Program Coordinator

Matthew R. Campbell, Fisheries Program Coordinator

INTRODUCTION

At Columbia River dams, U.S. Army Corps of Engineers (USACE) counts fish at viewing windows and designates jack Chinook Salmon as fish between 30 and 56 cm (12 and 22 inches) in length. Salmonids under 30 cm (12 inches) in length are not identified to species. Mini-jacks are precocious salmon generally under 30 cm in length and thus are not counted (Steve Richards, WDFW, personal communication). Throughout this report, unless otherwise stated, adult Chinook Salmon refers to reproductively mature fish returning to spawn, including jacks but excluding mini-jacks less than 30 cm.

Additionally, the USACE defines the Chinook Salmon run type by calendar date. Any Chinook Salmon counted at the window from March 1 to June 17 is considered spring run, June 18 to August 17 is considered summer run, and August 18 to December 31 is considered fall run. Fall-run Chinook Salmon passing LGR during the March 1 to August 17 time period are presented in this report for accounting purposes only and do not represent the entirety of the fall-run Chinook Salmon. For steelhead, the run year at LGR is defined to be from July 1 of the previous year to June 30 of the current year. The steelhead run year dates were chosen to be consistent with the upriver steelhead run year at Bonneville Dam as defined in the *U.S. v. Oregon* management agreement. Most steelhead pass LGR in the fall but are assigned to their spawn year the following spring.

The goal of this chapter is to summarize the abundance and composition of wild steelhead and spring-summer Chinook Salmon returning to LGR during spawn year (SY) 2019 as defined by the USACE calendar date designations. We also update the adult-to-adult productivity series for both species and the smolt-to-adult return (SAR) rate series for Chinook Salmon and steelhead last published by Camacho et al. (2019a). The objectives of this chapter are to:

1. Describe LGR adult trap operations and data collection during 2018-2019, which is the timeframe encompassing all steelhead and Chinook Salmon passing LGR for SY2019.

2. Estimate wild steelhead and Chinook Salmon escapement and age, sex, and size composition in aggregate and by genetic stock.

3. Evaluate wild steelhead and Chinook Salmon status using adult-to-adult productivity and replacement rates in aggregate and by genetic stock.

4. Estimate survival using smolt-to-adult return (SAR) rate for the aggregate return of wild Chinook Salmon and steelhead.

METHODS

Adult Trap Operations at Lower Granite Dam

Systematic samples of steelhead and Chinook Salmon returning to LGR were collected during daily operation of the adult fish trap by National Marine Fisheries Service (NMFS). The trap is located in the LGR fish ladder upstream from the fish counting window. The trap captures a systematic random sample of fish by operating a trap gate according to a predetermined sample rate. The trap gate is opened four times per hour for a length of time directed by a sample rate; the trap is operational 24 hours per day. The sample rate is determined based on sample size goals of the various projects using the adult trapping data combined with forecasted abundance of the targeted species, run, and rear type. Ideally, the sample rate is apportioned equally across the entire sampling season. However, the trap does not operate during weekends from March 1 to August 17, and in-season adjustments to the sample rate are sometimes needed to accommodate limitations at the trapping facility, changes to the forecast, or sample size goal modifications. Additionally, high (≥21°C or ≥70°F) and low (below freezing) water temperatures require the trapping facility to temporarily modify or cease operations.

During SY2019, the trap was closed November 19, 2018 through April 4, 2019 for the winter (Appendix A-1). The trap was also closed on weekends during the spring and summer periods (through August 17 both years). Outside these closures, daily trapping rates varied from 20 to 70%. For steelhead, 93.0% of the run passed the window while the trap was open (Appendix A-2). The majority of the steelhead run crossed LGR in the fall of 2018, but a second small pulse occurred in mid-March and April 2019. For Chinook Salmon, 71.0% of the run passed the window while the trap was open; this lower percentage was due to the weekend closures (Appendix A-3). Additional details on the trap can be found in Harmon (2003), Steinhorst et al. (2010), and USACE (2018, 2019).

Standard methods were used by NMFS and IDFG staff to process and biologically sample fish at the trap. All fish captured were anesthetized; examined for external marks, tags, and injuries; scanned for an internal coded wire tag (CWT) or passive integrated transponder (PIT) tag; and measured for fork length (FL, nearest cm).

All fish were classified by origin (hatchery or wild) based on a hierarchical key of external marks and internal tags identified at LGR and after post hoc genetic analysis conducted in the laboratory (Appendix A-4). At the LGR trap, the presence or absence of an adipose fin was examined first. All fish considered to have a clipped adipose fin (absent or partial clip evident by a healed scar) were classified as ad-clipped hatchery fish. Although most hatchery steelhead and Chinook Salmon have a clipped adipose fin (hereafter ad-clipped), some are released with an unclipped adipose fin (hereafter ad-intact) for supplementation or broodstock management purposes. All ad-intact fish were subsequently scanned for CWT and examined for ventral fin clips. Additionally, ad-intact steelhead were inspected for dorsal fin erosion, which is assumed to occur only in hatchery fish (Latremouille 2003). Any ad-intact fish with the presence of a CWT, ventral fin clip, and/or dorsal fin erosion (steelhead only) were classified as ad-intact hatchery fish. The trap crew sampled fin tissue from all ad-intact fish; genotyping for PBT analysis was conducted post hoc to further classify ad-intact hatchery fish. In sum, final classification of hatchery fish was made using any of five marks or tags: adipose fin clip (complete removal or partial clip), CWT, ventral fin clip, dorsal or ventral fin erosion (steelhead only), or PBT. Information from fish previously PIT tagged was not used to determine origin.

For all ad-intact fish, scale samples were taken from above the lateral line and posterior to the dorsal fin. Samples were stored in coin envelopes for transport to the IDFG Nampa Research Anadromous Ageing Laboratory. For all ad-intact fish, tissue samples for genetic analysis were taken from a small clip of the anal fin. Tissues were stored on a dry Whatman paper medium (LaHood et al. 2008) for transport to the IDFG Eagle Genetics Laboratory (EFGL). All ad-intact fish captured were also PIT tagged if not previously tagged for abundance estimation at instream PIT detectors upstream of LGR (Beasley and White 2010; QCI 2013; See et al. 2016; Orme and Kinzer 2018).

After processing, all fish were returned to the adult fish ladder to resume their upstream migration.

Trap Data Management

All data were entered into a NMFS cloud-based database via touch-screen computer systems located in the trap work area. This system allowed interested parties to access the data they needed at the end of each day and eliminated transcription errors from paper data sheets to electronic form. The IDFG LGR SQL server database automatically queries the NMFS database daily to populate tables used by IDFG for reporting purposes. The IDFG LGR SQL server database also queries and combines all genetic data from the EFGL Progeny database and the ageing data from the IDFG Nampa Research Anadromous Ageing Laboratory (NRAAL) BioSamples database to the associated trap records.

Valid Sample Selection

Not all trapped fish were deemed valid by IDFG for sample selection or analysis. Trapped fish that were missing data for any of the following five fields were considered invalid: date of collection, species, FL, origin (hatchery or wild), or adipose fin status (ad-clipped or ad-intact). Trapped fish less than 30 cm (FL) were considered invalid as they are not identified to species at the USACE fish-counting window. Further, the trap was not designed to efficiently trap these smaller fish (Darren Ogden, NMFS, personal communication); for Chinook Salmon, this includes all mini-jacks less than 30 cm. Finally, any sort-by-code PIT-tagged fish trapped outside the normal trap sampling timeframe was considered invalid. A computer program written by Tiffani Marsh (NMFS) was used to make this determination. Sort-by-code, or separation-by-code, is the process whereby PIT-tagged fish ascending the LGR fish ladder are diverted into the trap box using predetermined PIT-tag codes programmed into the trap gate computer.

Our goal was to age and genotype approximately 2,000 wild steelhead and 2,000 wild Chinook Salmon. In collaboration with our work, approximately 4,000 wild steelhead and 4,000 wild Chinook Salmon were PIT tagged and scale and genetic tissue samples were collected to estimate abundance at instream PIT detectors. We emphasize that both goals were complimentary and not mutually exclusive. Every ad-intact steelhead and Chinook Salmon trapped at LGR was genotyped. This simplified collaborative logistics and increased accuracy and precision of abundance estimates using GSI and PBT. All valid samples from wild fish were systematically subsampled if more than approximately 2,000 samples were available for each species. The result was a pool of samples collected systematically across the spawning run of each species and generally in constant proportion to their abundance. Hence, for either species, the sample pool can be considered a daily systematic sample (Steinhorst et al. 2017).

Scale Processing, Analysis, and Age Validation

Technicians processed scale samples in the IDFG Nampa Research Anadromous Ageing Laboratory according to protocols detailed in Wright et al. (2015). Ages are formatted using the European system where freshwater (FW) age is separated from saltwater (SW) age by a decimal. For steelhead repeat spawners, an ‘R’ is added to the saltwater age to designate the winter spent in freshwater while on the first spawning run (see Copeland et al. 2018 for ageing repeat spawners). Age classes are defined as the unique combinations of SW, FW, and repeat spawning ages. Brood year (BY) is the migration year minus the total age at spawning (sum of freshwater and saltwater ages, plus 1). Fish lacking either a freshwater or saltwater age were not used for analysis.

We validated wild fish saltwater-age assignments with known saltwater ages from hatchery and wild fish PIT tagged as juveniles and hatchery fish with CWT. Accuracy of age assignments was estimated by percent agreement between saltwater age and known emigration date determined from juvenile PIT-tag detection in the hydrosystem. Known saltwater-age fish were used to compute accuracy rates for Chinook Salmon and steelhead ages.

Genetics Tissue Processing and Analysis

Detailed methods for extraction of genomic DNA from tissue samples, DNA amplification, and SNP genotyping are described in Vu et al. (2015) and Campbell et al. (2015). Briefly, samples were processed using “Genotyping-in-Thousands by sequencing” (GT-seq) technique at either the IDFG genetics laboratory in Eagle, Idaho (EFGL), or the Columbia River Inter-Tribal Fish Commission’s genetics laboratory in Hagerman, Idaho. Steelhead were examined at a 379 SNP marker panel and Chinook Salmon were examined at a 343 SNP marker panel. Each panel contains SNPs for parental based tagging (PBT) and genetic stock identification (GSI), and sex-determination analysis.

Parental based tag analysis was conducted on all ad-intact adults to identify hatchery fish that were phenotypically wild. Since 2008, fin tissue has been sampled from nearly all adult steelhead and spring-summer Chinook Salmon broodstock spawned at Snake River hatcheries in Idaho, Oregon, and Washington (Delomas et al. 2020). The PBT project essentially “tags” all hatchery steelhead and spring-summer Chinook Salmon smolts released in the Snake River basin. This allows researchers to identify the exact parents of an individual, and thus its origin and total age (Steele et al. 2013). PBT is a critical tool to differentiate hatchery fish when no other physical tags (e.g., CWT and fin clips) are present.

Genetic stock identification is another genetic technique that estimates the reporting group (referred to here as genetic stocks) for wild fish. Genotypes were analyzed against genetic baseline populations to assign each individual to the genetic stock in which the probability of its genotype occurring is the greatest. Vu et al. (2015) and Powell et al. (2018) provide a detailed description of the Snake River genetic baselines used for both steelhead and Chinook Salmon GSI analyses (also see Figures 1-1 and 1-2). Genetic stocks are assemblages of baseline populations grouped primarily by genetic and geographic similarities and secondarily by political boundaries and management units (Ackerman et al. 2012). Individuals were assigned to genetic stocks using the maximum likelihood estimation method of Smouse et al. (1990) as implemented in the program gsi_sim (Anderson et al. 2008; Anderson 2010). The probability of membership to each population is summed within reporting units (allocate-sum procedure; Wood et al. 1987), and an individual’s genetic stock is assigned as the reporting unit with the maximum probability of membership.

Ten wild steelhead genetic stocks were used. The genetic stocks include: 1) UPSALM: upper Salmon River (including North Fork Salmon River and upstream); 2) MFSALM: Middle Fork Salmon River (including Chamberlain and Bargamin creeks); 3) SFSALM: South Fork Salmon River; 4) LOSALM: Little Salmon River and tributaries of the lower Salmon River; 5) UPCLWR: upper Clearwater River (Lochsa and Selway rivers); 6) SFCLWR: South Fork Clearwater River (including Clear Creek); 7) LOCLWR: lower Clearwater River; 8) IMNAHA: Imnaha River; 9) GRROND: Grande Ronde River; and 10) LSNAKE: tributaries of the lower Snake River both above (e.g., Alpowa and Asotin creeks) and below (primarily Tucannon River) LGR. Some Tucannon River steelhead ascend the dam and either stay upriver to spawn or fall back and spawn downriver. Results from some genetic stocks are aggregated to report by Snake River steelhead MPGs (Table 1).

Seven wild Chinook Salmon genetic stocks were used. The genetic stocks include: 1) UPSALM: upper Salmon River (including North Fork Salmon River and upstream); 2) MFSALM: Middle Fork Salmon River; 3) CHMBLN: Chamberlain Creek; 4) SFSALM: South Fork Salmon River; 5) HELLSC: Hells Canyon stock, an aggregate genetic stock that includes the Clearwater, Little Salmon, lower Salmon, Grande Ronde, Imnaha, and lower Snake rivers; 6) TUCANO: Tucannon River; and 7) FALL: Snake River fall Chinook Salmon. Chinook Salmon populations in TUCANO can be distinguished from HELLSC in GSI analyses because they exhibit low levels of introgression with fall Chinook Salmon (Narum et al. 2010). The TUCANO genetic stock was included in the baseline to represent fish that originated below LGR, but ascend the dam and either stay upriver to spawn or fall back and spawn downriver. Except for fall Chinook Salmon, these genetic stocks largely correspond to Snake River spring-summer Chinook Salmon MPGs (Table 1). The MFSALM and CHMBLN genetic stock results were aggregated to report the Middle Fork Salmon River MPG. Three collections of Snake River fall Chinook Salmon (Clearwater River, Nez Perce Tribal Hatchery, and Lyons Ferry Hatchery) were included in the baseline to distinguish fall Chinook Salmon trapped prior to August 18 from spring-summer Chinook Salmon using genetic data (Ackerman et al. 2014).

The resolution of the Snake River genetic baselines was evaluated in Vu et al. (2015). The GSI project continues to update the genetic baselines periodically in an effort to improve resolution. Further, the GSI project continues to develop methods and evaluate available tools to assess and improve the accuracy and precision of genetic stock proportion and abundance estimates. These efforts are reported separately in the annual progress reports for the GSI project (Hargrove et al. 2020).

Sex was not and generally cannot be reliably determined by personnel at the LGR trap, as fish typically do not exhibit sexually dimorphic characteristics when crossing LGR. A sex-determination assay developed by Campbell et al. (2012) was used and included in the genotyping process. The accuracy of the sex-determination assays was evaluated in Steele et al. (2016). Further details can be found in Campbell et al. (2012).

Wild Escapement by Origin, Genetic Stock, Size, Sex, and Age

The USACE daily window counts, which occur in the fish ladder downstream of the trap, were assumed to be the daily aggregate escapement to LGR for each species. Count data were downloaded from the FPC website: http://www.fpc.org/environment/home.asp. Additional daily window count operation information was obtained from USACE annual fish passage reports (USACE 2018, 2019). For Chinook Salmon, the adult count was combined with the jack count to derive the total count on a daily basis.

Window counts were decomposed into escapement estimates for reporting groups of interest with 90% confidence intervals (CI). The basic methods were developed by Steinhorst et al. (2017) and implemented in the SCOBI (Salmonid Composition Bootstrap Intervals) function in the SCOBI R package (https://github.com/mackerman44/SCOBI; Ackerman et al. *In Preparation*; R Development Team 2008; Steinhorst et al. 2017). SCOBI combined the window count with the adult trap sample data on a temporally stratified basis to account for changes in the trapping rate and run characteristics through time. The spawn year for each species was divided into “statistical week” strata with each stratum defined as a week (starts on Monday and ends on Sunday) or a series of adjacent weeks with sufficient trap numbers (n ≥100) to adequately estimate all proportions. Escapement by stratum was estimated by multiplying the window counts by the trap proportions. The total escapement to LGR was the sum of escapement estimates from each stratum, which equals the total window count for the spawn year. In essence, the stratum proportions were weighted by stratum run size of all fish from each species as counted at the window. We assumed 1) window counts represent true abundance, and 2) proportions are constant within each stratum.

The analysis decomposes total escapement (i.e. window count) into rearing type, primary, and secondary categories. These are hierarchical and each category is nested within the previous category (Figure 1-3). First, the total escapement is decomposed into rearing type (adipose-intact hatchery, adipose-clipped hatchery, and wild). Fish from each rearing type are then divided into primary categories. Hatchery-reared fish (ad-clipped and ad-intact) are divided into primary size categories (large and small). Wild-reared fish are divided into primary categories by genetic stock and Major Population Group. Wild fish genetic stocks are then further decomposed into secondary categories (size, sex, brood year, saltwater age, and age class).

Abundance estimates by rear type were calculated by multiplying the trapping proportions of each rear type for each stratum by the window count for that stratum and summing over the season. A parametric bootstrap is used to find 90% CIs on the estimated abundance of wild (W), ad-clipped hatchery (H), and ad-intact hatchery (HNC). The parametric bootstrap uses the number of adults trapped in each stratum along with the three estimated multinomial proportions for W, H, and HNC in that stratum to produce bootstrap pseudo values for numbers of fish by rearing category. These are converted to pseudo proportions by stratum and multiplied by weekly window counts to produce bootstrap estimates of totals by W, H, and HNC. The three bootstrap series of estimates are ordered and the fifth and ninety-fifth ordered values give the three one-at-a-time confidence intervals. All CIs are generated for the spawn year total rather than for individual strata.

The trap data are then categorized to one of the rearing types. Proportions by stratum are computed for the primary classification variable (size for H and HNC and genetic stock for W). Estimates of numbers of fish in each primary category are found by multiplying the stratum proportions by the stratum numbers of fish of that rearing type and summing over strata. Pseudovalues for numbers of fish of the given rearing type for each primary category for each stratum are produced by a second parametric bootstrap, which leads to confidence intervals for estimates of fish in the primary categories.

Finally, for each stratum a two-way table of proportions was calculated for combinations of the primary and secondary variable categories. For each stratum these proportions are applied to estimated numbers of fish of the given rearing type and primary category to get estimates of numbers of fish for each level of the secondary category. That is, if one fixes a primary category, then the estimated number of fish of that primary category is decomposed into estimates for each of the secondary categories. Summing over primary categories, the resulting estimate of fish in each secondary category is constrained to sum to the total fish found in the primary categories. Each row of a table of proportions for fixed stratum and primary category was used to produce multinomial parametric bootstrap pseudo values for numbers of fish in each secondary category leading to confidence intervals for the corresponding estimates.

Point estimates from all nested categories must sum to equal the parent category. Due to rounding error in the final output of data, additional steps were developed to adjust point estimates. First, all rear types must sum to the window count obtained from the FPC website (http://www.fpc.org/environment/home.asp). If rear types do not sum to window count, fish were added or subtracted from the rear type with the largest number of fish. Second, genetic stock estimates must sum to the wild fish estimate. If not, fish were added or subtracted from the genetic stock with the largest number of fish. The adjusted estimates for the genetic stocks were used to further adjust the MPG and composition estimates. Estimates for MPGs were adjusted to match the summation of corresponding genetic stocks (e.g., all CLWR genetic stocks combine to CLRWTR, all SALM genetic stocks combine to SALMON). For composition estimates (size, sex, age class), fish were added or subtracted from the group with the largest number of fish (e.g., male and female CHMBLN need to add up to the total genetic stock estimate for CHMBLN). For total age and saltwater age composition estimates within each genetic stock, estimates must sum to the corresponding aggregation of age class composition estimates within each genetic stock. Fish were added or subtracted from each total age and saltwater age group to match the corresponding aggregation of age classes, (e.g., saltwater age-2 CHMBLN must sum to the aggregated total estimate from age classes F1S2 and F2S2 for CHMBLN). After adjusting composition groups within each genetic stock, individual composition group estimates over all genetic stocks were summed to obtain aggregate estimates (e.g., male aggregate estimate is the sum of all male estimates from each genetic stock). All aggregate composition estimates must add up to the rear type estimate. In general, adjustments involved adding or subtracting less than five fish.

Reporting groups for each of the primary and secondary categories were defined based on criteria important for fishery management and monitoring and evaluation. Genetic stock encompassed the species specific reporting groups (ten for steelhead and seven for Chinook Salmon) described in the Genetics Tissue Processing and Analysis section above. Sex included a male and a female reporting group. Age class, brood year, and saltwater age reporting groups vary in number based on the freshwater and saltwater age structure observed from scale samples of trapped fish during the spawn year. Lastly, size included two length reporting groups (large, small); however, length cutoffs differ for each species. Large steelhead are greater than or equal to 78 cm FL, whereas small steelhead are less than 78 cm FL and correspond to lengths describing A-index and B-index steelhead. For Chinook Salmon, large fish are greater than or equal to 57 cm FL (24 inches total length) corresponding to adult sized fish, whereas small fish are less than 57 cm FL (24 inches total length) corresponding to jack sized fish. Fish length was recorded as a FL at the LGR adult trap. A linear regression equation for saltwater-caught Chinook Salmon in Southeast Alaska was used to convert the 24-inch (61 cm) total length cutoff to a FL equivalent of 57 cm (Conrad and Gutmann 1996).

Smolt-to-Adult Return Rate

To estimate the aggregate smolt-to-adult return (SAR) rate for wild steelhead and Chinook Salmon, the age composition of adults at LGR was combined with estimates of emigrating wild smolts at LGR. For steelhead, this is the second report to estimate SARs. Repeat spawning steelhead were not included in the SAR estimates because they were already accounted for on their maiden spawning migration. Furthermore, repeat spawners likely have different survival rates than smolts. For Chinook Salmon, adult age composition from SY2019 was incorporated into the age proportion series last published in Camacho et al. (2019a). Smolt production estimates were acquired from Camacho et al. (2019b).

To calculate a SAR for a particular smolt migration year (MY), the sum of ocean returns from that cohort was divided by the estimate of wild smolts arriving at LGR:

$$SAR_k = \frac{\sum_{l-1}^{4} r_{k+l}}{S_k},$$

where SAR_k is the smolt-to-adult return rate of smolt migration year k; r_{k+l} is the return from that cohort in year $k + l$; l is saltwater age; and S_k is the estimate of smolts migrating in year k. The maximum value of l is four because that is the maximum saltwater age observed for Chinook Salmon and steelhead at LGR (Copeland et al. 2004). Formulas from Fleiss (1981) were used to estimate the 95% confidence limits on SAR values. The lower limit is given by

$$\frac{\left(2np + t_{\propto/2}^{2} - 1\right) - t_{\propto/2}\sqrt{t_{\propto/2}^{2} - (2 + 1/n) + 4p(nq + 1)}}{2\left(n + t_{\propto/2}^{2}\right)},$$

and the upper limit by

$$\frac{\left(2np + t_{\propto/2}^{2} + 1\right) + t_{\propto/2}\sqrt{t_{\propto/2}^{2} + (2 + 1/n) + 4p(nq + 1)}}{2\left(n + t_{\propto/2}^{2}\right)},$$

where n is the number of smolts, p is the SAR value as a proportion, q is 1-SAR, and $t_{\propto/2}$ is 1.96.

RESULTS

Steelhead Escapement

The USACE total window count of steelhead for SY2019 was 51,818 fish (Table 1-1). The LGR trap captured 10,886 of them, of which 1,759 were valid wild fish (Appendix A-5). Our estimate of wild escapement is 8,287 fish (7,966–8,611 90% CI), which comprises approximately 16% of the window count (Table 1-1). The remaining 43,531 fish were of hatchery origin. We estimate ad-clipped hatchery escapement was 39,895 fish (39,527–40,255 90% CI) and ad-intact hatchery escapement was 3,636 fish (3,402–3,879 90% CI). External marks, internal tags, and genetics were used to determine that 8% of the total hatchery fish and 7% of the run were ad-intact hatchery fish. For all ad-intact steelhead, 30% were hatchery fish.

Steelhead by Genetic Stock, Size, Sex, and Age

Abundance of wild steelhead by genetic stock varied greatly with the GRROND having the highest abundance at 36% of the total and the LOSALM having the least at 2% (Appendix C-1). Escapement estimates for each genetic stock were as follows: GRROND 2,940 (2,729–3,152 90% CI); IMNAHA 542 (457–631 90% CI); LOCLWR 452 (378–532 90% CI); LOSALM 154 (107–204 90% CI); LSNAKE 1,238 (1,097–1,387 90% CI); MFSALM 454 (376–533 90% CI); SFCLWR 542 (450–643 90% CI); SFSALM 210 (160–262 90% CI); UPCLWR 710 (613–813 90% CI); and UPSALM 1,042 (930–1,155 90% CI).

The wild escapement estimate for the South Fork Clearwater stock increased slightly from the previous year. The SY2019 estimate for SFCLWR was 542 (450–643 90% CI) and the SY2018 estimate was 350 (282–419 90% CI). These confidence intervals do not overlap. The lower bound of the 90% confidence interval for SY2019 is 450, which is just above the upper bound of the 90% CI for SY2018 (419), suggesting that this increase was small, but statistically significant.

The wild escapement estimates for the Grande Ronde, Lower Clearwater, Lower Snake, and Middle Fork Salmon stocks declined significantly from last year (Figure 1-4). The point estimate for the Grande Ronde stock decreased by 1127 fish, the Lower Clearwater by 174 fish, the Lower Snake by 870 fish, and the Middle Fork Salmon by 219 fish. In all cases, the 90% confidence intervals did not overlap (upper bounds of SY2019 estimates were below the lower bounds of SY2018 estimates), indicating significant decreases.

The wild escapement estimates for the Imnaha, Lower Salmon, South Fork Salmon, Upper Clearwater, and Upper Salmon stocks did not change significantly from last year (Figure 1-4). The SY2019 confidence intervals overlap with the SY2018 confidence intervals. Although the point estimates for the South Fork Salmon and Upper Salmon stocks did increase by a few fish (5 fish and 15 fish, respectively), the lower bounds of the SY2019 confidence intervals are not greater than the upper bounds of the SY2018 confidence intervals, indicating that no significant increases occurred. Similarly, the point estimates for the Imnaha, Lower Salmon, and Upper Clearwater stocks decreased by 179 fish, 48 fish, and 25 fish, respectively. However, the upper bounds of the SY2019 confidence intervals did not fall below the lower bounds of the SY2018 confidence intervals, indicating that these declines were likewise not significant. Despite the lack of statistical significance for the change in estimated escapement, a plot of the 5-year trend does suggest a real and continued decline for these stocks.

Small-size steelhead (<78 cm fork length; A-Index for fisheries managed under the U.S. v. Oregon Management Agreement) dominated the SY2019 for ad-clipped hatchery, and wild runs (Table 1-1). Small hatchery ad-clipped steelhead were estimated at 26,776 (90% CI 26,347–27,204), and small wild steelhead were estimated at 7,055 (90% CI 6,748–7,327). Large hatchery ad-clipped steelhead were estimated at 13,119 (90% CI 12,762–13,474), and large wild were estimated at 1,232 (90% CI 1,122–1,322). For ad-intact hatchery runs, large-sized steelhead dominated by a slight margin. Large were estimated at 2,223 (90% CI 2,034–2,417). Small were estimated at 1,413 (90% CI 1,259–1,571).

Wild steelhead were female-biased, and females accounted for 65% of the overall wild return (Appendix C-2 and C-3). Female escapement was estimated at 5,431 (90% CI 5,185–5,633) and males at 2,856 (90% CI 2,699–2,989). Sex ratios for each genetic stock mirrored the aggregate wild run and ranged from 55% female for upper Salmon River to 77% female for the Middle Fork Salmon River.

Twenty-one different age classes were observed from the 1,605 wild fish that we were able to assign both a genetic stock and a total age (Appendix C-4 and C-5). Age at spawning ranged from three to nine years with freshwater age ranging from one to four years and saltwater age ranging from zero to three years. Some steelhead returned as repeat spawners. We estimated that 212 (90% CI 183–240) of the returning adults were hatched in brood year (BY) 2016 and were age-3; 2,544 (90% CI 2,407–2,658) were from BY2015 and were age-4; 3,721 (90% CI 3,529–3,874) were from BY2014 and were age-5; 1,583 (90% CI 1,475–1,674) were from BY2013 and were age-6; 172 (90% CI 144–198) were from BY2012 and were age-7; 52 (90% CI 39–68) were from BY2011 and were age-8; and 3 (90% CI 1–6) were from BY2010 and age-9. Saltwater age estimates were 25 (90% CI 15–37) zero-saltwater from MY2019; 3,813 (90% 3,614–3,982) one-saltwater from MY2018; 4,162 (90% 3,959–4,325) two-saltwater from MY2017; 30 (90% 19–42) three-saltwater from MY2016; and 257 (90% 214–307) repeat spawning steelhead not assigned to a specific migratory year.

The majority of the wild return, or 58%, emigrated to the ocean as freshwater age-2 and, excluding repeat spawners, 50% returned as saltwater age-2. For all genetic stocks, age-5 (fish that hatched in BY2014) was the dominant age cohort, with the exception of SFSALM and UPCLWR where age-6 (BY2013) was the dominant age cohort, and UPSALM where age-4 (BY2015) was the dominant age cohort. Furthermore, one-saltwater and two-saltwater fish made up the vast majority of returning steelhead to all genetic stocks (Appendix C-6). The mean length of one-saltwater and two-saltwater fish was below the 78 cm threshold for large steelhead (Appendix C-7).

Repeat spawning fish made up about 3% of all wild steelhead crossing LGR. Repeat spawners were observed in all genetic stocks except for LOSALM. The proportions of repeat spawners varied across the genetic stocks. Repeat spawners as a proportion of the run for each genetic stock ranged from 0.9% of the run (SFCLWR) to up to 9.3% of the run (MFSALM).

Readers accurately determined the saltwater-age of 100% of the scale samples (n = 34) from known saltwater-age steelhead collected during SY2019 (Appendix B-1). The known saltwater-age sample was 50% one-saltwater and 50% two-saltwater. There were no three-saltwater, four-saltwater fish, or repeat spawners in the known saltwater-age sample.

Steelhead Adult-to-Adult Productivity

Wild steelhead returning to LGR in SY2019 completed the BY2011 cohort necessary for an adult-to-adult productivity estimate. Brood year 2011 returned 35,772 adults from 44,133 parents resulting in an adult-to-adult productivity estimate of 0.81 recruits per spawner, which is below the 1.0 recruits per spawner necessary for replacement (Figure 1-5). A preliminary estimate of adult-to-adult productivity for the BY2012 cohort also placed it below replacement (Figure 1-5). Although unlikely to change significantly, the estimate for BY2012 is preliminary and will be completed in SY2020.

Two of the ten genetic stocks had adult-to-adult productivity estimates that were above replacement (LOCLWR at 1.16 and LSNAKE at 1.08; Figure 1-6). Estimates for all other genetic stocks were below replacement. Those below replacement estimates were as follows: UPSALM 0.80, MFSALM 0.47, SFSALM 0.43, LOSALM 0.45, UPCLWR 0.92, SFCLWR 0.50, IMNAHA 0.88, and GRROND 0.96. Preliminary estimates of adult-to-adult productivity by genetic stock for BY 2012 placed all genetic stocks below replacement (Figure 1-6). The estimates for BY 2012 are preliminary and will be completed in SY2020.

Steelhead Smolt-to-Adult Return Rate

This report presents the second estimate of a LGR to LGR smolt-to-adult return (SAR) rate for steelhead. With adult returns from SY2019, the SAR time series was completed for MY2010-2015. SARs ranged from a high of 5.33 (5.29–5.38 95% CI) in MY2012 to a low of 0.56 (0.54–0.58 95% CI) in MY2015 (Table 1-2; Figure 1-7). Four of the six completed MY cohorts were above the Northwest Power and Conservation Council (NPCC) fish and wildlife program minimum of 2% (NPCC 2009). However, the 5-year geometric mean SAR (2.36%) for the 2011-2015 cohorts (n = 5) is less than the target geometric mean of 4%.

Currently, the time series is complete for MY2010-2015. However, SARs could be calculated for MY2007-2009 with the addition of smolt abundances. This report strictly used smolt abundances from MY2010-2018 generated from Camacho et al. (2018b; 2019b) when genetic sampling of smolts at LGR occurred. Smolt abundance estimates previous to MY2010 will be unable to identify ad-intact hatchery fish from wild fish, thus biasing any smolt abundance estimate high and any SAR low. Furthermore, wild smolt abundance estimates by stock will not be possible without genetic tissues. In the future, SAR rates will be calculated for each wild steelhead stock.

Chinook Salmon Escapement

The USACE total window count of Chinook Salmon for SY2019 was 29,617 fish (Table 1-3). The LGR trap captured 6,379 of them, of which 1,153 were valid wild fish (Appendix A-6). Our estimate of wild escapement is 5,162 fish (4,933–5,389 90% CI), which comprises approximately 17% of the window count (Table 1-3). The remaining 24,455 fish were of hatchery origin. We estimate ad-clipped hatchery escapement was 22,339 fish (22,089–22,592 90% CI) and ad-intact hatchery escapement was 2,116 fish (1,960–2,269 90% CI). External marks, internal tags, and genetics were used to determine that 9% of the total hatchery fish and 7% of the run were ad-intact hatchery fish. For all ad-intact Chinook Salmon, 29% were hatchery fish.

Chinook Salmon by Genetic Stock, Size, Sex, and Age

Abundance of wild Chinook Salmon by genetic stock varied greatly with HELLSC having the highest percentage of the total at 42% and TUCANO having the least at 1% (Appendix D-1). Escapement estimates for each genetic stock were CHMBLN 72 (44–102 90% CI); FALL 562 (492–635 90% CI); HELLSC 2,153 (1,992–2,316 90% CI); MFSALM 748 (653–848 90% CI); SFSALM 886 (785–988 90% CI); TUCANO 29 (10–51 90% CI); and UPSALM 712 (621–804 90% CI).

Estimated wild escapement to LGR for the CHMBLN, HELLSC, MFSALM, SFSALM, and UPSALM stocks decreased in SY2019 compared to last year (Figure 1-8). These were significant decreases, as 90% confidence intervals did not overlap with those for SY2018 (the upper bounds of the confidence intervals for SY2019 were below the lower bounds of the confidence intervals for SY2018). This is consistent with the long-term trend for these stocks.

Large fish (≥57 cm, FL) dominated wild, ad-clipped hatchery, and ad-intact hatchery Chinook Salmon returns. Large ad-clipped hatchery Chinook Salmon were estimated at 17,669 (17,382–17,960 90% CI); large ad-intact hatchery at 1,891 (1,744–2,039 90% CI); and large wild at 4,194 (3,992–4,373 90% CI). Small ad-clipped hatchery Chinook Salmon were estimated at 4,670 (4,450–4,889 90% CI); small ad-intact hatchery at 225 (174–280 90% CI); and small wild at 968 (897–1,032 90% CI). Large fish accounted for the majority of Chinook Salmon returning to all wild genetic stocks (Appendix D-2).

The wild Chinook Salmon sex ratio was male-biased, and males accounted for 59% of the wild return (Appendix D-2 and D-3). Females were estimated at 2,092 (1,973–2,198 90% CI) and males were estimated at 3,070 (2,913–3,205 90% CI). Sex ratios for each genetic stock mirrored the aggregate wild run and ranged from 54% male for Hells Canyon to 80% male for Chamberlain.

Eight different age classes were observed from the 1,046 wild fish that we were able to assign both a genetic stock and a total age (Appendix D-4 and D-5). Age at spawning ranged from three to six years with freshwater age ranging from one to two years and saltwater age ranging from zero (mini-jacks) to four years. Age estimates were 15 (8–20 90% CI) age-6 fish from BY2013; 1,131 (1,053–1,203 90% CI) age-5 fish from BY2014; 3,048 (2,885–3,196 90% CI) age-4 fish from BY2015; and 968 age-3 fish (896–1,036 90% CI) from BY2016. Saltwater age estimates were 18 (11–26 90% CI) zero-saltwater mini jacks from MY2019; 992 (916–1,058 90% CI) one-saltwater jacks from MY2018; 3,191 (3,022–3,343 90% CI) two-saltwater fish from MY2017; 956 (888–1,017 90% CI) three-saltwater fish from MY2016; and 5 (1–8 90% CI) four-saltwater fish from MY2015.

The majority of the wild return (95%) emigrated to the ocean as freshwater age-1 and 62% returned as saltwater age-2. For all genetic stocks, age-4 was the dominant age class, except for FALL where age-5 was the dominant age class. Furthermore, two-saltwater fish dominated all stocks. All zero-saltwater mini-jacks assigned to the FALL genetic stock (Appendix D-6). The mean length of one-saltwater fish was below the 57 cm threshold for large Chinook Salmon (Appendix D-7).

Readers accurately determined the saltwater-age of 100% of the scale samples (n = 26) from known saltwater-age PIT-tagged and coded-wire-tagged Chinook Salmon collected during SY2019 (Appendix B-2). The known saltwater-age sample was 27% saltwater age-1, 70% saltwater age-2, and 3% saltwater age-3 fish. There were no saltwater age-4 fish in the known saltwater-age sample.

Chinook Salmon Adult-to-Adult Productivity

Wild Chinook Salmon returning to LGR in SY2019 completed the BY2013 cohort necessary for an adult-to-adult productivity estimate. Brood year 2013 returned 3,806 adults from 19,263 parents resulting in an adult-to-adult productivity estimate of 0.20 recruits per spawner, which is below the 1.0 recruits per spawner necessary for replacement (Figure 1-9). A preliminary estimate of adult-to-adult productivity for the BY2014 cohort also placed it below replacement (Figure 1-9). Although unlikely to change significantly, the estimate for BY2014 is preliminary and will be completed in SY2020.

Adult-to-adult productivity estimates were below replacement for six of the seven genetic stocks. Genetic stocks that were below replacement included UPSALM at 0.11; MFSALM at 0.12; SFSALM at 0.19; CHMBLN at 0.12; HELLSC at 0.24; and TUCANO at 0.29 (Figure 1-10). The FALL genetic stock was above replacement with an estimate of 1.06. Preliminary estimates of adult-to-adult productivity by genetic stock for BY2014 placed all genetic stocks below replacement (Figure 1-10). The estimates for BY2014 are preliminary and will be completed in SY2020.

Chinook Salmon Smolt-to-Adult Return Rate

With adult returns from SY2019, the SAR time series is complete for MY1996-2015. MY2015 returned 3,937 fish from 525,743 yearling emigrants for a SAR estimate of 0.75 (0.72–0.77 95% CI; Table 1-4; Figure 1-11). The 10-year geometric mean SAR was 1.34% and the 5-year geometric mean SAR was 1.49%.

SARs for the MY2015 cohort and both geometric means were below the NPCC fish and wildlife program minimum of 2% (NPCC 2009). Our estimated SAR rates in the past have been slightly higher but closely track the estimates provided by the Comparative Survival Study (CSS; McCann et al. 2015). In the future, SAR rates will be calculated for each spring-summer Chinook Salmon stock.

DISCUSSION

Abundance of returning SY2019 wild summer steelhead and spring-summer Chinook Salmon measured at Lower Granite Dam was low across the Snake River basin. For steelhead, overall escapement (all rear types combined) counted at the LGR window in SY2019 was the lowest on record going back to at least SY1998 (Table 1-1). Wild steelhead escapement was also the lowest, as was hatchery steelhead escapement. Abundance of wild, natural-origin steelhead was well below IDFG's "healthy and harvestable" escapement goals and NMFS' minimum abundance thresholds. Wild steelhead escapement was less than one-twelfth of IDFG's escapement goal of 104,500 fish, and less than half of NMFS' threshold of 21,000 fish, to the Snake River basin (IDFG 2019).

Large wild, large hatchery ad-clipped, and large hatchery ad-intact steelhead escapement increased slightly from SY2018 to SY2019 (Table 1-1), and this is one piece of good news. However, steelhead average length-at-age for two-saltwater fish failed to meet the length cutoff for the B-run size classification. Steelhead and fall Chinook Salmon fisheries in the Columbia and Snake rivers may be constrained by the abundance of large steelhead, often called B-run steelhead in fisheries regulations, counted at Bonneville dam. B-run steelhead are defined as ≥78 cm in length and are often associated with a two-saltwater age. In SY2019, two-saltwater returns were on average five cm smaller than the 78 cm length requirement (Appendix C-7). The reduced length-at-age is not novel or restricted to this spawn year, but a continuation of a developing trend (unpublished data). Fisheries managers should continue to monitor the declining average length of two-saltwater steelhead and consider how this may impact fishing regulations designed to protect B-run steelhead as well as public perception of fewer returning B-run steelhead.

Steelhead returning to Idaho waters to spawn have the capacity to be long lived relative to other anadromous salmonids returning to the same waters. This is due in part to their increased variation in juvenile outmigration timing, and their ability to exhibit iteroparity (Copeland et al. 2017, Copeland et al. 2019). During spawn year 2019, we collected a scale from a fish that we estimated to be 9 years total age (Appendix B-3). This represents the oldest estimated age collected at Lower Granite Dam to date.

Spring-summer Chinook Salmon returns were also very low in SY2019. Overall escapement (all rear types combined) counted at the LGR window in SY2019 was the lowest since SY1999 (Table 1-3). The return of hatchery adults was also the lowest since SY1999, whereas the total hatchery return, including both adults and jacks, was the lowest since SY2006. Total wild Chinook Salmon escapement, including both adults and jacks, was the lowest observed since SY1999 and this correlated with low redd counts in the Middle Fork Salmon River and elsewhere in Idaho (Felts et al. 2020). However, LGR escapement of wild adults only, not including jacks, was on par with escapement in SY2017. Abundance of wild- and natural-origin spring-summer Chinook Salmon was well below IDFG's "healthy and harvestable" escapement goals and NMFS' minimum abundance thresholds. Wild spring-summer Chinook Salmon escapement was approximately one-twenty-fifth of IDFG's escapement goal of 127,000 fish, and less than one-sixth NMFS' threshold of 31,500 fish, to the Snake River basin (IDFG 2019).

Despite the overall low returns for hatchery and wild Chinook Salmon in SY2019, there was an improvement in the number of returning wild jacks and hatchery jacks compared to last year. The number of wild jacks nearly doubled from SY2018, and the number of hatchery jacks increased by a margin of nearly 60%. This is encouraging, as it suggests an improvement in 2-saltwater returns is on the horizon for next year.

Low run sizes may cause small sample size problems or lead to abnormalities in trapping operations at Lower Granite Dam. In SY2019 we fell short of our general sample size goals for both steelhead and Chinook Salmon. Our sample size goal was to trap, PIT tag, and biologically sample 4,000 wild steelhead and 4,000 wild Chinook Salmon. We trapped only 1,759 wild steelhead and only 1,153 wild Chinook Salmon. Consequently, 21.2% of the estimated wild steelhead run, and 22.3% of the estimated wild Chinook Salmon run were trapped. For both species, we exceeded the 20% trapping guidance that was agreed upon by basin co-managers.

The small sample size for Chinook Salmon can be attributed almost entirely to low run sizes, but the small sample size for steelhead was a combination of both low runs and abnormalities in trap operations. Starting August 18, 2018, a new two-step sampling regime was adopted to meet fall Chinook Salmon broodstock collection targets (Appendix A-1 and A-2). The change was implemented because of concerns that run sizes were too small to meet fall Chinook Salmon broodstock requirements under normal trapping procedures. A 70% sample rate was used for roughly three weeks followed by 20% for the remainder of the fall trapping season. The following spring, due to anesthesia disposal and water supply problems, the trap was not opened until April 4, 2019, so we missed almost an entire month of the spring portion of the steelhead run. Once the trap was open, we set the sample rate to 20% (trapping rate 28% 5 days per week) for the rest of the spring due to low runs. In sum, we over-sampled the steelhead run during our fall trapping efforts and under-sampled the run during our spring trapping efforts.

Spawn year 2019 provides an example of how low run sizes and trap operation changes may cause small sample sizes in future years. Managers would be well served to reconsider their sample size needs in anticipation of similar or worse sample size problems in the future.

Estimates for three genetic stocks reported in this document are not complete for the entirety of that stock. A genetic stock can have an incomplete estimate in two ways. The first way is that the genetic stock, wholly or partially, contains populations that originate below LGR. The LSNAKE (steelhead) and TUCANO (Chinook Salmon) stocks contain the Tucannon River population located below LGR. Some returning adults born in the Tucannon River overshoot their natal stream and stray above LGR. Without abundance information from the Tucannon River for each species, estimates for the LSNAKE and TUCANO should be considered a minimum for the returns to the Snake River basin. The second way is that a genetic stock overlaps run designations defined by USACE calendar dates. The FALL (Chinook Salmon) genetic stock reported here only includes fall-run Chinook Salmon that cross LGR during the spring-summer Chinook Salmon run timing (March 1–August 17). The vast majority of the FALL genetic stock cross LGR after August 17. However, by accounting for FALL Chinook Salmon trapped on August 17 and earlier, we get a better estimate of the true spring-summer stocks returning to the Snake River. Additionally, preliminary evidence from PIT tags suggests some (<30 PIT-tagged fish in any given year) spring-summer Chinook Salmon cross LGR after August 17. However, quantifying abundances of spring-summer Chinook Salmon during the USACE fall-run timing designation is not within the scope of this report. Reporting estimates from the incomplete genetic stocks is mainly for accounting purposes and inferences should not be made using the associated results. The inclusion of these stocks provides critical information for a more refined decomposition of the aggregate run at LGR into desired reporting groups.

Our wild (and hatchery) escapement estimates are based on unadjusted window counts, i.e. we treat the counts as a complete census. Unadjusted window counts were a critical component of the ESA listing and have been used for decades to evaluate population performance in the hydrosystem. Therefore, our products are clearly and directly related to the common currency. However, there are a number of potential biases when estimating total adult escapement at LGR using unadjusted window counts. Some returning fish are known to fallback below LGR after successfully crossing above. A portion of these fallback fish re-ascend the LGR ladder, essentially being counted twice at the window, while others stay below LGR. Furthermore, the window is not counted 24 hours a day throughout the season (USACE 2018, 2019). We recognize that it is possible that our wild escapement estimates at LGR are slightly biased.

However, our estimates are likely more accurate than estimates based solely on window counts due to our accounting and removal of ad-intact hatchery fish from wild fish estimates using PBT, which began in SY2011 (Steele et al. 2011; Camacho et al. 2017, 2018a, 2019a). In the future, we plan to continue to refine our stock assessments for both species by accounting for fallback with reascension and nighttime passage. While some technical and conceptual concerns have been addressed, others need to be resolved while clearly maintaining a transparent relationship with window count data. Accounting for these issues will increase the value of the series to address multiple management and assessment needs.

This chapter summarized the abundance and composition of wild steelhead and spring-summer Chinook Salmon returning to LGR during spawn year 2019 as defined by the USACE calendar date designations. We estimated wild steelhead and Chinook Salmon escapement and age, sex, and size composition in aggregate and by genetic stock. We also updated the adult-to-adult productivity series for both species and the smolt-to-adult return (SAR) rate series for steelhead and Chinook Salmon. We noted overall declining trends in escapement, productivity, and smolt-to-adult return rates for both species. The following chapter connects present status of Idaho steelhead stocks to their status at the time of ESA listing.

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TABLES

Table 1-1. Estimated annual escapement, by fish size and origin, of steelhead, spawn years 1998-2019. Large fish are greater than or equal to 78 cm (FL) and small fish are less than 78 cm (FL). Ad-clipped and ad-intact refer to the adipose fin. Estimates were generated by IDFG and are the USACE window counts decomposed using adult trap data (Alan Byrne, IDFG, personal communication; Camacho et al. 2017, 2018a, 2019a; present study).

		Estimated number of steelhead at LGR that were:							
Spawn year(a)	**LGR window count**	**Large wild(b)**	**Large hatchery ad-clipped**	**Large hatchery ad-intact(b)**	**Small wild(b)**	**Small hatchery ad-clipped**	**Small hatchery ad-intact(b)**	**Total hatchery**	**Total wild**
1998	86,646	1,325	10,878	0	7,424	67,019	0	77,897	8,749
1999	70,662	2,301	17,455	0	7,074	43,832	0	61,287	9,375
2000	74,051	914	8,834	0	10,184	54,119	0	62,953	11,098
2001	117,302	2,886	17,128	0	17,689	79,589	10	96,727	20,575
2002	268,466	3,174	30,677	0	37,545	191,091	5,979	227,747	40,719
2003	222,176	13,623	51,358	6,618	28,308	110,535	11,734	180,245	41,931
2004	172,510	7,254	23,058	2,132	21,892	106,334	11,840	143,364	29,146
2005	151,646	4,774	23,179	2,005	18,297	94,225	9,166	128,575	23,071
2006	158,165	3,544	26,143	3,345	14,586	96,644	13,903	140,035	18,130
2007	149,166	1,633	33,332	5,880	7,877	85,210	15,234	139,656	9,510
2008	155,142	2,924	20,513	3,446	11,242	102,374	14,643	140,976	14,166
2009	178,870	5,659	40,713	6,998	18,216	94,205	13,079	154,995	23,875
2010	323,382	4,529	16,555	2,700	38,210	231,003	30,385	280,643	42,739
2011	208,296	9,584	31,574	4,118	34,549	110,750	17,721	164,163	44,133
2012	180,320	4,198	17,801	2,113	35,240	113,038	7,930	140,882	39,438
2013	109,186	3,337	13,695	3,970	19,806	63,611	4,767	86,043	23,143
2014	108,154	1,885	5,546	1,593	23,470	70,332	5,328	82,799	25,355
2015	165,591	6,928	21,067	3,639	38,861	89,341	5,755	119,802	45,789
2016	136,150	3,130	8,465	1,408	30,806	88,296	4,045	102,214	33,936
2017	101,826	3,001	25,724	4,145	12,575	52,825	3,556	86,250	15,576
2018	74,097	263	3,845	539	10,454	56,738	2,258	63,380	10,717
2019	51,818	1,232	13,119	2,223	7,055	26,776	1,413	43,531	8,287

[a] Steelhead at Lower Granite Dam are considered fish passing July 1 through June 30; most steelhead pass the dam in the fall but are assigned to their spawn year the following spring.

[b] Spawn year 2011 was the first year of adult PBT returns used to adjust wild and hatchery ad-intact fish estimates.

Table 1-2. Estimated number of wild steelhead smolts, number of returning adults by saltwater age, and percent smolt-to-adult return (% SAR) rate at Lower Granite Dam. Scale samples were used for all smolt migration years. Repeat spawners (shaded) were not used to estimate SARs. SAR 95% confidence intervals are in parentheses.

		Adults returning to Lower Granite Dam by saltwater age				
Smolt migration year	**Estimated number of smolts(a)**	**1**	**2**	**3**	**Repeat spawners**	**%SAR (95% CI)**
2005	n/a	n/a	n/a	902	n/a	n/a
2006	n/a	n/a	12,129	869	270	n/a
2007	n/a	10,844	16,404	252	441	n/a
2008	n/a	25,175	32,096	345	643	n/a
2009	n/a	11,360	24,538	157	555	n/a
2010	851,481	14,051	14,596	317	386	3.40 (3.36–3.44)
2011	911,602	7,785	7,750	364	278	1.74 (1.72–1.77)
2012	890,665	16,936	30,450	124	484	5.33 (5.29–5.38)
2013	792,037	14,482	21,839	121	222	4.60 (4.56–4.65)
2014	816,219	11,598	13,499	71	124	3.08 (3.05–3.12)
2015	669,442	1,706	2,040	30	257	0.56 (0.54–0.58)
2016(b)	805,433	8,498	4,169	-	-	1.57 (1.55–1.60)
2017(c)	908,556	3,804	-	-	-	0.42 (0.41–0.43)

(a) Smolt abundance for 2010-2017 derived from SCRAPI program (Camacho et al. 2018b, 2019b).

(b) Preliminary SAR until saltwater age-3 is added (SY2020).

(c) Preliminary SAR until saltwater age-2 and age-3 are added (SY2021).

Table 1-3. Estimated annual escapement, by origin and saltwater age, of Chinook Salmon, spawn years 1998-2019. Jacks are saltwater age-1 and include saltwater age-0 mini-jacks; adults are saltwater age-2 and older. Estimates were generated by IDFG and are the USACE window counts decomposed using adult trap data (Camacho et al. 2017, 2018a, 2019a; present study).

		Estimated number of Chinook Salmon at Lower Granite Dam that were:							
Spawn year(a)	**Window count**	**Wild adults(b)**	**Wild jacks(b)**	**Total wild**	**Hatchery adults(b)**	**Hatchery jacks(b)**	**Total hatchery**	**Total adults(b)**	**Total jacks(b)**
1998	14,646	5,378	122	5,500	8,831	315	9,146	14,209	437
1999	10,647	2,695	236	2,931	3,861	3,855	7,716	6,556	4,091
2000	51,835	7,347	1,500	8,847	30,414	12,574	42,988	37,761	14,074
2001	192,632	37,063	1,621	38,684	148,630	5,318	153,948	185,693	6,939
2002	101,226	27,743	340	28,083	69,441	3,702	73,143	97,184	4,042
2003	99,463	29,270	2,349	31,619	57,761	10,083	67,844	87,031	12,432
2004	86,501	16,808	982	17,790	62,701	6,010	68,711	79,509	6,992
2005	35,100	8,691	386	9,077	25,118	905	26,023	33,809	1,291
2006	31,223	8,775	292	9,067	21,312	844	22,156	30,087	1,136
2007	42,551	7,694	1,114	8,808	21,034	12,709	33,743	28,728	13,823
2008	88,776	14,046	2,333	16,379	53,027	19,370	72,397	67,073	21,703
2009	111,580	12,963	3,454	16,417	45,477	49,686	95,163	58,440	53,140
2010	134,684	26,281	1,368	27,649	97,273	9,762	107,035	123,554	11,130
2011	134,594	22,407	4,176	26,583	69,636	38,375	108,011	92,043	42,551
2012	84,771	20,298	1,242	21,540	59,221	4,010	63,231	79,519	5,252
2013	70,966	12,407	6,856	19,263	30,556	21,147	51,703	42,963	28,003
2014	114,673	26,351	3,987	30,338	65,415	18,920	84,335	91,766	22,907
2015	132,432	21,499	1,910	23,409	96,163	12,860	109,023	117,662	14,770
2016	81,753	15,939	813	16,752	58,187	6,814	65,001	74,126	7,627
2017	48,192	4,108	1,685	5,793	30,180	12,219	42,399	34,288	13,904
2018	42,232	6,863	519	7,382	31,820	3,030	34,850	38,683	3,549
2019	29,617	4,152	1,010	5,162	19,528	4,927	24,455	23,680	5,937

[a] Spring-summer Chinook Salmon at Lower Granite Dam are considered fish passing March 1 through August 17.

[b] For spawn years 2005-2019 (unshaded), the wild vs. hatchery and adults vs. jacks splits were estimated using scale samples, other biological data, and starting in 2011 parentage based tagging (PBT) samples collected at the LGR adult trap. For spawn years 1998-2004 (shaded gray), the splits were estimated using fin ray samples collected on the spawning grounds and biological samples collected at the adult trap.

Table 1-4. Estimated number of wild Chinook Salmon smolts, number of returning adults by saltwater age, and percent smolt-to-adult return (%SAR) rate at Lower Granite Dam. Fin ray samples were used to estimate age composition for adults returning from smolt migration years 1996-2004 (above the dashed line) whereas scale samples were used for smolt migration years 2005-2018 (below the dashed line). SAR 95% confidence intervals are in parentheses.

Smolt migration year	**Estimated number of smolts(a)**	**Adults returning to Lower Granite Dam by saltwater age**					**%SAR (95% CI)**
		0(b)	**1**	**2**	**3**	**4**	
1996	419,826	n/a	n/a(c)	628	451	0	0.26 (0.24–0.27)
1997	161,157	n/a	122	2,162	409	23	1.69 (1.62–1.75)
1998	599,159	n/a	236	6,938	1,056	281	1.42 (1.39–1.45)
1999	1,560,298	n/a	1,500	35,984	12,455	481	3.23 (3.20–3.26)
2000	1,344,382	n/a	1,621	15,007	22,724	43	2.93 (2.90–2.96)
2001	490,534	n/a	340	6,065	1,799	53	1.68 (1.65–1.72)
2002	1,128,582	n/a	2,349	14,966	2,739	24	1.78 (1.75–1.80)
2003	1,455,786	n/a	982	5,899	1,886	10	0.60 (0.59–0.62)
2004	1,517,951	n/a	351	6,865	3,903	27	0.73 (0.72–0.75)
2005	1,734,464	35	280	3,781	2,703	22	0.39 (0.38–0.40)
2006	1,227,474	12	1,104	11,316	2,937	0	1.25 (1.23–1.27)
2007	787,150	10	2,306	10,004	1,368	0	1.74 (1.71–1.77)
2008	856,556	27	3,431	24,914	7,658	59	4.21 (4.17–4.26)
2009	894,629	23	1,344	14,751	6,258	14	2.50 (2.47–2.54)
2010	1,268,659	23	3,985	13,980	4,523	0	1.77 (1.75–1.80)
2011	1,184,839	189	1,194	7,870	1,408	0	0.90 (0.88–0.92)
2012	1,674,268	49	6,780	24,942	2,866	27	2.07 (2.05–2.09)
2013	1,006,960	76	3,921	18,633	5,709	33	2.82 (2.79–2.85)
2014	1,406,596	67	1,894	10,203	1,258	0	0.95 (0.94–0.97)
2015	525,743	16	766	2,817	333	5	0.75 (0.72–0.77)
2016(d)	1,424,036	47	1,651	6,530	956	-	0.64 (0.63–0.66)
2017(e)	1,171,926	34	490	3,191	-	-	0.32 (0.31–0.33)
2018(f)	1,437,312	29	992	-	-	-	0.07 (0.06–0.08)
2019(g)			-	-	-	-	

(a) Smolt abundance for 2010-2018 derived from SCRAPI program (Camacho et al. 2018b, 2019b).

(b) Mini-jack (saltwater age-0) samples were not sampled on the spawning grounds, thus mini-jack fin rays are not available (n/a) for smolt migration years 1996-2004; only mini-jacks ≥30 cm, FL, were sampled for scales at Lower Granite Dam for smolt migration years 2005-2018.

(c) Jack (saltwater age-1) fin ray samples were not collected on the spawning grounds and are not available (n/a) for smolt migration year 1996.

(d) Preliminary SAR until saltwater age-4 is added (SY2020).

(e) Preliminary SAR until saltwater age-3 and age-4 are added (SY2021).

(f) Preliminary SAR until saltwater age-2 through age-4 are added (SY2022).

(g) Preliminary SAR until saltwater age-1 through age-4 are added (SY2023).

FIGURES

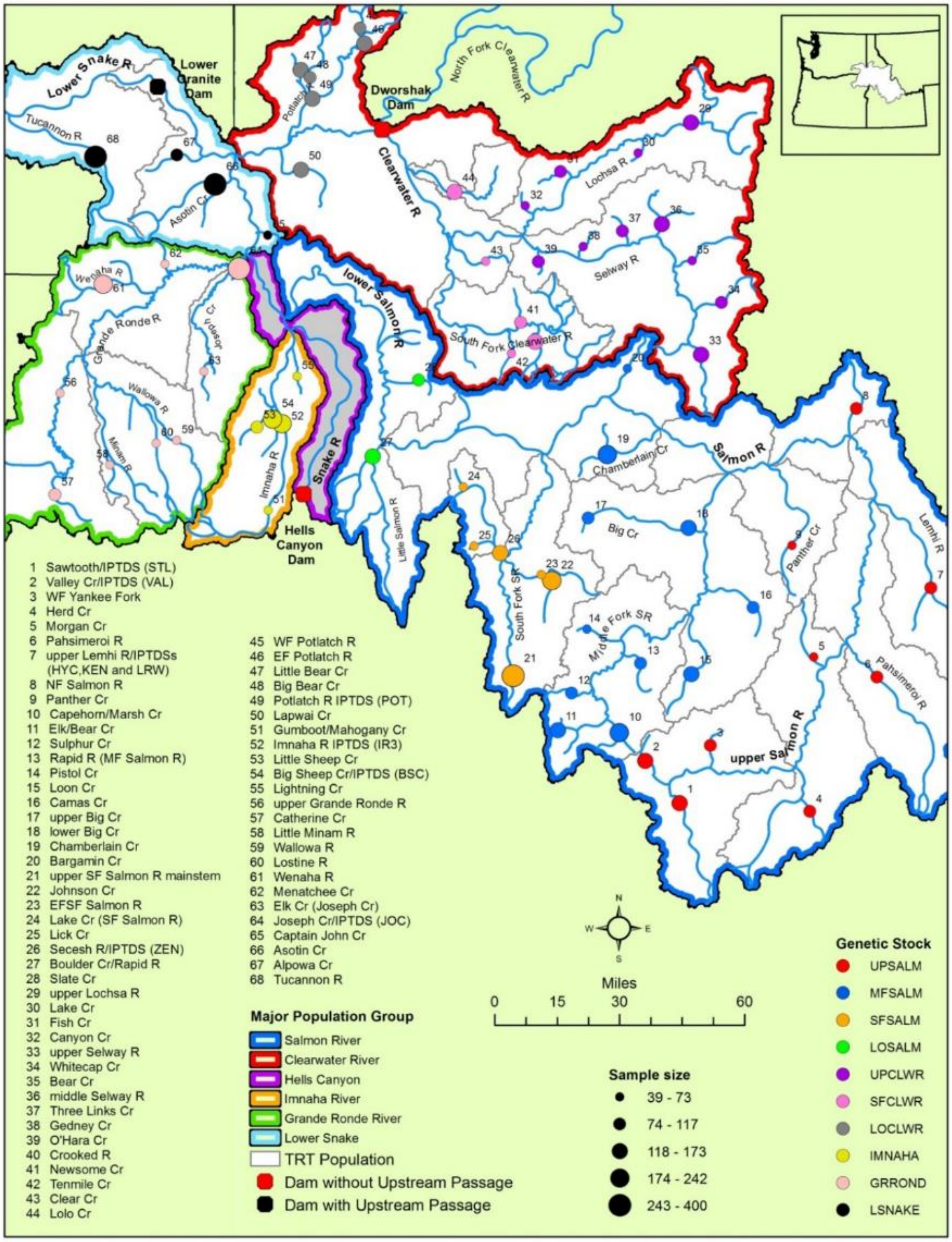

Figure 1-1. Genetic stocks and baseline collections used for steelhead mixed stock analysis at Lower Granite Dam, spawn years 2009-2019 (Vu et al. 2015). The Hells Canyon Tributaries major population group (shaded gray) does not support independent populations and is considered extirpated (NMFS 2016). See text for genetic stock abbreviations.

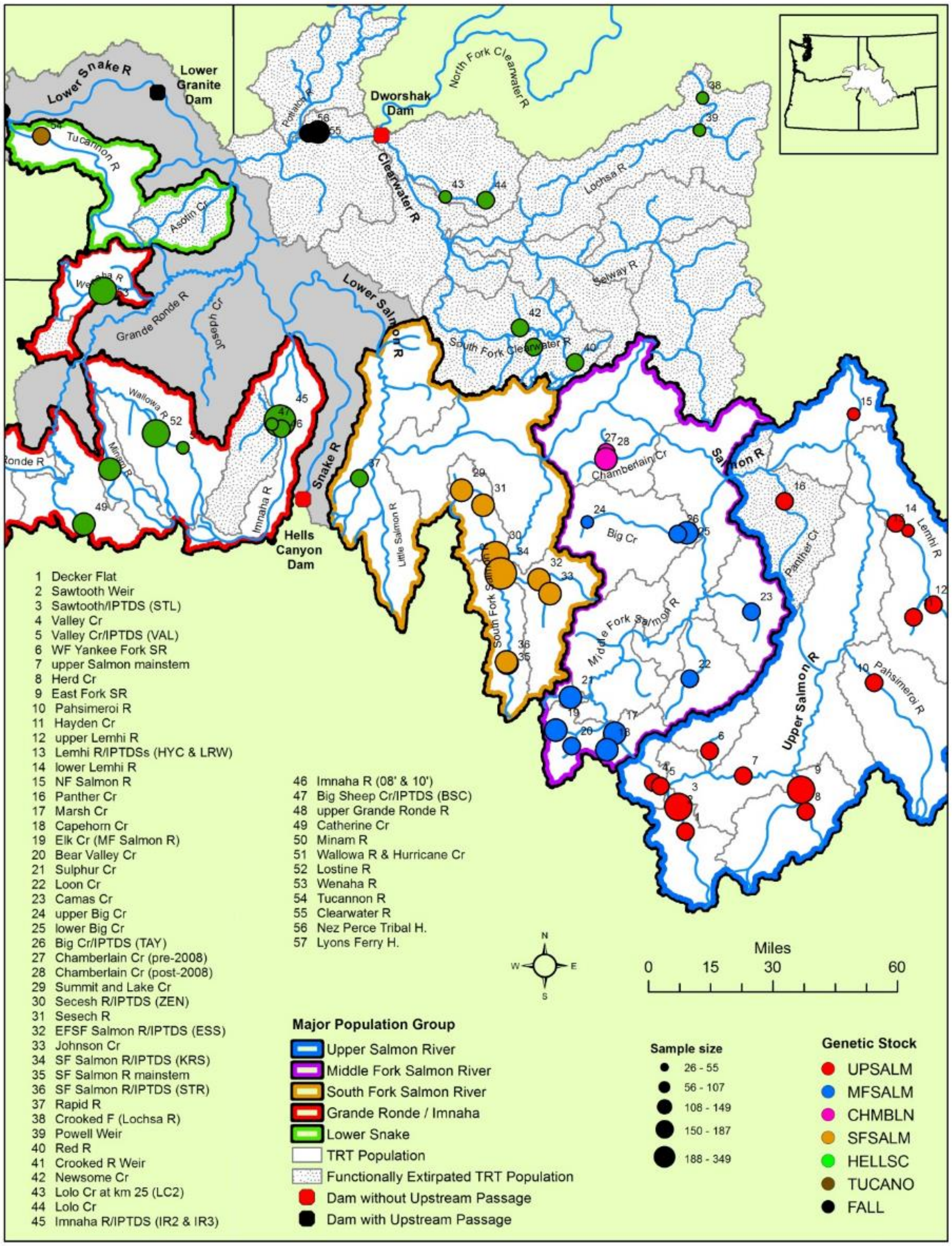

Figure 1-2. Genetic stocks and baseline collections used for Chinook Salmon mixed stock analysis at Lower Granite Dam, spawn years 2009-2019 (Vu et al. 2015). Reintroduced fish exist in functionally extirpated TRT populations as mapped. See text for genetic stock abbreviations.

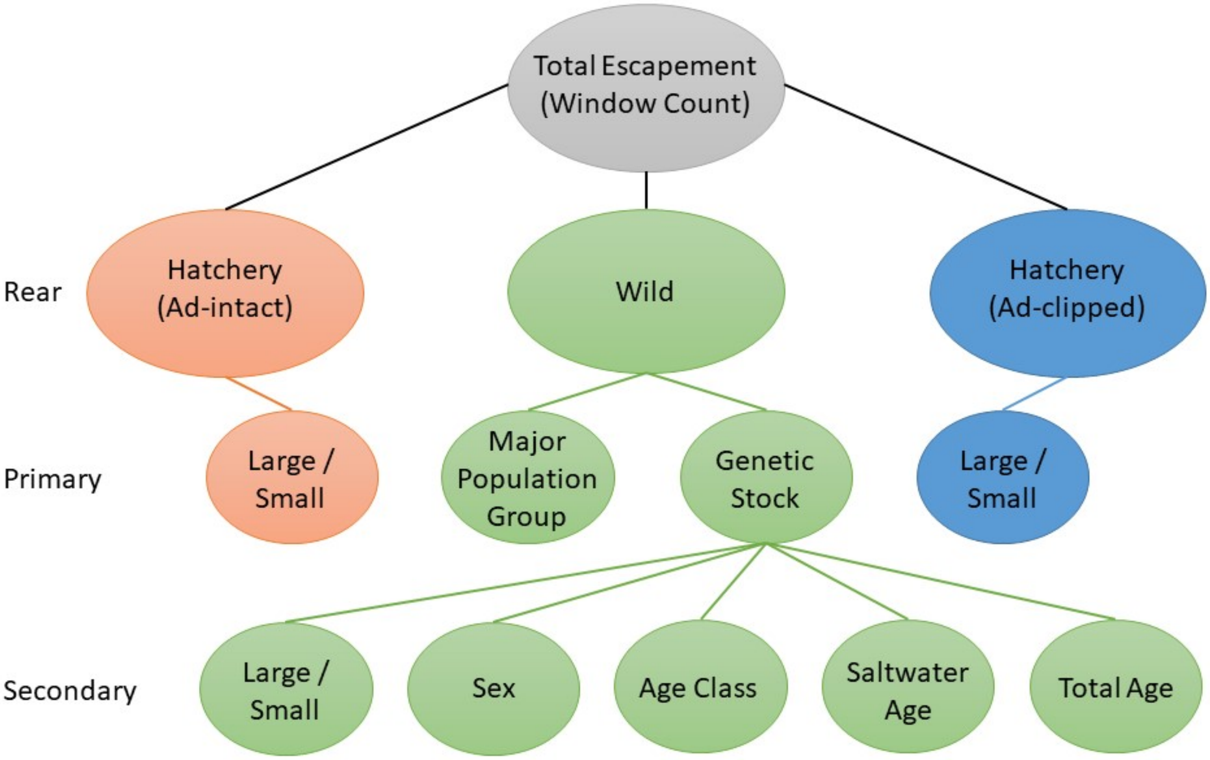

Figure 1-3. Schematic of the Salmonid Compositional Bootstrap Intervals (SCOBI) Lower Granite Dam decomposition model. Large/Small refer the fork length designations for Chinook Salmon large (≥57 cm) and small (<57 cm) and steelhead large (≥78 cm) and small (<78 cm). Fish less than 30 cm (FL) are not designated to species and are ignored.

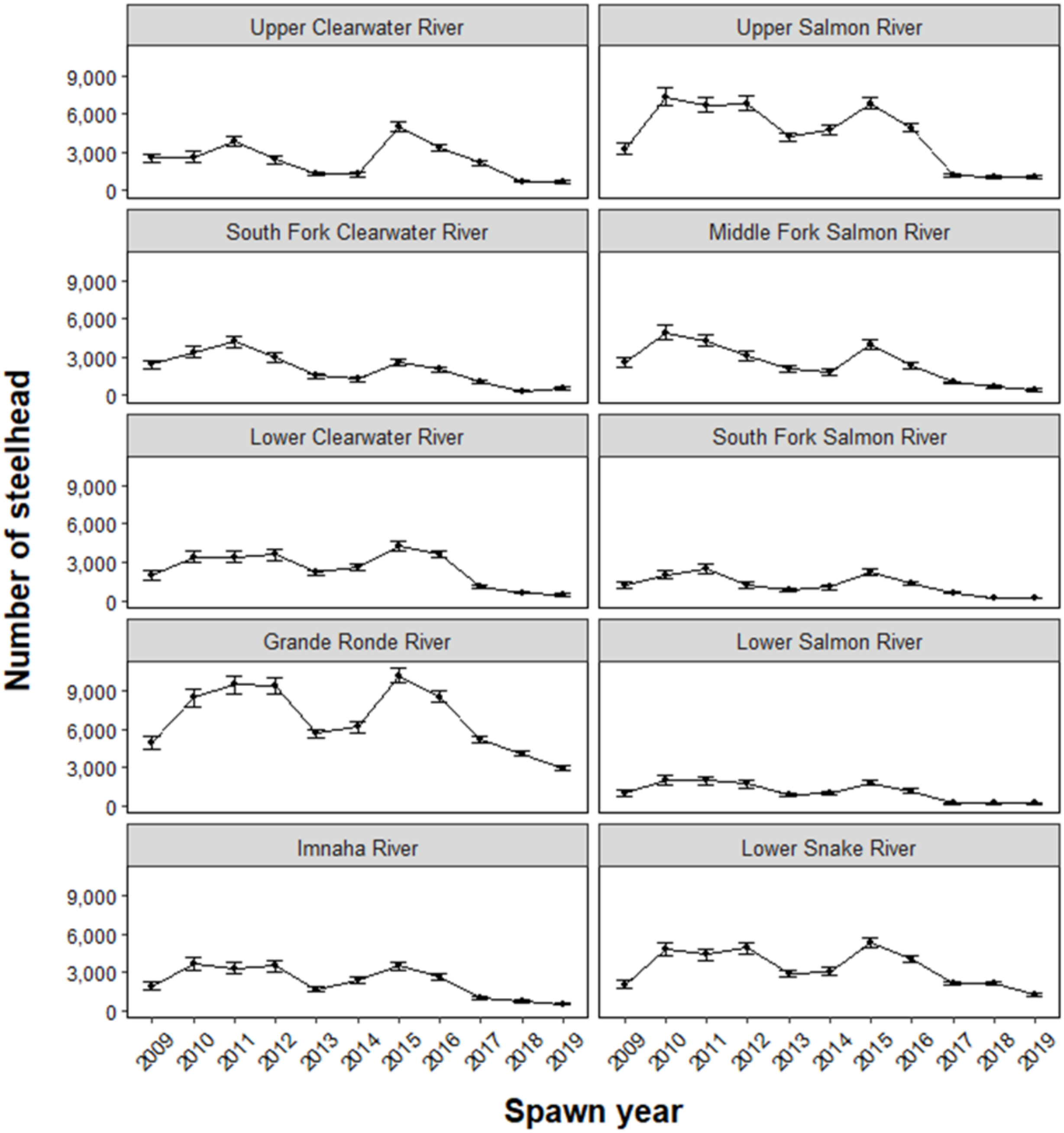

Figure 1-4. Estimated escapement by stock of wild steelhead at Lower Granite Dam for spawn years 2009-2019. Confidence intervals are at 90%.

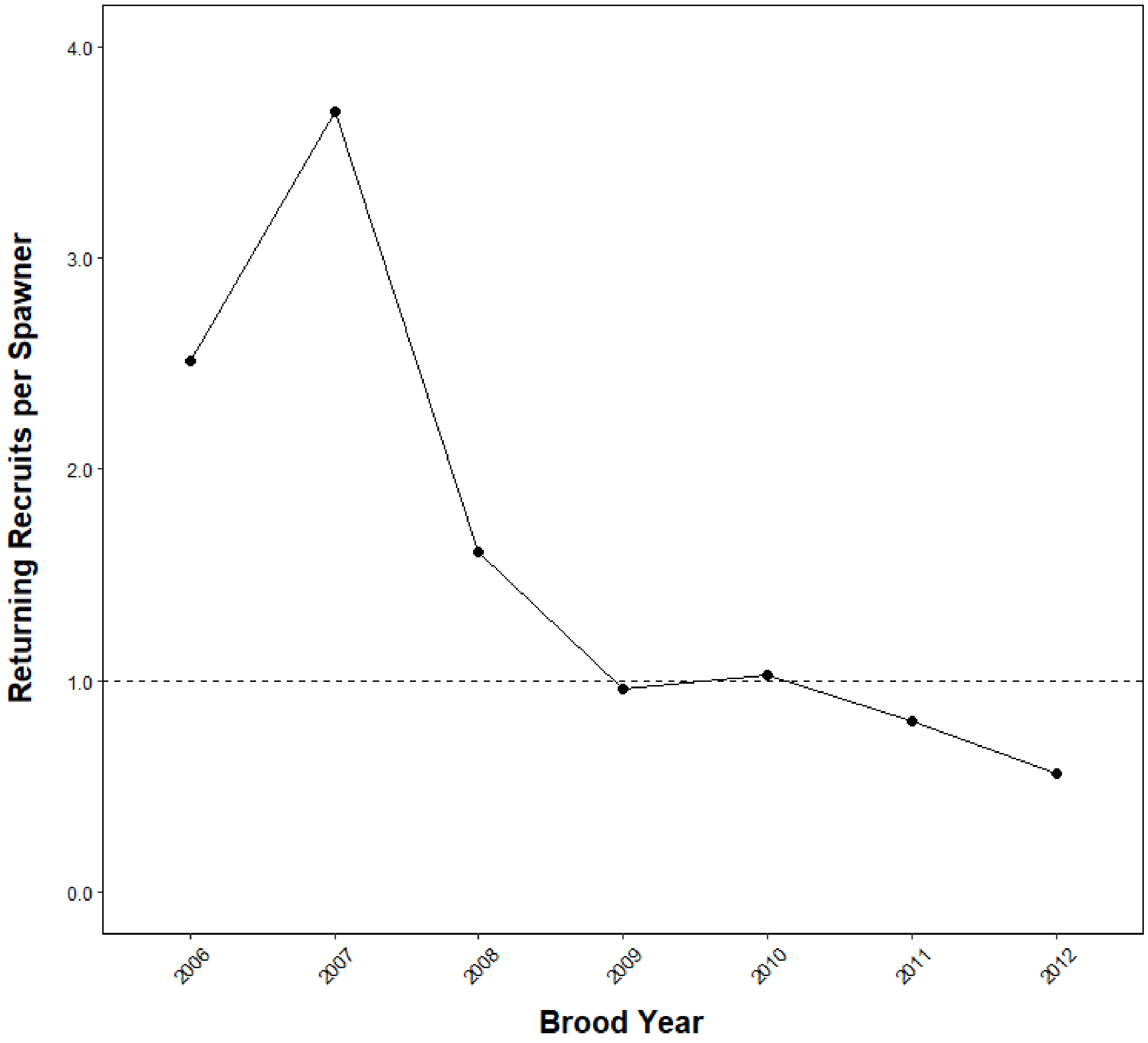

Figure 1-5. Adult-to-adult productivity (returning recruits per parent spawner) of wild steelhead at Lower Granite Dam. The dashed line at 1.0 recruits per spawner represents replacement. Spawn year 2019 completed brood year 2011. Note brood year 2012 is shown for reference, but it represents a preliminary result that will be completed in SY 2020.

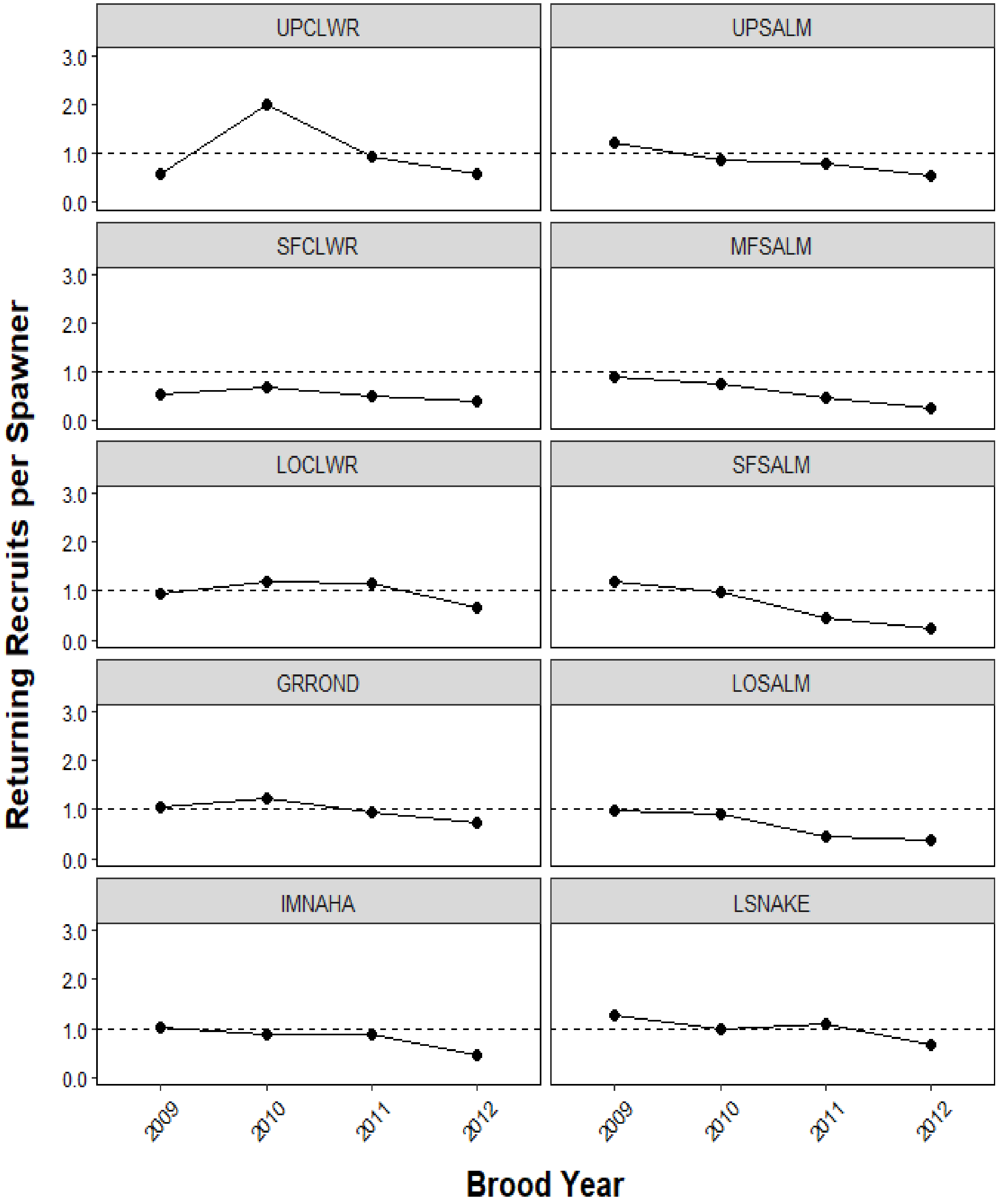

Figure 1-6. Adult-to-adult productivity (returning recruits per parent spawner) for each genetic stock of wild steelhead at Lower Granite Dam. The dashed line at 1.0 recruits per spawner represents replacement. Spawn year 2019 completed brood year 2011. Note brood year 2012 is shown for reference, but it represents a preliminary result that will be completed in SY 2020.

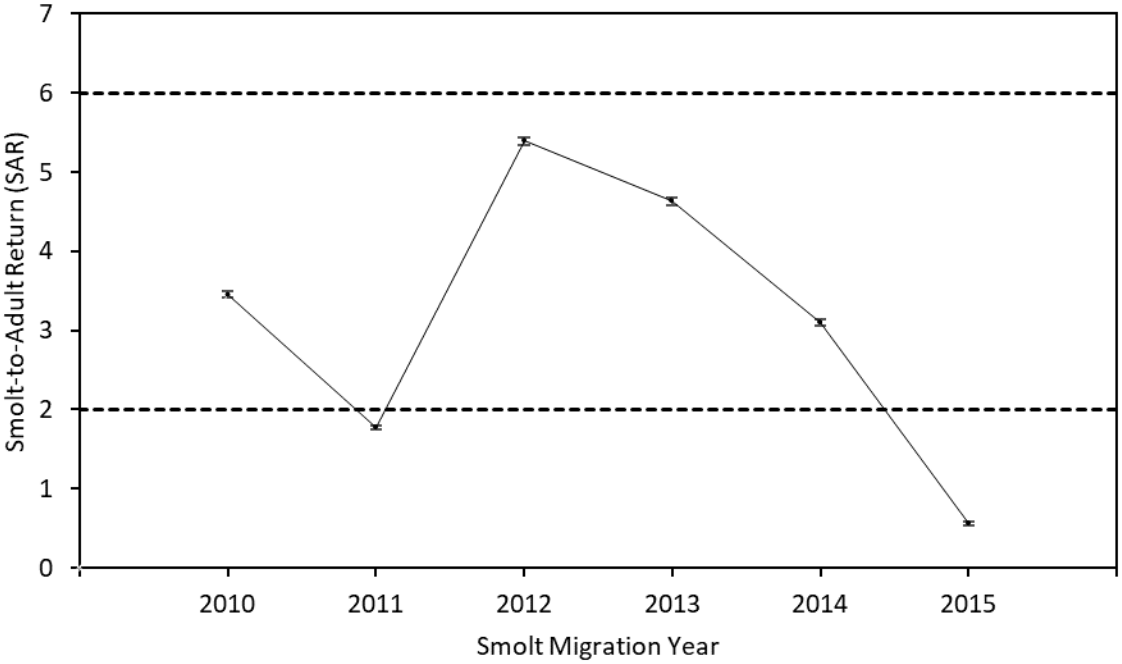

Figure 1-7. Estimated wild steelhead smolt-to-adult return (SAR) rate of emigrant smolts and adult returns to Lower Granite Dam. Confidence intervals are at 95%. The dashed lines represent the lower and upper range SAR objectives for wild steelhead established by the Northwest Power and Conservation Council (NPCC 2009). See Table 1-2 for numbers.

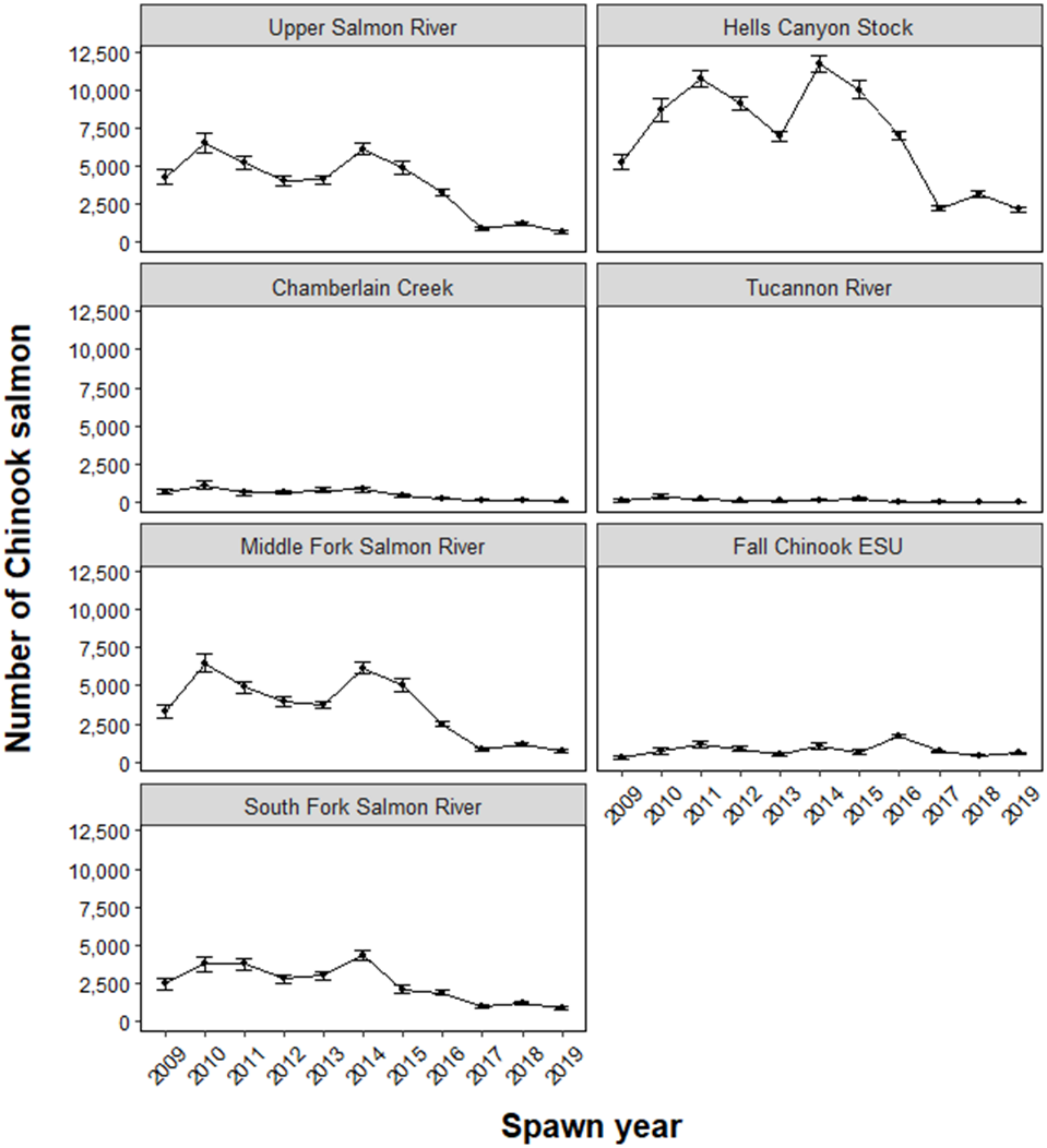

Figure 1-8. Estimated escapement by stock of wild Chinook Salmon at Lower Granite Dam during March 1 to August 17 of spawn years 2009-2019. Confidence intervals are at 90%. Hells Canyon stock is an aggregate genetic stock that includes Chinook Salmon from the Clearwater, Little Salmon, lower Salmon, Grande Ronde, Imnaha, and lower Snake rivers.

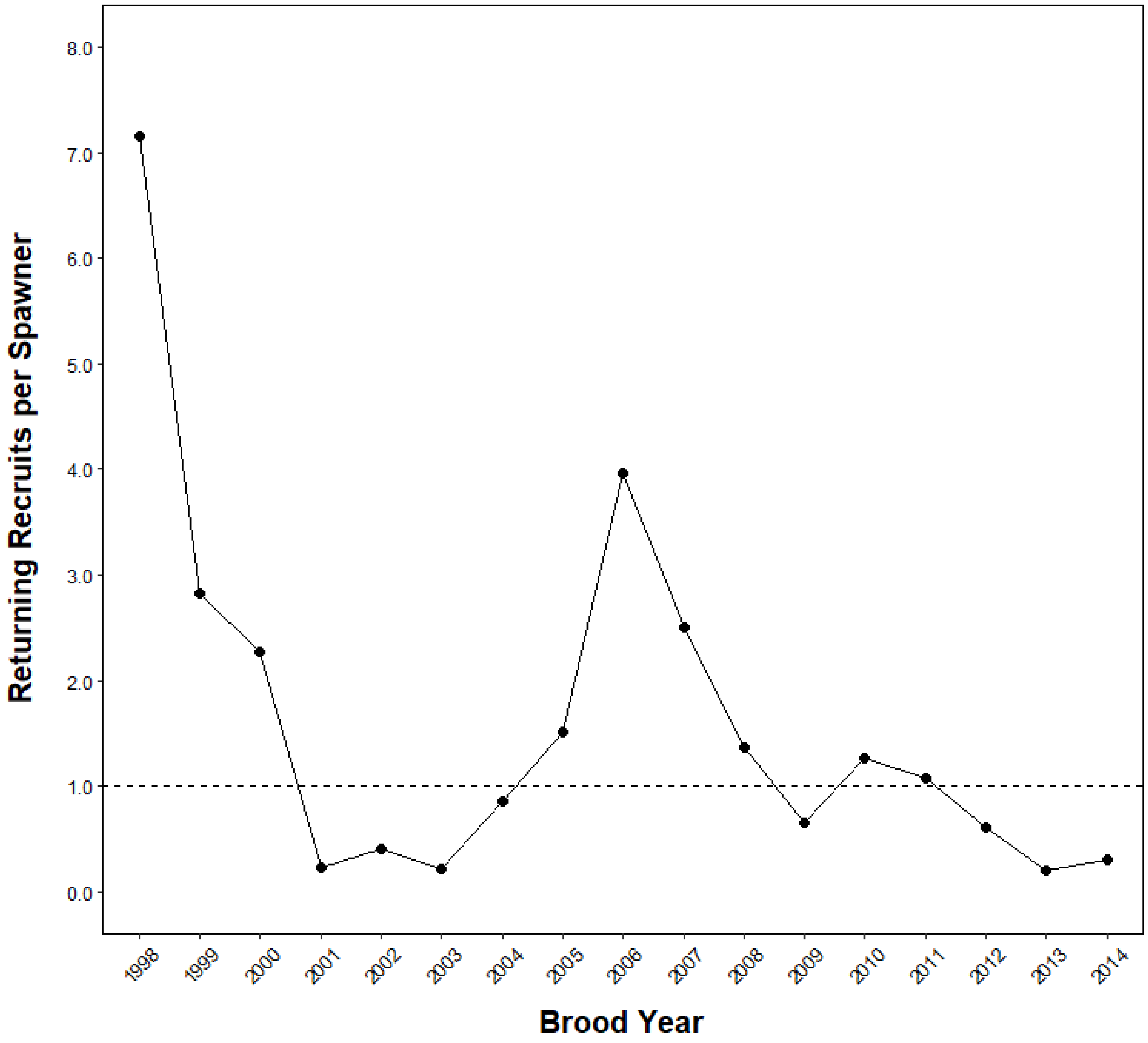

Figure 1-9. Adult-to-adult productivity (returning recruits per parent spawner) of wild Chinook Salmon at Lower Granite Dam. The dashed line at 1.0 recruits per spawner represents replacement. Spawn year 2019 completed brood year 2013. Note brood year 2014 is shown for reference, but it represents a preliminary result that will be completed in SY 2020.

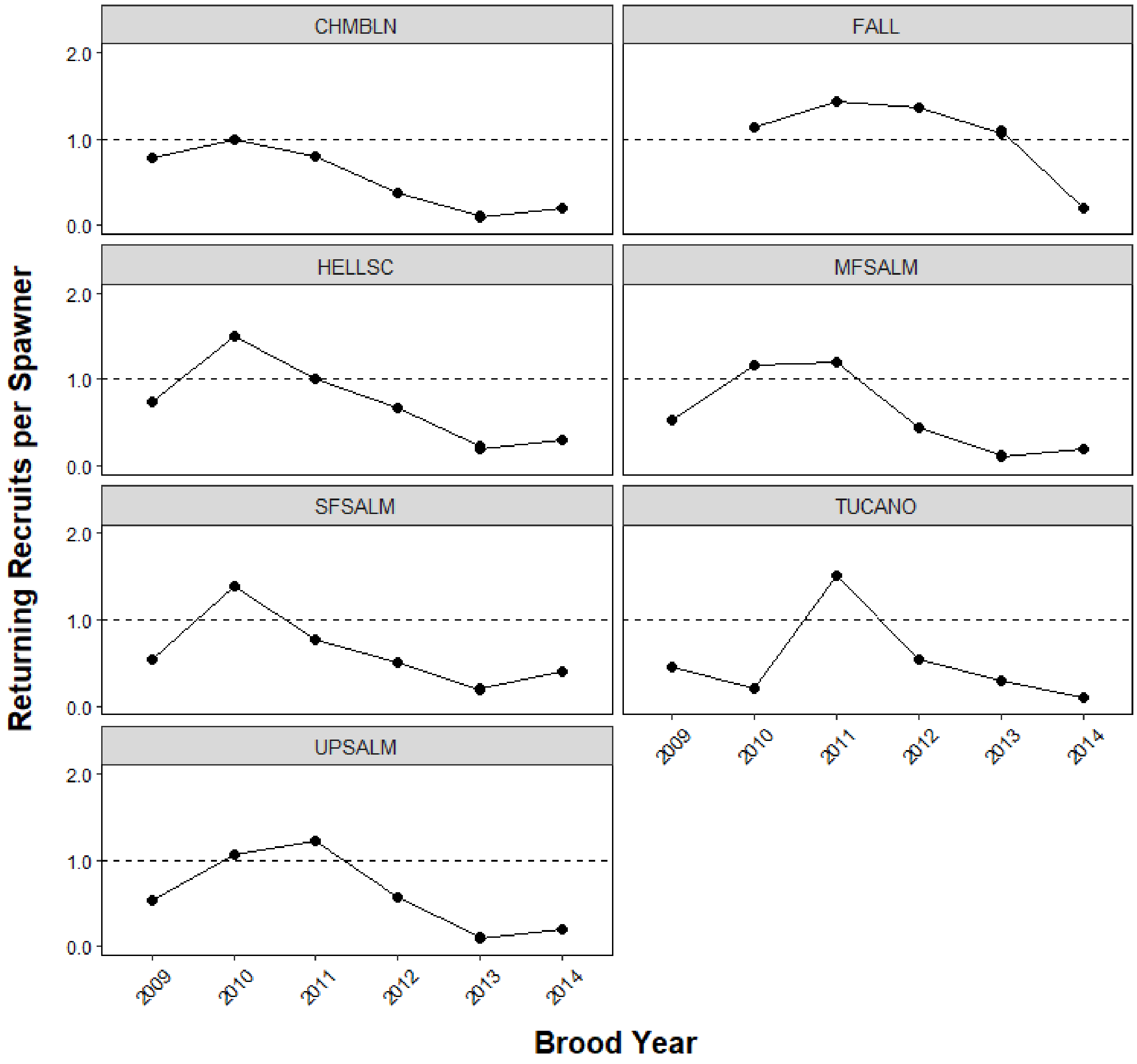

Figure 1-10. Adult-to-adult productivity (returning recruits per parent spawner) for each genetic stock of wild Chinook Salmon at Lower Granite Dam. The dashed line at 1.0 recruits per spawner replacement. Spawn year 2019 completed brood year 2013. Note brood year 2014 is shown for reference, but it represents a preliminary result that will be completed in SY 2020.

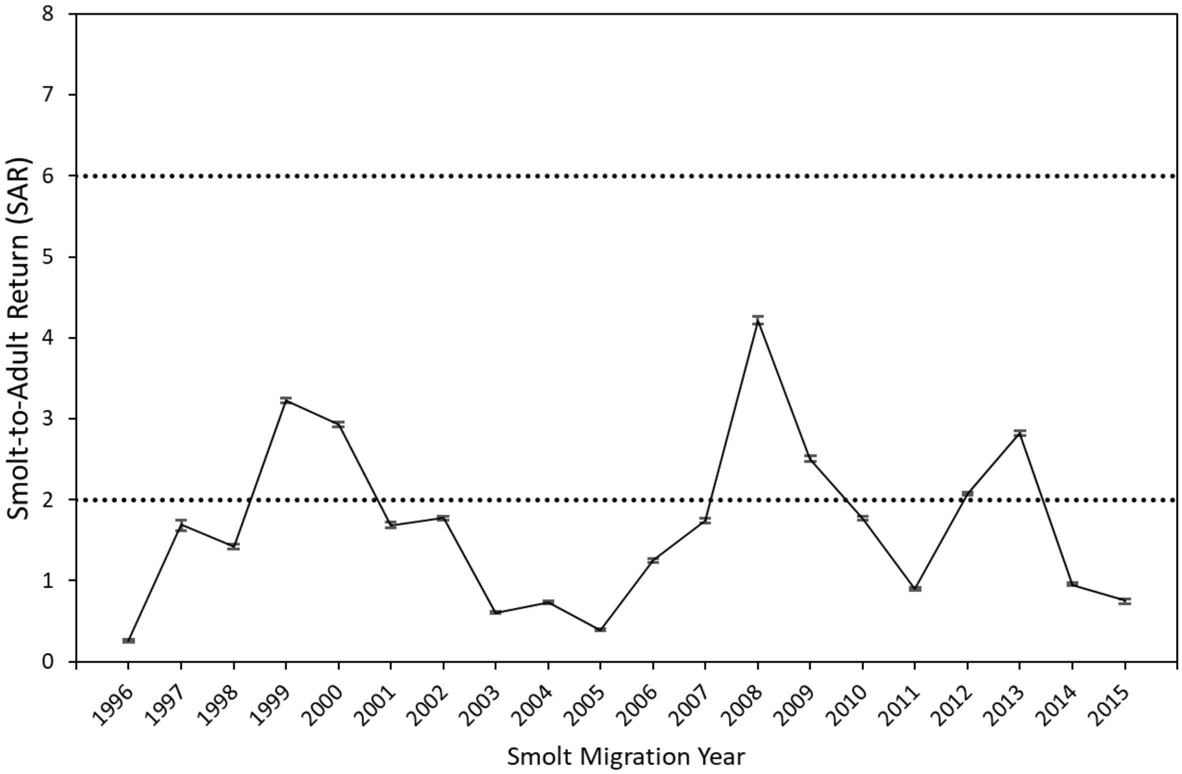

Figure 1-11. Estimated wild Chinook Salmon smolt-to-adult return (SAR) rate of emigrant smolts and adult returns to Lower Granite Dam. Confidence intervals are at 95%. The dashed lines represent the lower and upper range SAR objectives for wild Chinook Salmon established by the Northwest Power and Conservation Council (NPCC 2009). See Table 1-4 for numbers.

CHAPTER 2 ─ ABUNDANCE AND PRODUCTIVITY OF IDAHO STEELHEAD STOCKS INCLUDING RECONSTRUCTED ESTIMATES BEFORE THE 2009 SPAWN YEAR

ABSTRACT

Little population-specific data was available for Snake River steelhead, especially for Idaho populations, during the ESA listing process and previous status assessments. Status and viability were primarily based on counts of adipose-intact steelhead at Lower Granite Dam. Instead of population identity, steelhead were split into two length groups. This chapter reviews the recent data series and updates the reconstruction of Idaho steelhead populations before formal sampling began at Lower Granite Dam in spawn year 2019. The reconstructed estimates provide the best available means to connect present status of Idaho steelhead stocks to status at the time of ESA listing.

Authors:

Timothy Copeland, Fisheries Program Coordinator

Katherine M. Lawry, Fisheries Biologist

INTRODUCTION

Little population-specific data was available for Snake River steelhead, especially for Idaho populations, during the ESA listing process (Busby et al. 1996) and during the first two five-year status assessments (Good et al. 2005; Ford 2011). Status and viability was primarily based on counts of adipose-intact steelhead at Lower Granite Dam. Instead of population identity, steelhead were split into two length groups (A-run [<78 cm fork length] and B-run [≥78 cm FL]; Copeland et al. 2017). Assessments were then performed on an 'average' population of each run type using assumed age compositions (ICBTRT 2009).

Several metrics needed for ESA status reviews depend on long-term data series. Abundance is assessed using a ten-year geometric mean and productivity is assessed using a twenty-year data series. The five-year assessments have also looked at the slope of short- and long-term trends as a measure of population growth rate (lambda). Viability assessments compare abundance in five-year blocks to status at the time of listing (i.e., 1991-1996 abundances). Ideally, these assessments would be conducted for each population. To address the need for more specific data, two initiatives using genetic methods and PIT tags were proposed in the late 2000s (Ford 2011). The first abundance and productivity estimates based on genetic stock identification at Lower Granite Dam for spawn years 2009-2014 were used in the 2015 status review (Ford 2015). The run year at Lower Granite Dam is defined to be from July 1 of the previous year to June 30. Steelhead run year dates at Lower Granite Dam were chosen to be consistent with the upriver steelhead run year at Bonneville Dam as defined in the U.S. v. Oregon management agreement. Most steelhead pass Lower Granite Dam in the fall but are assigned to their spawn year (SY) the following spring.

The estimates for abundance and productivity used in Ford (2015) were not formally published in a report. The purpose of this chapter is to review the recent data series and update the reconstruction of Idaho steelhead populations before formal sampling began at Lower Granite Dam in SY2009. This work provides an explicit link from the present status of Idaho steelhead populations to status prior to and at time of ESA listing.

METHODS

We review stock and age composition estimates for wild steelhead SY2009-2019 made by Camacho et al. (2017, 2018a, 2019a) and in Chapter 1 of this report. For age composition, we focus on the three most common ages (4, 5, and 6 years). An average stock composition is then applied to the wild summer steelhead counts made at Lower Granite Dam for the run years 1984-1985 (SY1985) until 2007-2008 (SY2008; ODFW and WDFW 2015). Within each stock, an average age composition is applied to decompose each estimate into production by brood year. We report abundance for each spawn year and productivity for each completed brood year within the range of these data.

RESULTS AND DISCUSSION

Stock proportions at Lower Granite Dam exhibited a shift after 2016. Idaho stock proportions during SY2017-2019 were the three lowest values since 2009 with the following three exceptions. The South Fork Clearwater stock had its lowest proportion in SY2018. The South Fork Salmon stock had its lowest proportions in SY2018 and SY2019. The Upper Clearwater stock had its highest value in SY2017.

Age composition with stock was remarkably stable for most of the time series. However, we noticed for most stocks that SY2017 was composed of the lowest proportion of four-year-olds and the highest proportions of five- and six-year-olds and SY2018 was the opposite. Age-4 is composed almost entirely of one-ocean fish, whereas age-5 and age-6 have higher proportions of two-ocean fish. We suspect that the unprecedented ocean conditions seen recently have affected Snake River steelhead during SY2017-2019 in ways not experienced previously.

We used averages from SY2009-2016 to decompose Lower Granite Dam counts before SY2009, whereas the data specific to each year were used thereafter (Appendix E-1 and E-2). All stocks exhibited an extended period of low abundance during SY1994-2000 (Figure 2-1). Most Idaho stocks showed peaks in 2003, 2011, and 2015. Abundance of all Idaho stocks dropped precipitously after SY2015 to low levels in 2018 and 2019.

We computed productivities for brood years 1985-2012, which were complete through age-7 (Figure 2-2). Brood years 1985-2001 were reconstructed using only averaged data, whereas brood years 2006-2012 were reconstructed using each year's data (Appendix E-1 and E-2). All Idaho stocks were below replacement (ln[R/S]<0) during brood years (BY) 1985-1993. Productivities increased above replacement for brood years with low spawning abundance but decline below replacement during brood years 2001-2003. In general, productivities peaked again for BY2007 and declined afterwards.

We assessed the ability of abundance and productivity estimates made at Lower Granite Dam to reflect the trends seen in Idaho spawning tributaries. The latter are based on data collections made at weirs for more than 20 years (East Fork Salmon River, Fish Creek, Pahsimeroi River, Rapid River, Salmon River at Sawtooth). With one exception, correlations were statistically significant (Table 2-1). The exception was productivity for the East Fork Salmon River. This is the population in the group that is intentionally supplemented with hatchery fish, hence productivity will be affected by the management program in a way not experienced by the other populations.

We concluded that the estimates made at Lower Granite Dam are reasonable surrogates for those made within populations in the absence of population-specific data. The estimates made using recent stock and age composition data are more defensible than the generalized A-run vs. B-run analyses made in the past. The reconstructed estimates provide the best available means to connect present status of Idaho steelhead stocks to status at the time of ESA listing.

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TABLES

Table 2-1. Correlations of abundance and productivity estimated at weirs versus those estimated at Lower Granite Dam by genetic stock. Correlation coefficients are reported with p-values in parentheses. Fish Creek is compared to the Upper Clearwater stock, Rapid River is compared to the Lower Salmon stock, and all others are compared to the Upper Salmon stock.

Weir	**Abundance**	**Productivity**
East Fork Salmon	0.42 (0.01)	0.01 (0.95)
Fish Creek	0.90 (<0.001)	0.85 (<0.001)
Pahsimeroi	0.66 (<0.001)	0.80 (<0.001)
Rapid River	0.67 (<0.001)	0.54 (<0.001)
Sawtooth	0.77 (<0.001)	0.80 (<0.001)

FIGURES

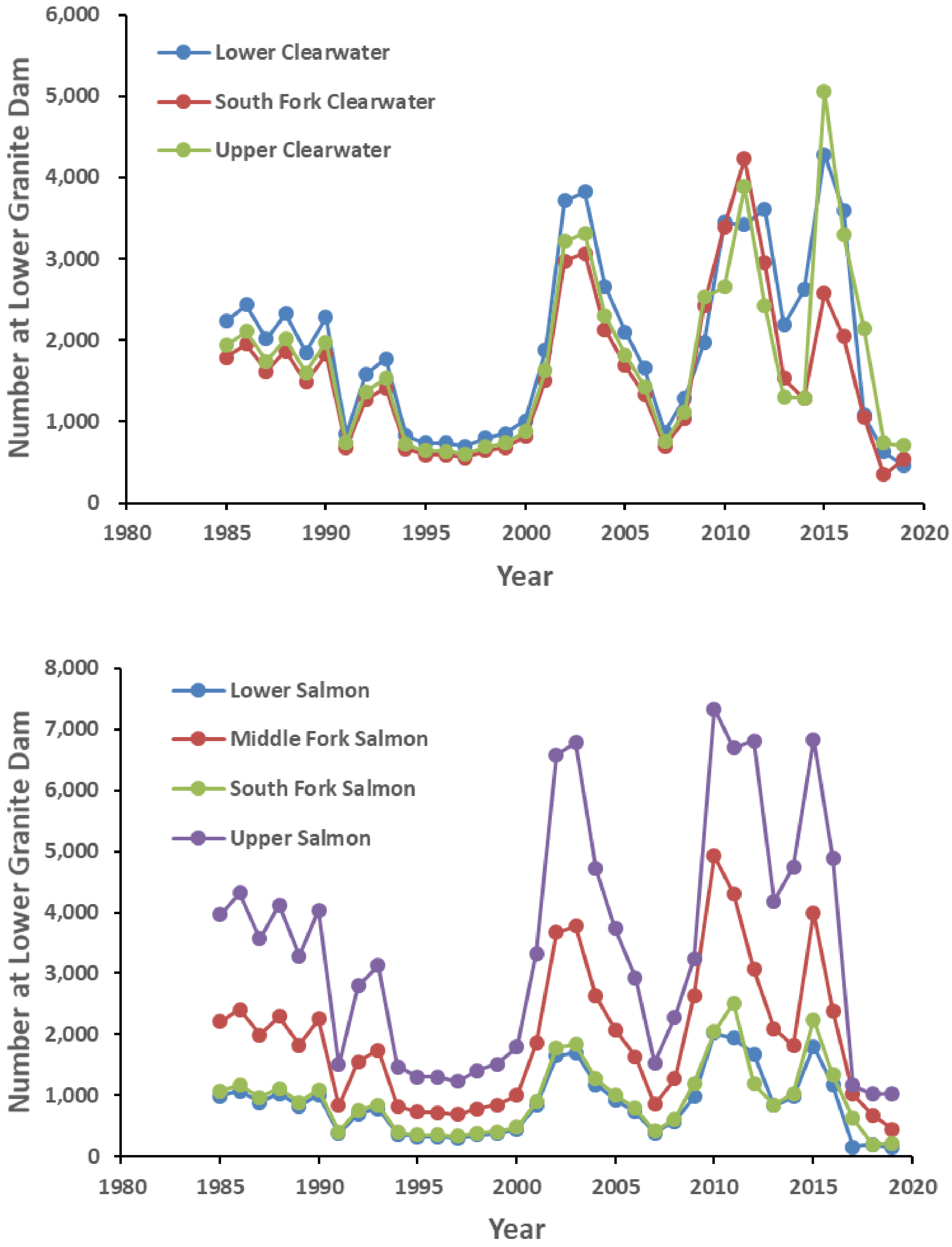


Figure 2-1. Abundance of Idaho steelhead stocks at Lower Granite Dam, spawn years 1985-2019. Clearwater MPG stocks are in the top panel and Salmon MPG stocks are in the bottom panel.

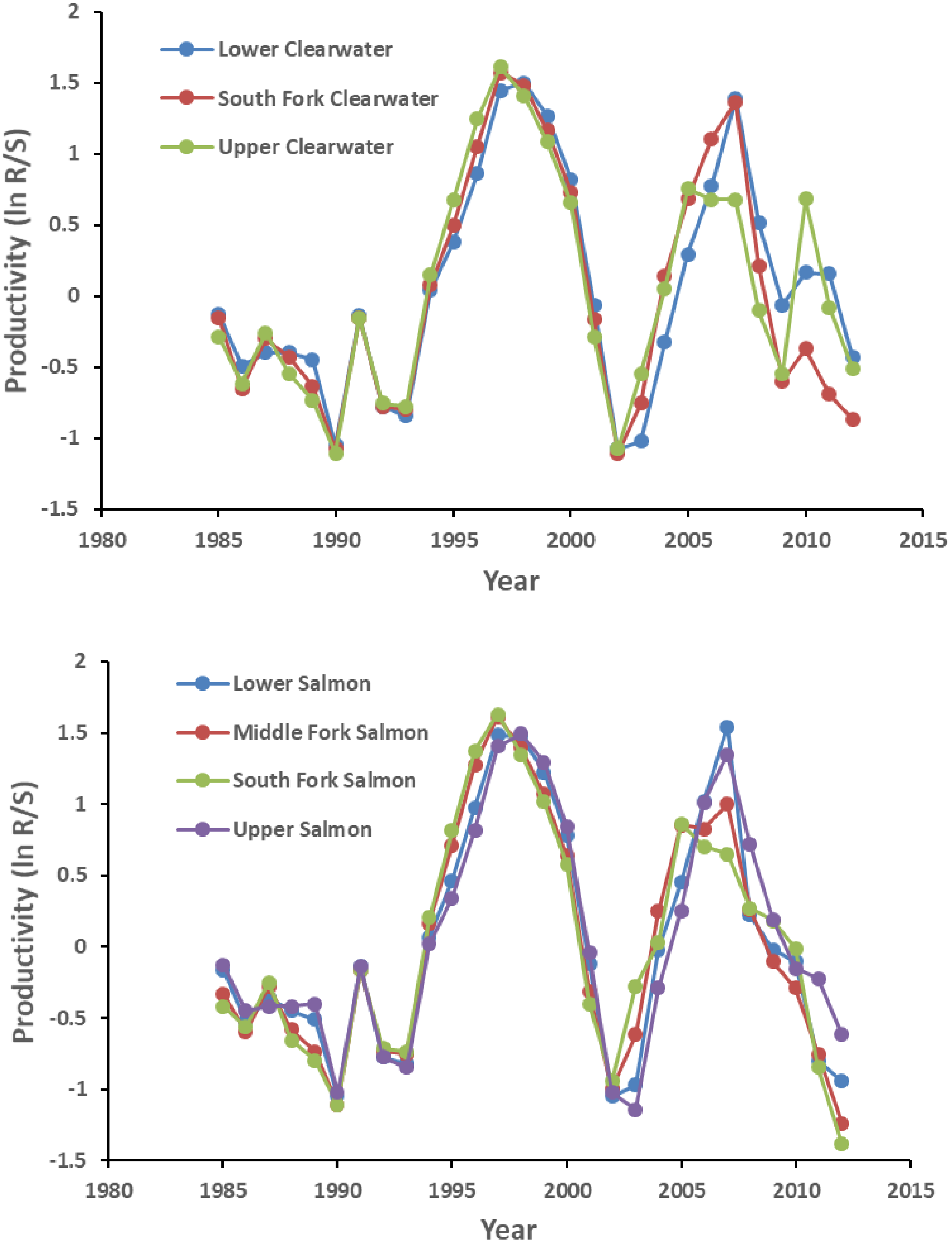


Figure 2-2. Productivity of Idaho steelhead stocks at Lower Granite Dam, brood years 1985-2012. Clearwater MPG stocks are in the top panel and Salmon MPG stocks are in the bottom panel.

APPENDICES

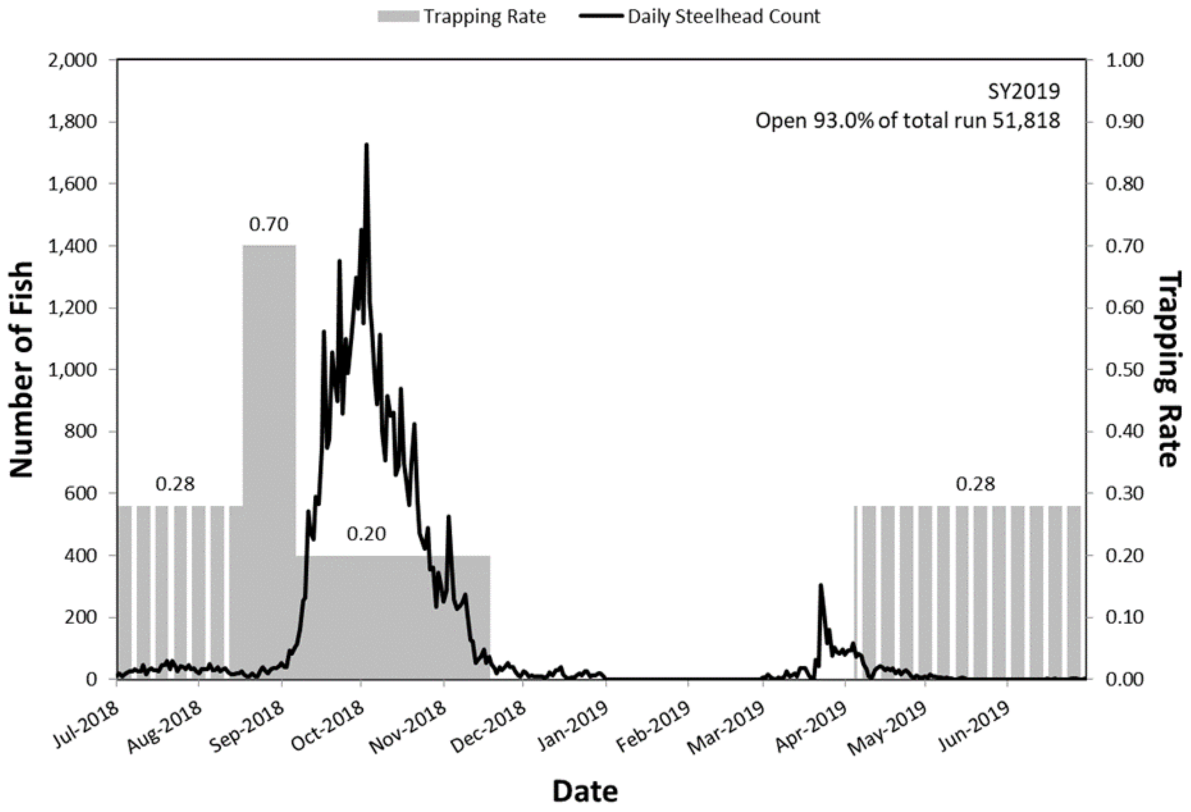
Appendix A: Annual Lower Granite Dam trapping operations, 2018-2019.

Appendix A-1. Annual Lower Granite Dam trapping operations, 2018-2019. Shaded areas are outside the 2019 spawn year (July 1, 2018 to June 30, 2019 for steelhead and March 1, 2019 to August 17, 2019 for Chinook Salmon).

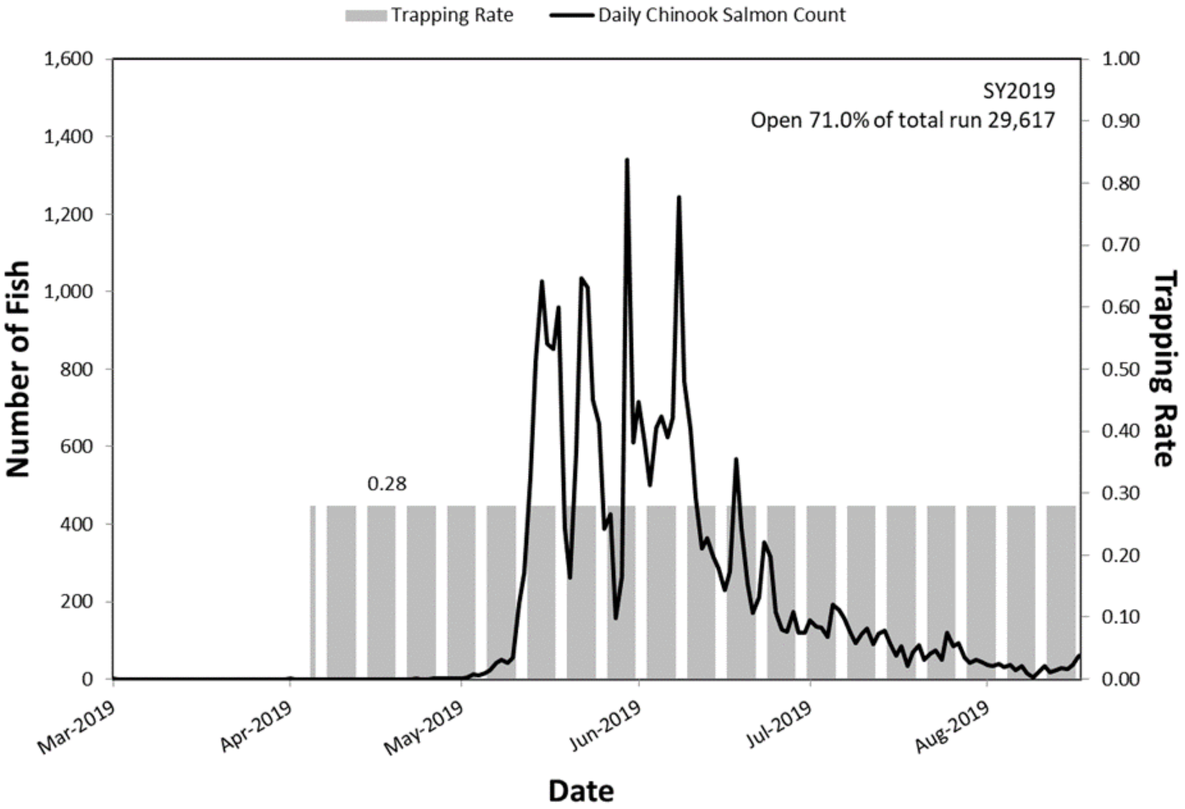
Calendar date	Trap operation	Comments
2018		
January 1–March 6	Closed	Winter closure
March 7–August 17	5 d/week, 28% Daily Rate	
August 18–September 6	7 d/week, 70% Daily Rate[a]	
September 7–November 18	7 d/week, 20% Daily Rate	
November 19–December 31	Closed	Winter closure
2019		
January 1– April 4	Closed	Winter closure; anesthesia disposal and water supply problems
April 5–August 17	5 d/week, 28% Daily Rate	
August 18–September 6	7 d/ week, 70% Daily Rate[a]	
September 7–12	Closed	Hot water closure
September 13–16	7 d/ week, 100% Daily Rate[a]	
September 17–November 12	7 d/ week, 20% Daily Rate	
November 13–December 31	Closed	Winter closure

(a) Trap rate exceeded co-manager agreement for a trap rate maximum of 20% (7 d/week) to accommodate fall-run Chinook Salmon broodstock collection at the LGR trap.

Appendix A-2. Daily number of steelhead counted at the Lower Granite Dam window, spawn year 2019. Vertical gray bars indicate when the trap was open and daily trapping rate.



Appendix A-3. Daily number of Chinook Salmon counted at the Lower Granite Dam window, spawn year 2019. Vertical gray bars indicate when the trap was open and daily trapping rate.



Appendix A-4. A hierarchical (top to bottom) key of external marks and internal tags used to determine hatchery origin steelhead and Chinook Salmon at Lower Granite Dam (LGR), spawn years 2009-2019. Only fish failing to meet criteria are considered wild.

If the LGR mark or tag is:	**Then the origin at window is:**	**Then the origin at trap is:**	**And the final origin is:**
Adipose fin clip	Hatchery	Hatchery	Hatchery
Coded wire tag (CWT)	N/A[a]	Hatchery	Hatchery
Ventral fin clip	N/A	Hatchery	Hatchery
Dorsal or ventral fin erosion (steelhead only)	N/A	Hatchery	Hatchery
Parentage based tag (PBT)	N/A	N/A	Hatchery[b]
Passive integrated transponder (PIT)	N/A	N/A	N/A[c]

[a] N/A = not applicable.

[b] Started in SY2011 with complete coverage by SY2013.

[c] Minor discrepancies occur between the PIT-tag database (PTAGIS) and LGR trap databases (LGTrappingDB, BioSamples, and Progeny) that prevent the use of PIT-tags to determine origin at this time.

Appendix A-5. Weekly window counts and valid adult trap samples of steelhead at Lower Granite Dam, spawn year 2019.

SCOBI strata	Statistical week[(a)]	Sampling period	Number of days	Days trap open[(b)]	Window count	Total valid fish trapped	Valid wild fish trapped	Number of valid wild fish samples used in SCOBI analysis: Genetic stock	Size	Sex	Age
Fall 2018											
1	26A - 36[(c)]	7/1 - 9/9	71	58	2,766	943	391	387	387	387	359
2	37	9/10 - 9/16	7	7	3,639	770	195	195	195	195	181
3	38	9/17 - 9/23	7	7	6,920	1,416	209	209	209	209	191
4	39	9/24 - 9/30	7	7	7,697	1,608	194	194	194	194	185
5	40	10/1 - 10/7	7	7	8,544	1,787	192	192	192	192	176
6	41	10/8 - 10/14	7	7	5,904	1,319	139	138	138	138	127
7	42	10/15 - 10/21	7	7	5,051	1,105	131	130	130	130	119
8	43	10/22 - 10/28	7	7	3,113	776	103	103	103	103	94
9	44 - 53[(c)]	10/29 - 12/31	64	21	5,286	979	145	144	144	144	133
Spring 2019											
10	9 - 26B[(c)]	3/1 - 6/30	122	61	2,898	183	60	60	60	60	40
Total:			306	189	51,818	10,886	1,759	1,752	1,752	1,752	1,605

(a) Statistical weeks are grouped to try to provide a minimum sample size of 100 valid fish with a genotype and age.

(b) See Appendix A-1 for trapping operation details.

(c) Includes a partial week.

Appendix A-6. Weekly window counts and valid adult trap samples of Chinook Salmon at Lower Granite Dam, spawn year 2019.

SCOBI strata	Statistical week[(a)]	Sampling period	Number of days	Days trap open[(b)]	Window count	Total valid fish trapped	Valid wild fish trapped	Number of valid wild fish samples used in SCOBI analysis			
								Genetic stock	Size	Sex	Age
1	9 - 20(c)	3/1 - 5/19	80	31	6,182	1,231	133	132	132	131	121
2	21	5/20 - 5/26	7	5	4,656	1,064	140	139	139	139	131
3	22	5/27 - 6/2	7	5	4,120	770	84	82	82	82	70
4	23	6/3 - 6/9	7	5	5,143	939	158	158	158	158	144
5	24	6/10 - 6/16	7	5	2,646	695	138	138	138	138	123
6	25	6/17 - 6/23	7	5	2,214	517	113	112	112	111	104
7	26-27	6/24 - 7/7	14	10	2,210	563	136	136	136	135	127
8	28-33(c)	7/8 - 8/17	41	30	2,446	600	251	250	250	250	226
Total:			170	96	29,617	6,379	1,153	1,147	1,147	1,144	1,046

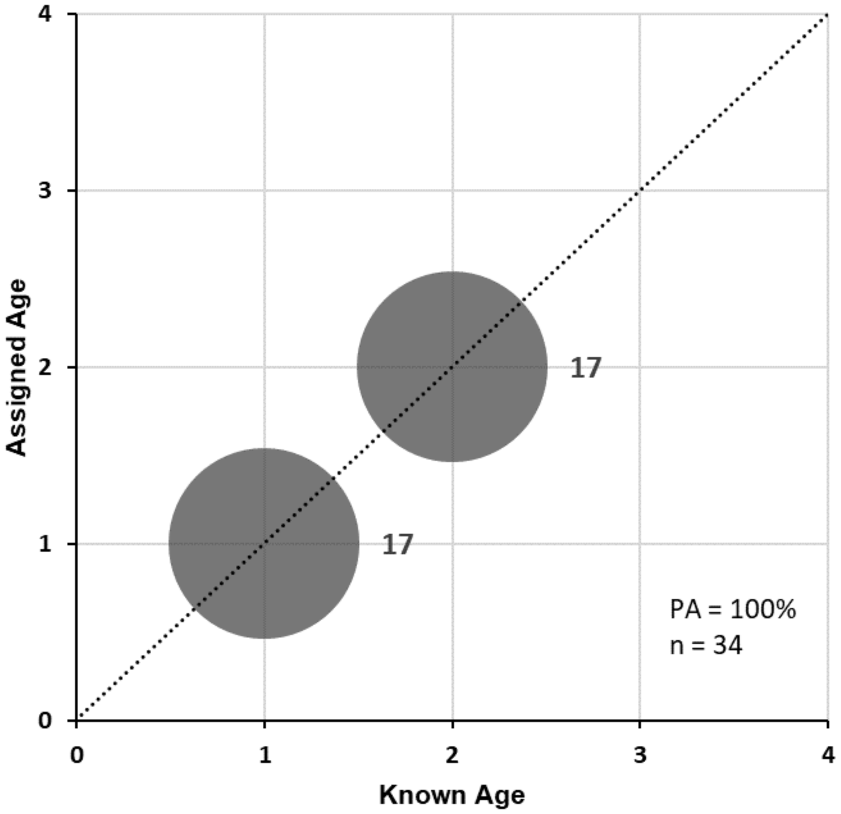
(a) Statistical weeks are grouped to try to provide a minimum sample size of 100 valid fish with a genotype and age.

(b) See Appendix A-1 for trapping operation details.

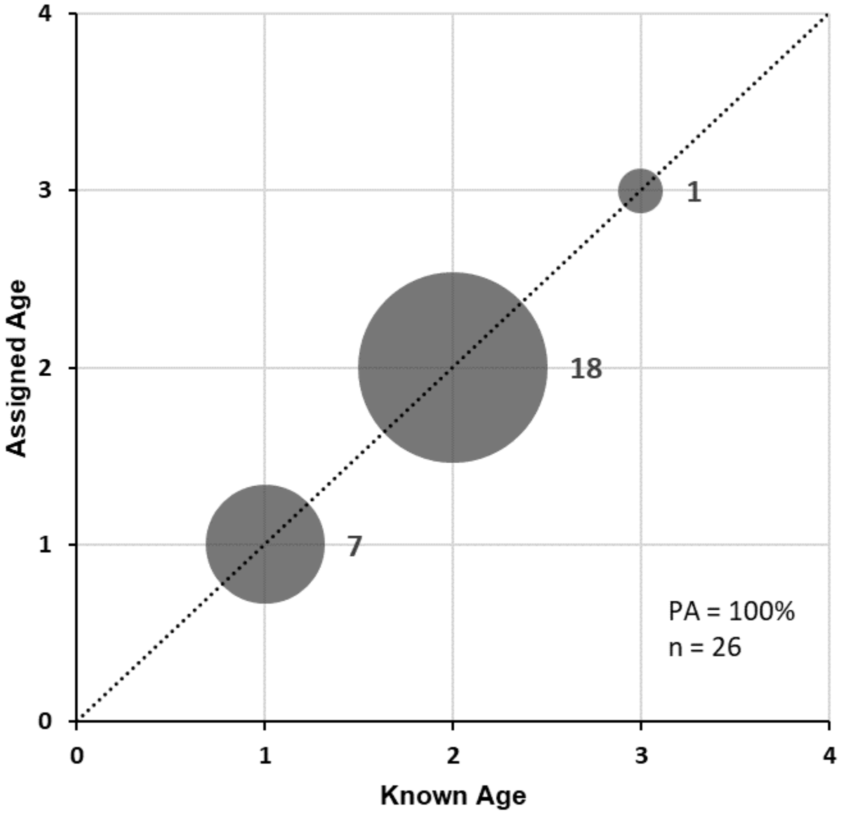
(c) Includes a partial week.

Appendix B: Steelhead and Chinook Salmon age validation.

Appendix B-1. Age bias plot illustrating pairwise comparisons of scale assigned saltwater-age with known age for steelhead at Lower Granite Dam, spawn year 2019 (Micah Davison, IDFG, scale data; PTAGIS, PIT-tag data). Dashed line represents the 1:1 relationship. PA = percent agreement.



Appendix B-2. Age bias plot illustrating pairwise comparisons of scale assigned saltwater-age with known age for Chinook Salmon at Lower Granite Dam, spawn year 2019 (Micah Davison, IDFG, scale data; PTAGIS, PIT-tag data). Dashed line represents the 1:1 relationship. PA = percent agreement.



Appendix B-3. The story of a really old steelhead.

Steelhead returning to Idaho waters to spawn have the capacity to be long-lived relative to other anadromous salmonids returning to the same waters. This is due in part to their more variable juvenile outmigration timing and their ability to exhibit iteroparity (Copeland et al. 2017, Copeland et al. 2019). During spawn year 2019, we collected a scale from a steelhead that we estimated to be 9 years total age (Figure B-3). This represents the oldest estimated age from a scale of any species collected at Lower Granite Dam to date.

The fish that provided us with this scale sample was a member of the brood year 2010 cohort. After spending two winters in freshwater as a juvenile, it began its outmigration to saltwater in spring 2012. It then spent two winters feeding far out in the Pacific Ocean before returning to its natal stream in fall 2014, where it spent the winter in freshwater and spawned the following spring 2015. Having survived the spawning process, it returned to the Pacific Ocean to spend the winter. It returned in fall 2016 to spend another winter in freshwater and spawn once again in spring 2017. Having survived once more, it returned to the ocean to spend the winter before returning in fall 2018, where it was sampled at Lower Granite Dam adult fish trapping facility as a member of the spawn year 2019 return.

The fish was trapped at Lower Granite Dam on August 25, 2018 (spawn year 2019) while on its way upstream, and a scale was collected at that time. Observers noted that the fish had suffered and survived a seal bite, and they injected a PIT tag into the fish prior to releasing it to rejoin the run. PIT tag tracking information shows that the fish was detected the following spring 2019 when it was on its way back downstream. It was detected on April 25, 2019 at the Little Goose Dam Juvenile Bypass Facility array and detected again on August 11, 2019 farther downstream at Bonneville Dam. After another winter in the ocean, evidence suggests that the fish was on its way back upstream to Idaho to spawn again in spawn year 2020, as the most recent PIT array detection was at Lower Granite Dam on October 9, 2019.

This is evidence that this fish survived spawning in spawn year 2019 and was on its way back upstream as a consecutive repeat spawner in spawn year 2020, which represents three successful spawning events (2015, 2017, and 2019) and an attempted fourth (2020). As a member of the brood year 2010 cohort, it would then be estimated to be 10 years total age.

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Copeland, T., B. J. Bowersox, M. W. Ackerman, and C. Camacho. 2019. Patterns of Iteroparity in Wild Snake River Steelhead. Transactions of the American Fisheries Society, 148(5), 926-937.

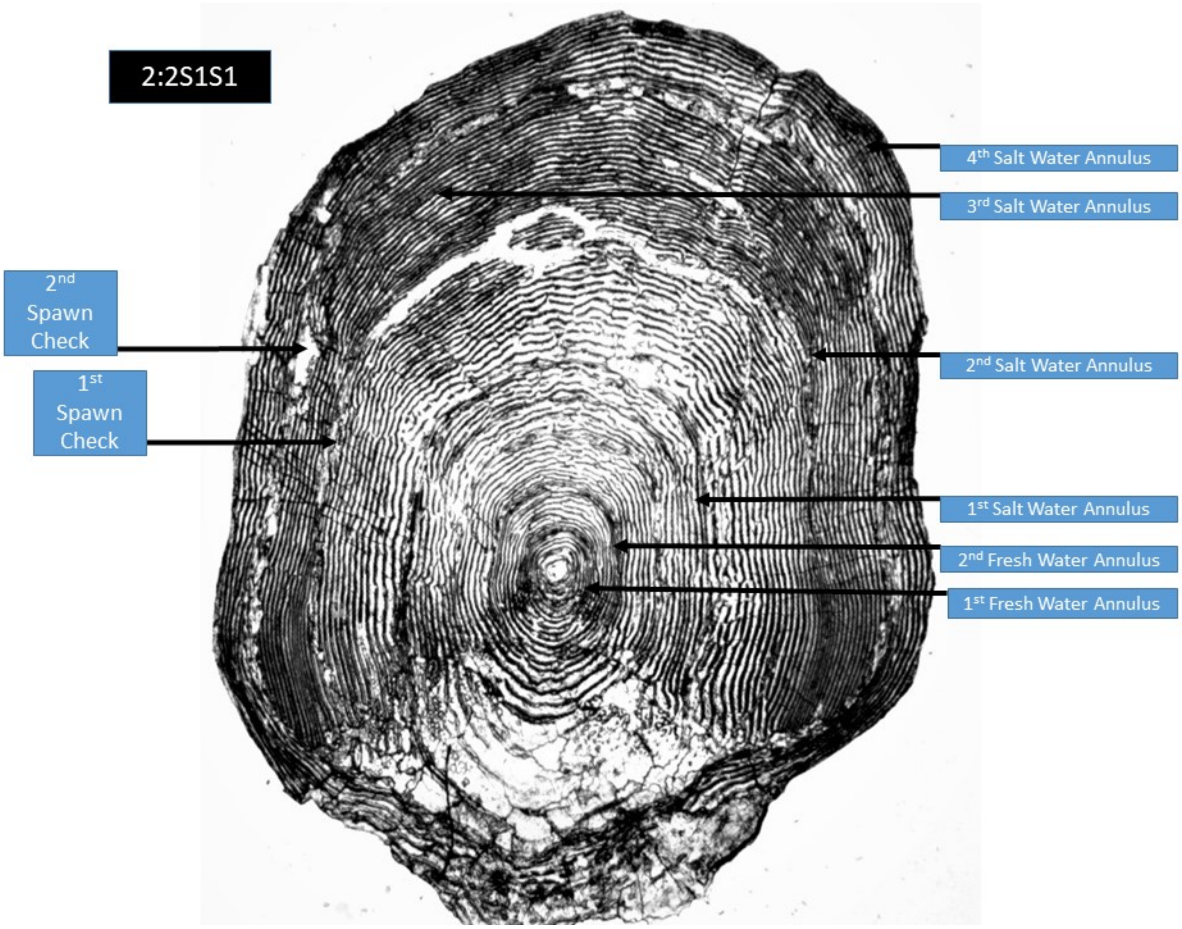
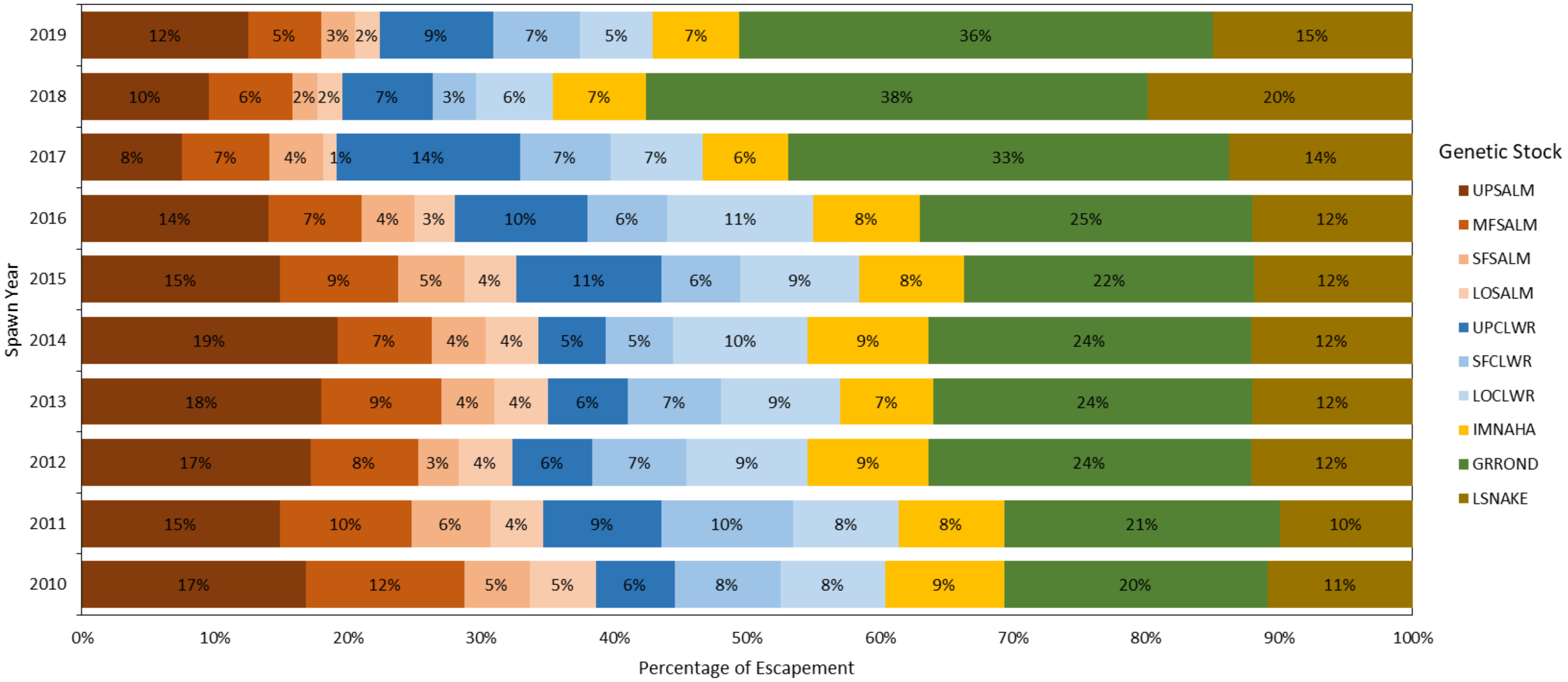


Figure B-3. This is thought to be the oldest scale collected at Lower Granite Dam to date. The scale was collected at Lower Granite Dam in spawn year 2019 and aged as 2:2S1S1 (age-9) by the Nampa Research Anadromous Ageing Lab.

Appendix C: Wild steelhead at Lower Granite Dam, spawn year 2019.

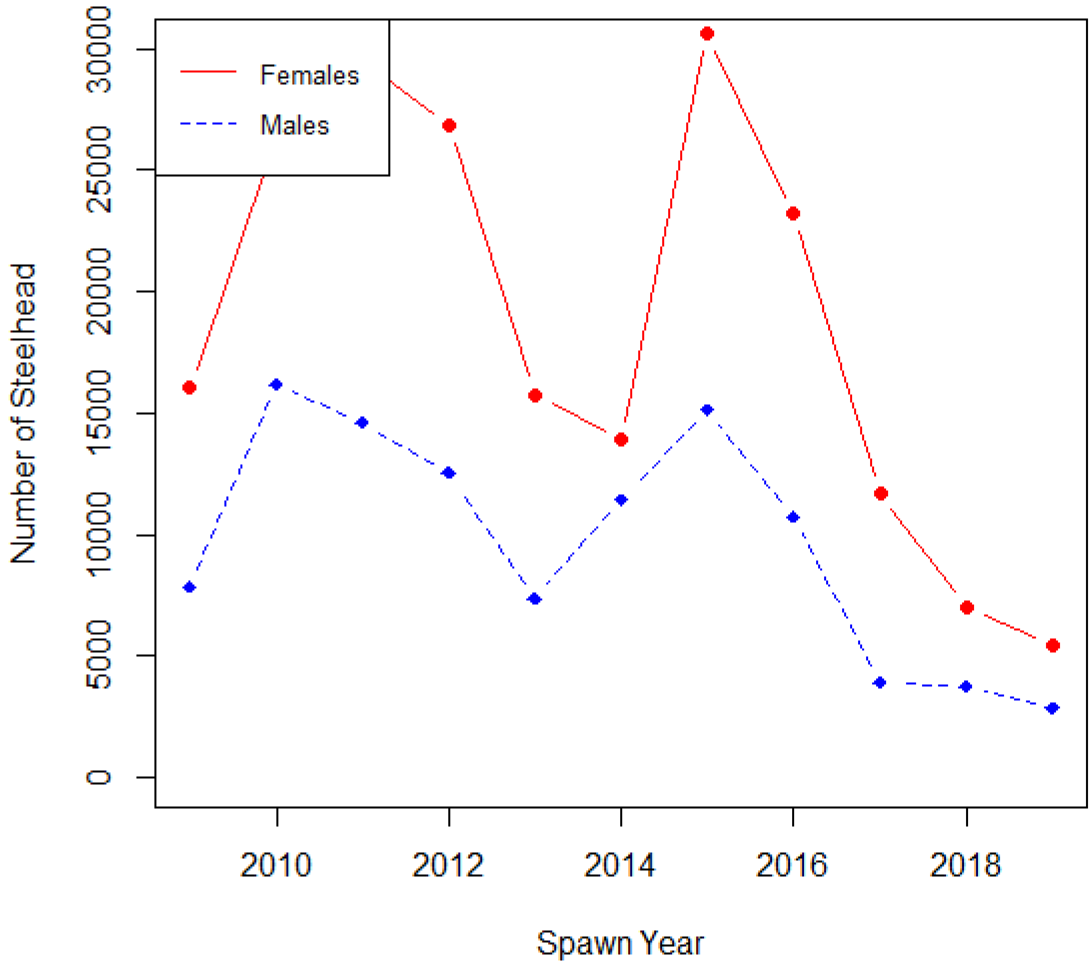
Appendix C-1. Percentage of the estimated escapement of wild steelhead by genetic stock to the overall estimated wild escapement at Lower Granite Dam, spawn years 2010-2019. See text for stock abbreviations.



Appendix C-2. Estimated escapement of wild steelhead at Lower Granite Dam by sex and by size for each genetic stock, spawn year 2019. L = lower bound and U = upper bound of 90% confidence intervals. See text for stock abbreviations.

Genetic stock	Estimated number of steelhead at Lower Granite Dam that were:														
	Female			Male			Large			Small			Total wild		
	Estimate	L	U	Estimate	L	U	Estimate	L	U	Estimate	L	U	Estimate	L	U
UPSALM	570	503	634	472	408	535	14	7	21	1,028	916	1,141	1,042	930	1,155
MFSALM	353	288	420	104	79	127	97	73	120	360	293	430	457	380	538
SFSALM	171	127	213	39	24	53	138	100	172	72	49	91	210	160	262
LOSALM	108	69	149	46	27	67	10	3	17	144	100	193	154	107	204
UPCLWR	536	460	611	174	139	209	504	429	574	206	167	244	710	613	813
SFCLWR	339	277	399	203	158	250	262	211	311	280	219	341	542	450	643
LOCLWR	303	247	355	149	112	190	44	29	58	408	338	481	452	378	532
IMNAHA	325	267	378	217	175	259	27	18	37	515	431	598	542	457	631
GRROND	1,869	1,733	2,002	1,071	974	1,167	93	76	111	2,847	2,641	3,055	2,940	2,729	3,152
LSNAKE	857	748	969	381	332	431	43	32	56	1,195	1,051	1,335	1,238	1,097	1,387
Total	5,431	5,185	5,633	2,856	2,699	2,989	1,232	1,122	1,322	7,055	6,748	7,327	8,287	7,966	8,611

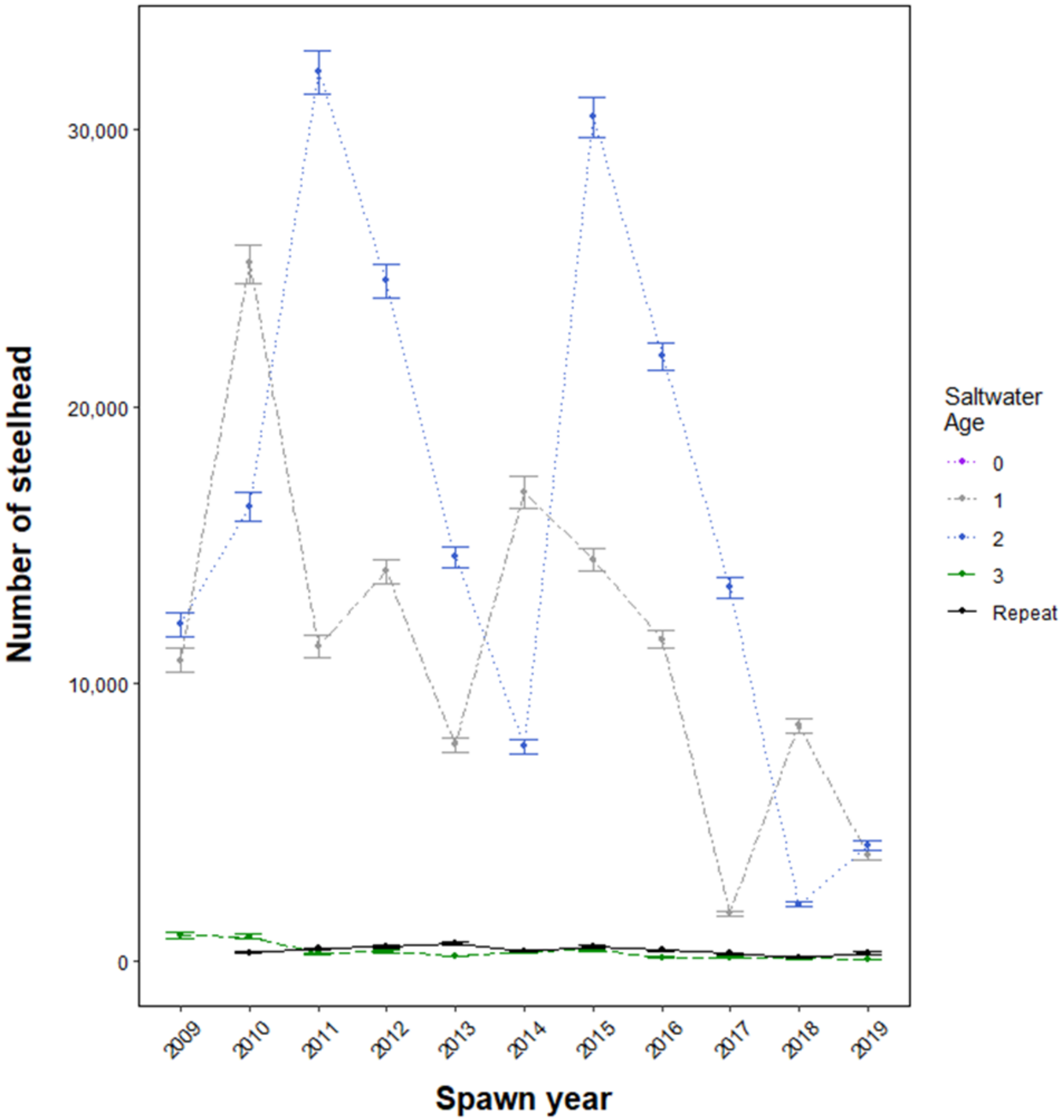
Appendix C-3. Estimated escapement by sex of wild steelhead at Lower Granite Dam, spawn years 2009-2019.



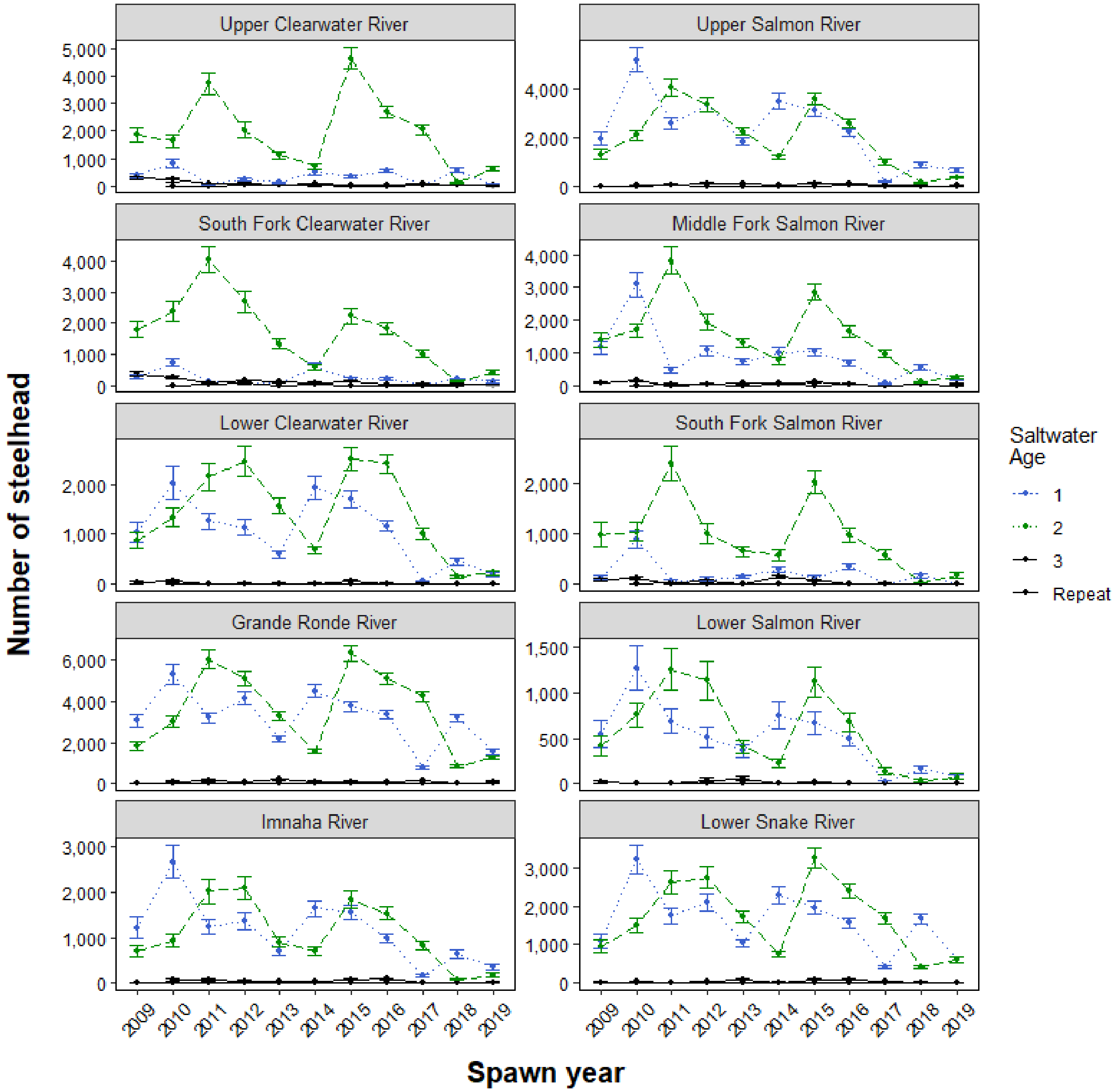
Appendix C-4. Estimated escapement of wild steelhead at Lower Granite Dam by age class, brood year, and migration year for each genetic stock, spawn year 2019. Only individual fish that had both a total age and an assigned stock were used (n = 1,605). See text for stock abbreviations.

	Smolt migration year (MY), brood year (BY), and age class																					
	MY2012	MY2014		MY2015						MY2016							MY2017				MY2018	
Genetic stock	BY10	BY11	BY12	BY12	BY12	BY12	BY13	BY13	BY13	BY12	BY13	BY13	BY14	BY14	BY15	BY15	BY13	BY14	BY15	BY16	BY16	Total wild
	2.2S1S1	3.2S1	2.2S1	3.3	3.2S	3.1S1	2.3	2.2S	2.1S1	4.2	3.2	3.1S	2.2	2.1S	1.2	1.1S	4.1	3.1	2.1	1.1	2.0	
UPSALM	0	0	0	0	0	0	0	1	9	11	89	3	244	14	18	0	6	171	445	31	0	1,042
MFSALM	0	5	0	0	0	5	0	0	0	21	168	0	58	32	0	0	17	111	40	0	0	457
SFSALM	0	0	0	9	0	0	0	0	0	10	117	6	53	0	0	0	0	10	5	0	0	210
LOSALM	0	0	0	0	0	0	0	0	0	3	49	0	24	0	0	0	3	35	35	5	0	154
UPCLWR	0	5	0	0	0	6	6	5	0	26	383	0	200	0	21	0	0	33	25	0	0	710
SFCLWR	0	0	0	0	0	0	5	5	0	0	83	0	289	0	35	0	0	34	80	11	0	542
LOCLWR	0	0	0	0	5	0	5	0	0	0	47	0	159	12	21	0	5	43	144	11	0	452
IMNAHA	0	5	0	0	0	0	0	5	0	0	42	0	121	12	18	0	3	169	151	16	0	542
GRROND	3	31	11	0	0	22	0	5	3	40	345	10	779	19	88	4	8	551	920	76	25	2,940
LSNAKE	0	6	0	0	0	3	5	0	0	0	137	0	397	5	66	0	8	146	428	37	0	1,238
Total	3	52	11	9	5	36	21	21	12	111	1,460	19	2,324	94	267	4	50	1,303	2,273	187	25	8,287

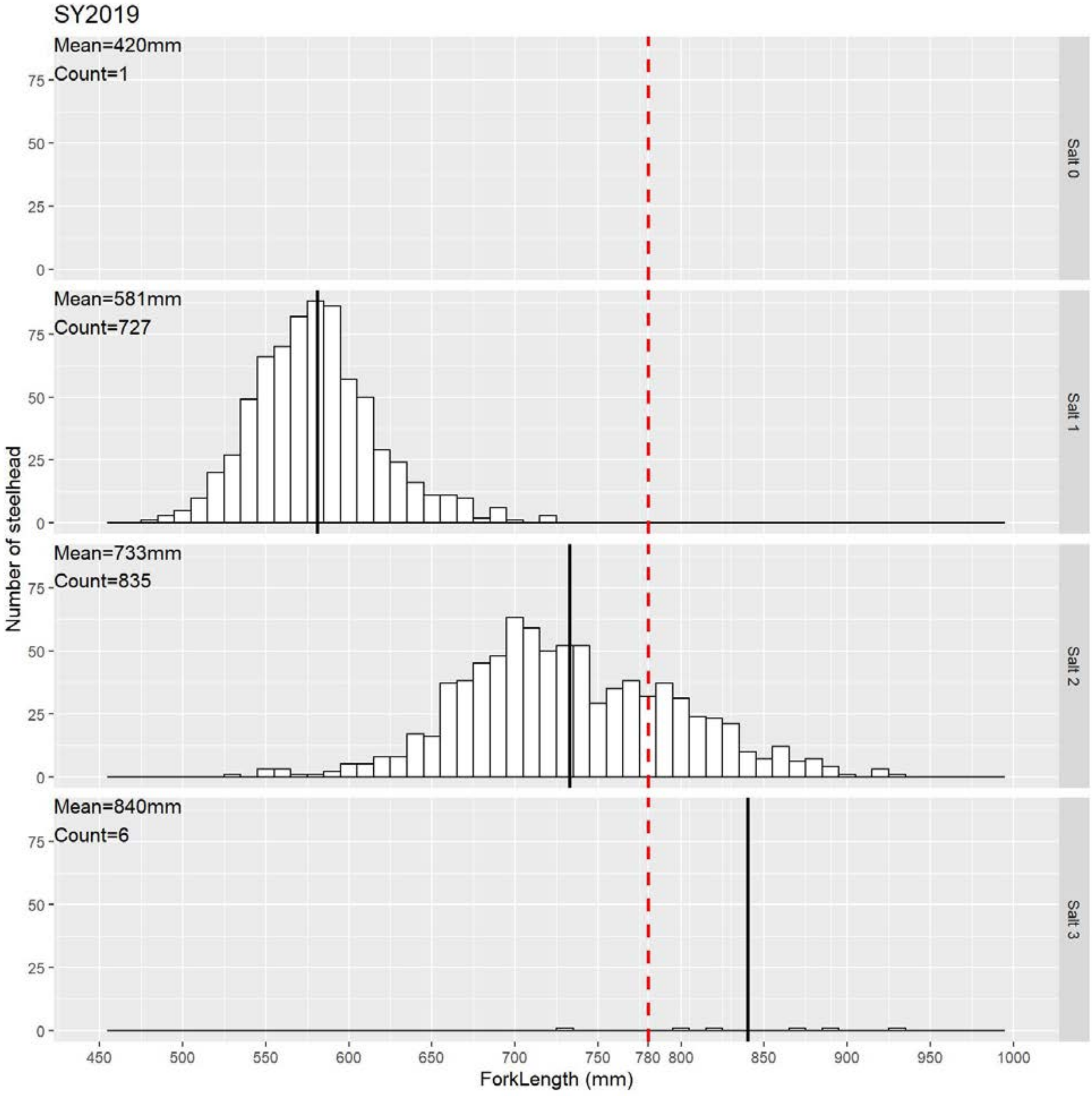
Appendix C-5. Estimated escapement by saltwater age of wild steelhead at Lower Granite Dam, spawn years 2009-2019. Confidence intervals are at 90%. Repeat refers to steelhead showing evidence of participating in multiple spawning years.



Appendix C-6. Estimated escapement by genetic stock and saltwater age of wild steelhead at Lower Granite Dam, spawn years 2009-2019. Confidence intervals are at 90%. Repeat refers to steelhead showing evidence of participating in multiple spawning years.

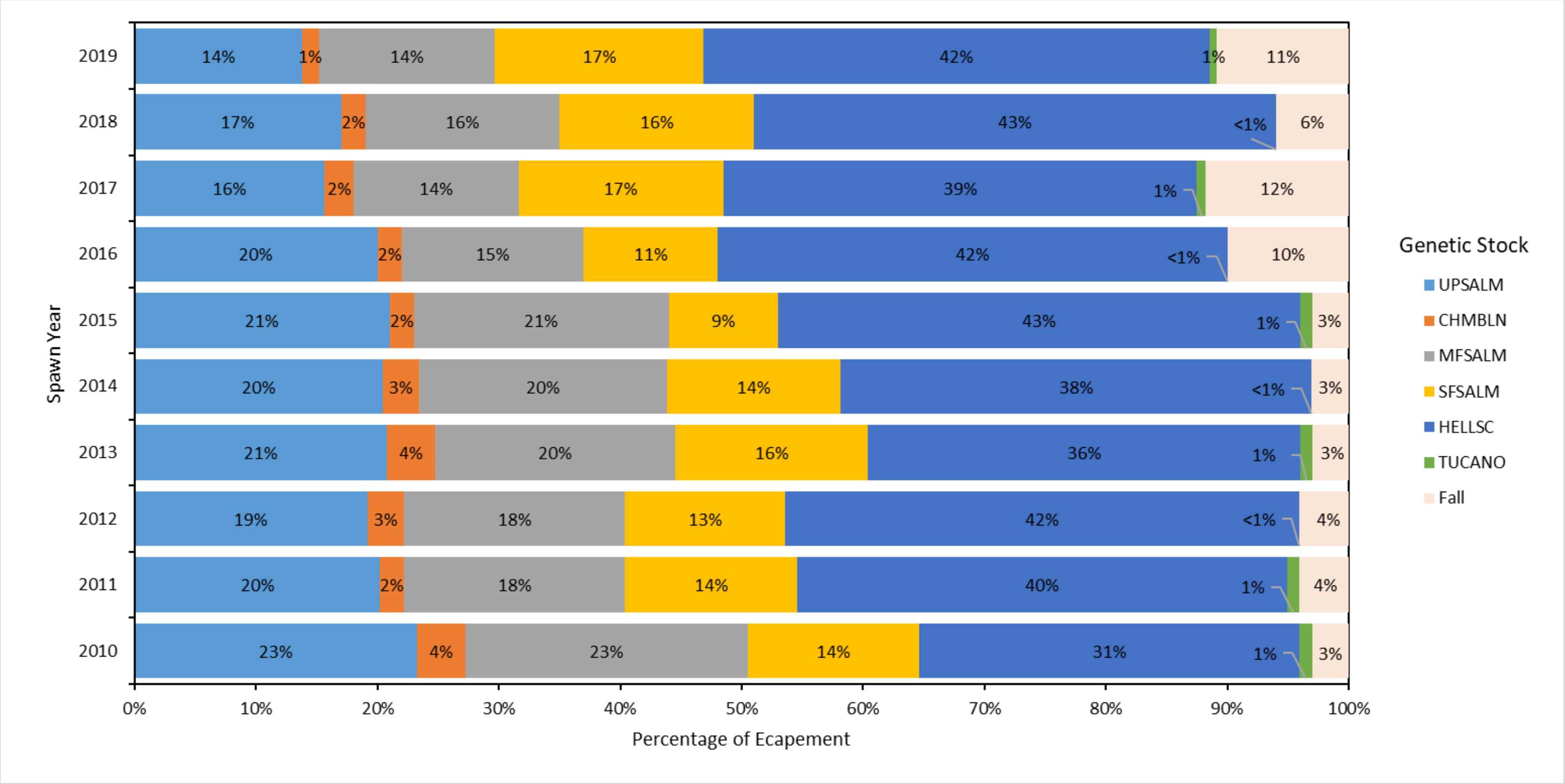


Appendix C-7. Length frequency distribution by saltwater age of wild steelhead trapped at Lower Granite Dam, spawn year 2019. Solid black vertical line represents the mean length for each saltwater age. Dashed vertical red line represents the 780 mm (FL) cutoff for determining large-sized steelhead.



Appendix D: Wild Chinook Salmon at Lower Granite Dam, spawn year 2019.

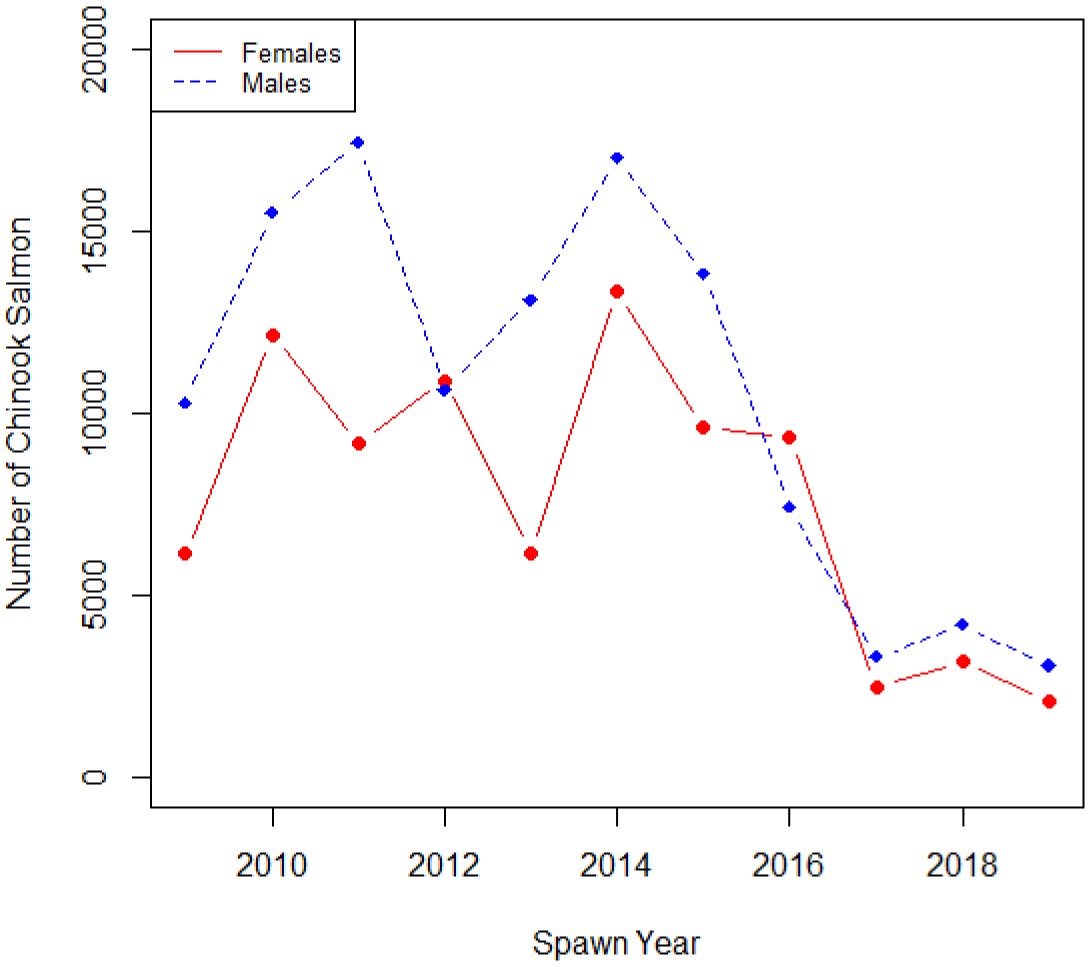
Appendix D-1. Percentage of the estimated escapement of wild Chinook Salmon by genetic stock to the overall estimated wild escapement at Lower Granite Dam, spawn years 2010-2019. See text for stock abbreviations.



Appendix D-2. Estimated escapement of wild Chinook Salmon at Lower Granite Dam by sex and by size for each genetic stock, spawn year 2019. L = lower bound and U = upper bound of 90% confidence intervals. See text for stock abbreviations.

Genetic stock	Estimated number of Chinook Salmon at Lower Granite Dam that were:														
	Female			Male			Large			Small			Total wild		
	Estimate	L	U	Estimate	L	U	Estimate	L	U	Estimate	L	U	Estimate	L	U
UPSALM	263	220	304	449	385	512	586	502	667	126	100	152	712	621	804
CHMBLN	14	4	24	58	34	84	40	21	61	32	16	47	72	44	102
MFSALM	210	175	244	538	463	609	500	429	569	248	207	289	748	653	848
SFSALM	358	308	408	528	461	591	703	617	785	183	153	213	886	785	988
HELLSC	977	894	1,061	1,176	1,081	1,268	1,863	1,721	2,003	290	253	326	2,153	1,992	2,316
TUCANO	10	0	20	19	5	36	25	9	46	4	0	12	29	10	51
FALL	260	221	299	302	259	345	476	415	538	86	68	104	562	492	635
Total	2,092	1,973	2,198	3,070	2,913	3,205	4,194	3,992	4,373	968	897	1,032	5,162	4,933	5,389

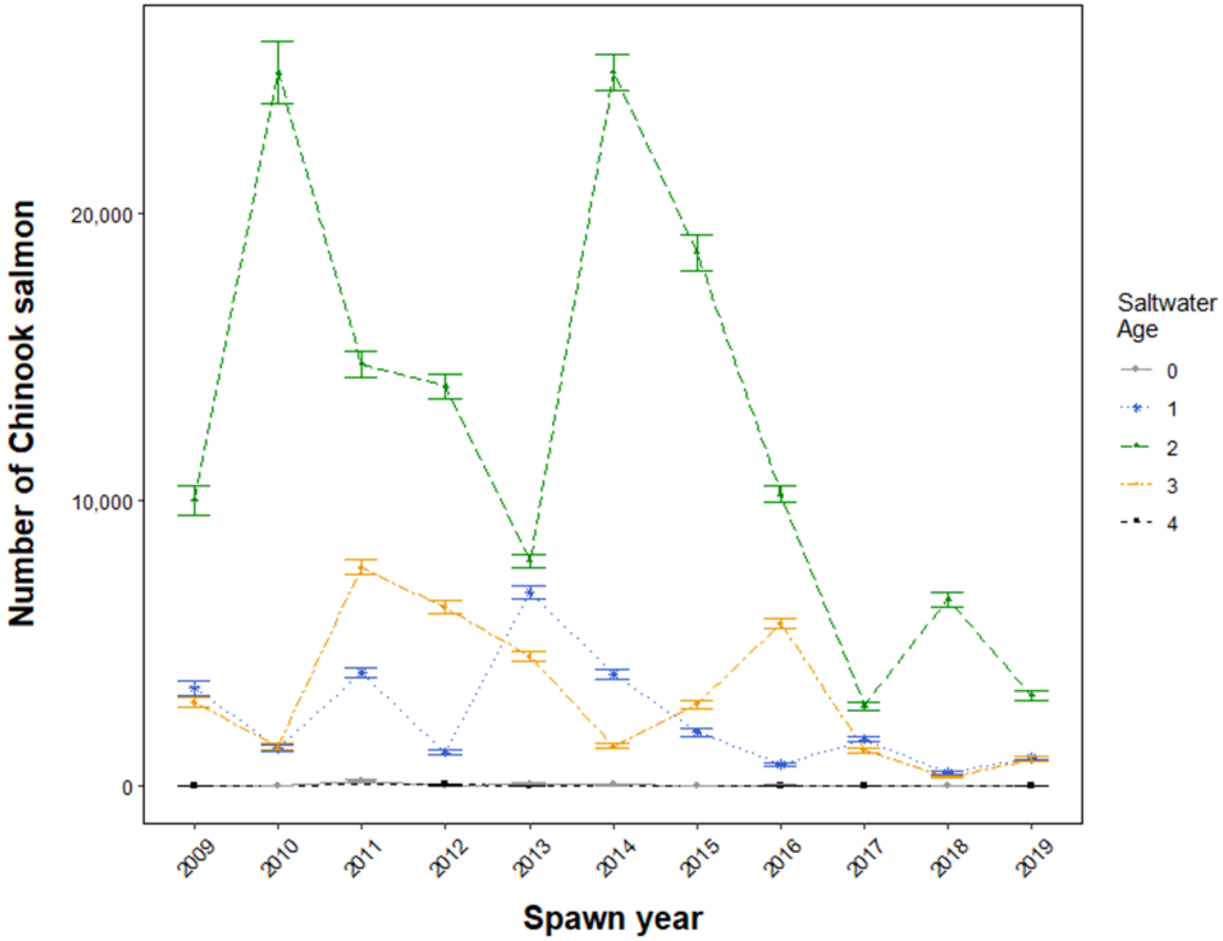
Appendix D-3. Estimated escapement by sex of wild Chinook Salmon at Lower Granite Dam, spawn years 2009-2019.



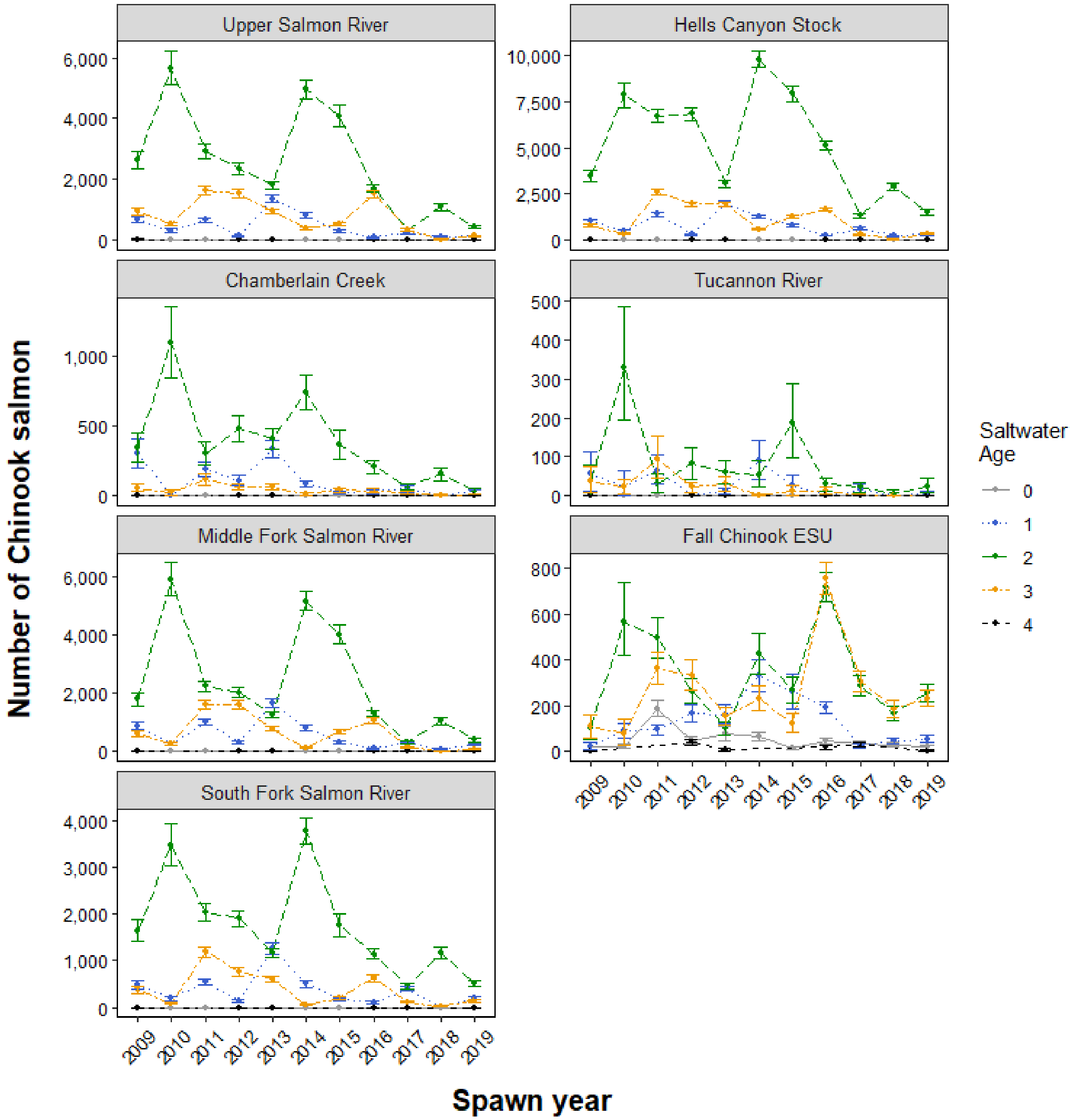
Appendix D-4. Estimated escapement of wild Chinook Salmon at Lower Granite Dam by age class, brood year, and migration year for each genetic stock, spawn year 2019. Only individual fish that had both a total age and an assigned stock were used (n = 1,046). See text for stock abbreviations.

	Smolt migration year (MY), brood year (BY), and age class								
	MY2015	**MY2016**		**MY2017**		**MY2018**		**MY2019**	
	BY13	**BY13**	**BY14**	**BY14**	**BY15**	**BY15**	**BY16**	**BY16**	**Total**
Genetic stock	**1.4**	**2.3**	**1.3**	**2.2**	**1.2**	**2.1**	**1.1**	**2.0**	**wild**
UPSALM	0	0	136	10	432	0	134	0	712
CHMBLN	0	0	5	0	35	0	32	0	72
MFSALM	0	0	95	9	390	4	250	0	748
SFSALM	0	0	148	5	521	5	207	0	886
HELLSC	0	0	340	9	1,502	15	287	0	2,153
TUCANO	0	0	0	0	25	0	4	0	29
FALL	5	10	222	152	101	18	36	18	562
Total	5	10	946	185	3,006	42	950	18	5,162

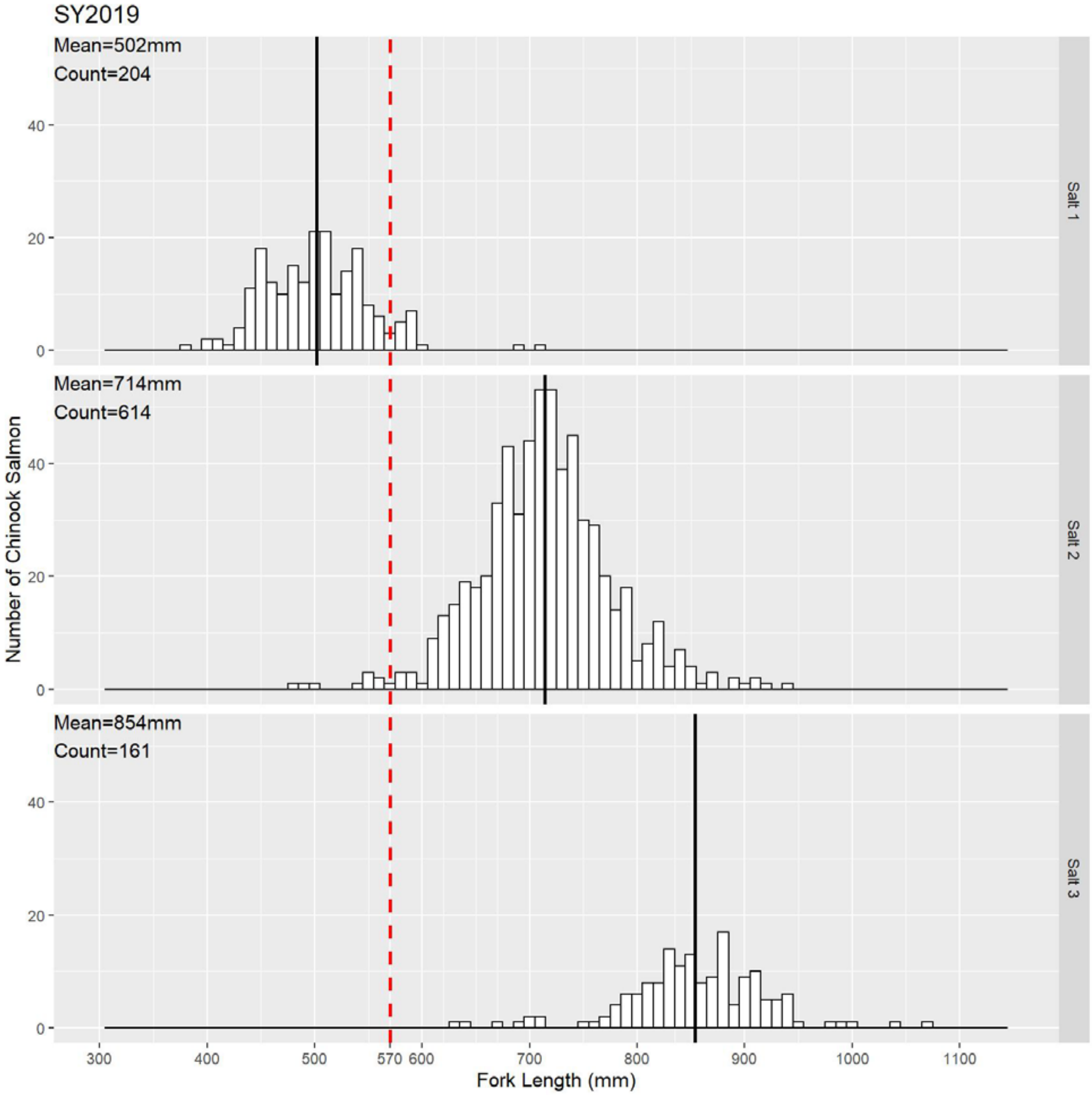
Appendix D-5. Estimated escapement by saltwater age of wild Chinook Salmon at Lower Granite Dam, spawn years 2009-2019. Confidence intervals are at 90%. Saltwater age-0 refers to mini-jacks.



Appendix D-6. Estimated escapement by genetic stock and saltwater age of wild Chinook Salmon at Lower Granite Dam, spawn years 2009-2019. Confidence intervals are at 90%. Saltwater age-0 refers to mini-jacks.



Appendix D-7. Length frequency distribution by saltwater age of wild Chinook Salmon trapped at Lower Granite Dam, spawn year 2019. Solid black vertical line represents the mean length for each saltwater age. Dashed vertical red line represents the 570 mm (FL) cutoff for determining large-sized Chinook Salmon.



Appendix E: Abundance and productivity for Idaho steelhead stocks.

Appendix E-1: Abundance and productivity (adult recruits per spawner) for Clearwater River steelhead stocks.

	Stock					
	Lower Clearwater		**South Fork Clearwater**		**Upper Clearwater**	
Brood year	**Abundance**	**Productivity**	**Abundance**	**Productivity**	**Abundance**	**Productivity**
1985	2,236	0.88	1,792	0.86	1,937	0.75
1986	2,437	0.61	1,953	0.52	2,111	0.54
1987	2,015	0.67	1,615	0.74	1,745	0.77
1988	2,328	0.67	1,866	0.65	2,017	0.58
1989	1,854	0.64	1,486	0.53	1,606	0.48
1990	2,280	0.35	1,827	0.34	1,975	0.33
1991	848	0.87	679	0.86	734	0.86
1992	1,580	0.46	1,267	0.46	1,369	0.47
1993	1,770	0.43	1,418	0.45	1,533	0.46
1994	832	1.04	667	1.08	721	1.16
1995	740	1.46	593	1.64	641	1.96
1996	735	2.37	589	2.87	637	3.48
1997	696	4.25	558	4.82	603	5.00
1998	798	4.48	640	4.40	692	4.10
1999	856	3.56	686	3.21	741	2.96
2000	1,013	2.27	812	2.08	877	1.93
2001	1,878	0.94	1,505	0.85	1,626	0.75
2002	3,716	0.34	2,978	0.33	3,219	0.34
2003	3,827	0.36	3,067	0.47	3,315	0.58
2004	2,660	0.72	2,132	1.15	2,304	1.05
2005	2,105	1.34	1,687	1.98	1,824	2.13
2006	1,655	2.16	1,326	3.03	1,433	1.97
2007	868	4.03	696	3.92	752	1.97
2008	1,293	1.68	1,036	1.24	1,120	0.90
2009	1,971	0.94	2,428	0.55	2,533	0.58
2010	3,446	1.18	3,395	0.69	2,652	1.98
2011	3,421	1.17	4,228	0.50	3,885	0.92
2012	3,613	0.65	2,950	0.42	2,426	0.60
2013	2,187	--	1,530	--	1,298	--
2014	2,627	--	1,284	--	1,288	--
2015	4,287	--	2,580	--	5,064	--
2016	3,598	--	2,046	--	3,300	--
2017	1,084	--	1,055	--	2,149	--
2018	626	--	350	--	735	--
2019	454	--	541	--	707	--

Appendix E-2. Abundance and productivity (adult recruits per spawner) for Salmon River steelhead stocks.

	Stock							
Brood	**Lower Salmon**		**Middle Fork Salmon**		**South Fork Salmon**		**Upper Salmon**	
Year	**Abundance**	**Productivity**	**Abundance**	**Productivity**	**Abundance**	**Productivity**	**Abundance**	**Productivity**
1985	992	0.85	2,209	0.72	1,074	0.66	3,961	0.88
1986	1,081	0.59	2,407	0.55	1,171	0.57	4,316	0.64
1987	894	0.70	1,990	0.76	968	0.78	3,569	0.66
1988	1,033	0.64	2,300	0.56	1,118	0.52	4,124	0.66
1989	823	0.60	1,831	0.48	891	0.45	3,284	0.67
1990	1,012	0.35	2,252	0.33	1,095	0.33	4,038	0.36
1991	376	0.87	837	0.85	407	0.85	1,502	0.87
1992	701	0.46	1,561	0.48	759	0.49	2,799	0.46
1993	786	0.44	1,748	0.47	850	0.48	3,135	0.43
1994	369	1.07	822	1.18	400	1.23	1,475	1.02
1995	328	1.59	731	2.04	355	2.26	1,310	1.41
1996	326	2.66	726	3.59	353	3.95	1,302	2.27
1997	309	4.42	687	5.02	334	5.11	1,233	4.07
1998	354	4.37	789	4.05	384	3.85	1,414	4.45
1999	380	3.40	845	2.92	411	2.77	1,516	3.65
2000	450	2.19	1,001	1.89	487	1.79	1,794	2.33
2001	833	0.89	1,855	0.73	902	0.67	3,326	0.96
2002	1,649	0.35	3,671	0.37	1,785	0.39	6,582	0.36
2003	1,698	0.38	3,780	0.54	1,838	0.76	6,778	0.32
2004	1,181	0.98	2,628	1.28	1,278	1.03	4,712	0.75
2005	934	1.57	2,080	2.35	1,011	2.37	3,730	1.29
2006	734	2.77	1,635	2.29	795	2.02	2,931	2.75
2007	385	4.68	857	2.72	417	1.92	1,537	3.85
2008	574	1.25	1,277	1.30	621	1.31	2,290	2.05
2009	985	0.98	2,635	0.90	1,198	1.20	3,242	1.21
2010	2,025	0.90	4,927	0.75	2,046	0.99	7,334	0.86
2011	1,941	0.45	4,312	0.47	2,512	0.43	6,699	0.80
2012	1,683	0.39	3,069	0.29	1,196	0.25	6,808	0.54
2013	834	--	2,097	--	843	--	4,188	--
2014	984	--	1,821	--	1,030	--	4,742	--
2015	1,805	--	4,000	--	2,247	--	6,833	--
2016	1,170	--	2,385	--	1,334	--	4,894	--
2017	157	--	1,021	--	627	--	1,174	--
2018	202	--	676	--	205	--	1,027	--
2019	154	--	454	--	210	--	1,035	--

Prepared by:

Katherine M. Lawry
Fisheries Biologist

Carlos A. Camacho
Fisheries Biologist

John S. Hargrove
Fisheries Biologist 2

Thomas Delomas
Fisheries Biologist 2

Micah Davison
Supervisory Fisheries Biologist

Marika E. Dobos
Fisheries Biologist

William C. Schrader
Principal Fisheries Biologist

Timothy Copeland
Fisheries Program Coordinator

Matthew R. Campbell
Fisheries Program Coordinator

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

J. Lance Hebdon
Anadromous Fisheries Manager

James P. Fredericks, Chief
Bureau of Fisheries