



**WILD ADULT STEELHEAD AND CHINOOK SALMON  
ABUNDANCE AND COMPOSITION AT  
LOWER GRANITE DAM,  
SPAWN YEAR 2020**

**ANNUAL PROGRESS REPORT**



Photo: IDFG

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**2020 Annual Report**

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## ABBREVIATIONS AND ACRONYMS

BPA	Bonneville Power Administration
BY	Brood Year
CI	Confidence Interval
CHMBLN	Chamberlain Creek Genetic Stock
CLRWTR	Clearwater River Genetic Stock
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
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
MPG	Major Population Group
MY	Smolt Migration Year
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRAAL	Nampa Research Anadromous Ageing Laboratory
NWFSC	Northwest Fisheries Science Center
PBT	Parentage Based Tag
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
TUCANO	Tucannon River Genetic Stock
UPCLWR	Upper Clearwater River Genetic Stock
UPSALM	Upper Salmon River Genetic Stock
USACE	U. S. Army Corps of Engineers
W	Wild
WDFW	Washington Department of Fish and Wildlife

## TABLE OF CONTENTS

	<u>Page</u>
ACKNOWLEDGEMENTS .....	i
ABSTRACT .....	1
INTRODUCTION .....	2
METHODS.....	3
Adult Trap Operations at Lower Granite Dam .....	3
Chinook Salmon Adjustments due to COVID-19 Closure .....	5
Trap Data Management .....	5
Valid Sample Selection .....	5
Scale Processing, Analysis, and Age Validation.....	6
Genetics Tissue Processing and Analysis.....	6
Wild Escapement by Origin, Genetic Stock, Size, Sex, and Age .....	8
Smolt-to-Adult Return Rate .....	10
RESULTS .....	11
Steelhead Escapement .....	11
Steelhead by Genetic Stock, Size, Sex, and Age .....	11
Steelhead Adult-to-Adult Productivity .....	12
Steelhead Smolt-to-Adult Return Rate .....	13
Chinook Salmon Escapement .....	13
Chinook Salmon by Genetic Stock and Age .....	13
Chinook Salmon by Size and Sex .....	13
Chinook Salmon Adult-to-Adult Productivity .....	14
Chinook Salmon Smolt-to-Adult Return Rate .....	14
DISCUSSION.....	14
LITERATURE CITED .....	18
TABLES .....	24
FIGURES.....	31
APPENDICES.....	43

## LIST OF TABLES

	<u>Page</u>
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). Extirpated populations are shaded. ....25
Table 2.	Estimated annual escapement, by fish size and origin, of steelhead, spawn years 1998–2020. Large fish were greater than or equal to 78 cm fork length (FL) and small fish were 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; Lawry et al. 2020; present study). .....27
Table 3.	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. Included in parentheses are 95% confidence intervals for SARs.....28
Table 4.	Estimated annual escapement, by origin and saltwater age, of Chinook Salmon, spawn years 1998–2020. Jacks were saltwater age-1 and include saltwater age-0 mini-jacks; adults were 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; Lawry et al. 2020; present study). Spawn year 2020 estimates were generated using LGR window count data and run reconstruction methods. ....29
Table 5.	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 2005–2019 (below the dashed line). SAR 95% confidence intervals are in parentheses. ....30



## LIST OF FIGURES

		<u>Page</u>
Figure 1.	Map of steelhead genetic stocks and sample collections included in the Snake River basin SNP baseline version 3.1 (Powell et al. 2018) used for genetic stock identification at Lower Granite Dam. A detailed description of collections can be found in Hargrove et al. (2021). The Hells Canyon Tributaries major population group does not support independent populations and is considered extirpated (NMFS 2016). See Genetic Tissue Processing and Analysis section for genetic stock abbreviations.....	32
Figure 2.	Map of Chinook Salmon genetic stocks and sample collections included in the Snake River basin SNP baseline version 3.1 (Powell et al. 2018) used for genetic stock identification at Lower Granite Dam. A detailed description of collections can be found in Hargrove et al. (2022). Reintroduced fish exist in functionally extirpated TRT populations as mapped. See Genetic Tissue Processing and Analysis section for genetic stock abbreviations.....	33
Figure 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 ( $\geq 57$ cm, fork length [FL]) and small ( $< 57$ cm, FL) and steelhead large ( $\geq 78$ cm, FL) and small ( $< 78$ cm, FL). Fish less than 30 cm (FL) are not designated to species and are ignored.....	34
Figure 4.	Estimated escapement by genetic stock of wild steelhead at Lower Granite Dam for spawn years 2009–2020. Confidence intervals are at 90%. .....	35
Figure 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 2020 completed brood year 2012. Note brood year 2013 was shown for reference, but represents a preliminary result that will be completed in SY2021. ....	36
Figure 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 2020 completed brood year 2012. Note brood year 2013 was shown for reference, but represents a preliminary result that will be completed in SY2021.....	37
Figure 7.	Estimated wild steelhead smolt-to-adult return (%SAR) rate of emigrant smolts and adult returns to Lower Granite Dam for smolt migration years 2010-2016. 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 3 for numbers.....	38
Figure 8.	Estimated escapement by genetic stock of wild Chinook Salmon at Lower Granite Dam for spawn years 2009–2020. Confidence intervals, when shown, are at 90%. Spawn year 2020 estimates were generated using run reconstruction and does not include jacks or have confidence intervals.....	39
Figure 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 2020 completed brood year 2014. Note brood year 2015 was shown for reference, but represents a preliminary result that will be completed in SY2021. ....	40

Figure 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 2020 completed brood year 2014. Note brood year 2015 was shown for reference, but represents a preliminary result that will be completed in SY2021.....41

Figure 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 5 for numbers. ....42

## LIST OF APPENDICES

	<u>Page</u>
Appendix A: Annual Lower Granite Dam trapping operations, 2019–2020. ....	44
Appendix A-1. Annual Lower Granite Dam trapping operations, 2019–2020. Shaded areas were outside the 2020 spawn year (July 1, 2019 to June 30, 2020 for steelhead and March 1 to August 17, 2020 for Chinook Salmon).....	45
Appendix A-2. Daily number of steelhead counted at the Lower Granite Dam window, spawn year 2020. Vertical gray bars indicate when the trap was open and daily trapping rate. 88.7% of the steelhead passed LGR when the trap was open. See Appendix A-1 and text for explanation of various trap closures. ....	46
Appendix A-3. Daily number of Chinook Salmon counted at the Lower Granite Dam window, spawn year 2020. Vertical gray bars indicate when the trap was open and daily trapping rate. 8.2% of the Chinook Salmon passed LGR when the trap was open. See Appendix A-1 and text for explanation of various trap closures. ....	47
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 2009–2020. Only fish failing to meet criteria were considered wild. ....	48
Appendix A-5. Weekly window counts and valid adult trap samples of steelhead at Lower Granite Dam, spawn year 2020. Data were summarized by weekly strata for analysis using the Salmonid Composition Bootstrap Intervals (SCOBI) method.....	49
Appendix B: Run reconstruction methods used for spring-summer Chinook Salmon estimates, spawn year 2020.....	50
Appendix B-1. Methodology for spring-summer Chinook Salmon run reconstruction at Lower Granite Dam, spawn year 2020. ....	51
Appendix C: Steelhead age validation.....	58
Appendix C-1. Age bias plot illustrating pairwise comparisons of scale assigned saltwater-age with known age for steelhead at Lower Granite Dam, spawn year 2020 (NRAAL, scale data; PTAGIS, PIT-tag data). Dashed line represents the 1:1 relationship. PA = percent agreement. ....	59
Appendix D-1. Percentage of the estimated escapement of wild steelhead by genetic stock to the overall estimated wild escapement at Lower Granite Dam, spawn years 2010–2020. See Genetic Tissue Processing and Analysis section for stock abbreviations. ....	61
Appendix D-2. Estimated escapement of wild steelhead at Lower Granite Dam by sex and by size for each genetic stock, spawn year 2020. L = lower bound and U = upper bound of 90% confidence intervals. See Genetic Tissue Processing and Analysis section for stock abbreviations. ....	62
Appendix D-3. Estimated escapement by sex of wild steelhead at Lower Granite Dam, spawn years 2009–2020. Confidence intervals are at 90%. ....	63
Appendix D-4. Estimated escapement of wild steelhead at Lower Granite Dam by smolt migration year (MY), brood year (BY), and age class for each genetic stock, spawn year 2020. Only individual fish that had both a total age and an assigned stock were used (n = 1,884). Age class format is European: freshwater age.saltwater age. R represents consecutive year repeat	

spawners who spawned two years in a row, and R1 represents skip spawners who spent one year in saltwater between spawning years. See Genetic Tissue Processing and Analysis section for stock abbreviations. ....64

Appendix D-5. Estimated escapement by saltwater age of wild steelhead at Lower Granite Dam, spawn years 2009–2020. Confidence intervals are at 90%. Repeat refers to steelhead showing evidence of previous spawning events.....65

Appendix D-6. Estimated escapement by genetic stock and saltwater age of wild steelhead at Lower Granite Dam, spawn years 2009–2020. Confidence intervals are at 90%. Repeat refers to steelhead showing evidence of previous spawning events.....66

Appendix D-7. Length frequency distribution by saltwater age of wild steelhead trapped at Lower Granite Dam, spawn year 2020. Solid black vertical line represents mean fork length (FL) at saltwater age. Dashed vertical red line represents the 780 mm (FL) cutoff for determining large-sized steelhead.....67

Appendix E: Wild Chinook Salmon at Lower Granite Dam, spawn year 2020. ....68

Appendix E-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 2010–2020. Spawn year 2020 stock-specific estimates were generated using run reconstruction methods and do not include jacks in the total wild count. See Genetic Tissue Processing and Analysis section for stock abbreviations. ....69

Appendix E-2. Estimated escapement of wild adult Chinook Salmon at Lower Granite Dam using run reconstruction and historic data, spawn year 2020. Stock-specific estimates do not include jacks. See Genetic Tissue Processing and Analysis section for stock abbreviations.....70

Appendix E-3. Estimated escapement by saltwater age of wild Chinook Salmon at Lower Granite Dam, spawn years 2009-2020. Confidence intervals, when present, are at 90%. Spawn year 2020 saltwater age estimates were generated using run reconstruction methods and do not have confidence intervals. ....71

## ABSTRACT

This report summarizes the abundance and composition of wild adult steelhead *Oncorhynchus mykiss* and spring-summer Chinook Salmon *O. tshawytscha* returning to Lower Granite Dam in spawn year 2020. We used a combination of window counts and biological samples collected using a systematic random sample design 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, and smolt-to-adult return rate for each species. For steelhead, the combined window count was 34,410 hatchery and wild fish. The estimated wild steelhead escapement was 9,634 fish (9,337–9,933 90% CI), which comprised 28% of the window count. The Grande Ronde River genetic stock was the most abundant followed by the Lower Snake River. Small steelhead (<78 cm, FL) dominated the total hatchery run, the total wild run, and all wild genetic stocks. The wild steelhead aggregate at Lower Granite Dam was female biased (65%) with female percentages of genetic stocks that ranged from 53% for the Upper Clearwater River to 74% for the Lower Salmon River. We observed 19 different age classes for wild steelhead. Total age for adults at Lower Granite Dam ranged from three to eight years, with freshwater ages that ranged from one to five years, and saltwater ages that ranged from zero to three years with additional fish returning as repeat spawners. Adult-to-adult productivity was completed for brood year 2012 and was 0.56 returning recruits per spawner. Productivities for all wild steelhead genetic stocks were below replacement. The smolt-to-adult return rate for the aggregate wild steelhead run was 1.58% for smolts crossing Lower Granite Dam in migration year 2016. For spring-summer Chinook Salmon, the combined window count was 34,786 hatchery and wild fish. Few Chinook Salmon were trapped at the dam during spawn year 2020 due to COVID-19 trap closures; therefore, Chinook Salmon decomposition estimates were generated using a combination of run reconstruction methods and previous years' data. The estimated wild Chinook Salmon escapement was 9,774 fish, which comprised 28% of the window count. The Hells Canyon genetic stock was the most abundant followed by the Upper Salmon River. Two-saltwater fish dominated the wild return, comprising 84% of wild Chinook Salmon. Adult-to-adult productivity was completed for brood year 2014 at 0.31 returning recruits per spawner. Productivities for all wild Chinook Salmon genetic stocks were below replacement. The smolt-to-adult return rate for the aggregate wild Chinook Salmon run was 0.64% for smolts crossing Lower Granite Dam in migration year 2016. We noted overall declining trends in escapement, productivity, and smolt-to-adult return rates for both species over the past five years.

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## INTRODUCTION

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; Lawry et al. 2020). 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.

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 total 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 LGR 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 (Joint Columbia River Management Staff 2020). Most steelhead pass LGR in the fall but are assigned to their spawn year the following spring.

The goal of this report is to summarize the abundance and composition of adult wild steelhead and spring-summer Chinook Salmon returning to LGR during spawn year (SY) 2020 as defined by the USACE calendar date designations. We also update the abundance trends for 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 Lawry et al. 2020. The objectives of this report are to:

1. Describe LGR adult trap operations and data collection during 2019-2020, which is the timeframe encompassing all steelhead and Chinook Salmon passing LGR for SY2020.
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 SAR rate for the aggregate return of wild steelhead and Chinook Salmon.

## **METHODS**

### **Adult Trap Operations at Lower Granite Dam**

Systematic samples of adult 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 computerized trap gate according to a predetermined sample rate. The trap gate was opened four times per hour for a length of time directed by the programmed sample rate; the trap was operational 24 hours per day. The sample rate was 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 did not operate during weekends from March 1 to August 17, and the trap rate was adjusted to still sample at the sample rate goal by compensating for the two non-trapping weekend days. In-season adjustments to the sample rate were sometimes needed to accommodate limitations at the trapping facility, changes to the forecast, or sample size goal modifications. Additionally, high ( $\geq 21^{\circ}\text{C}$  or  $\geq 70^{\circ}\text{F}$ ) and low ( $\leq 0^{\circ}\text{C}$  or  $\leq 32^{\circ}\text{F}$ ) water temperatures require the trapping facility to temporarily modify or cease operations.

During SY2020, the trap was closed September 7 through September 12, 2019 due to high water temperatures (Appendix A-1). It was also closed November 13, 2019 through March 1, 2020 for the winter. In addition to these closures, a unique situation occurred during SY2020 when the trap was shut down from March 25 through July 1, 2020 to comply with COVID-19 safety policies. Outside these closures, daily trapping rates varied from 20 to 100%. The trapping rate was set at 100% from September 13 through September 16, 2019 to make up for fall Chinook Salmon broodstock sampling that was missed the week prior during the high water temperature closure. For steelhead, 88.7% 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 2019, but a second small pulse occurred in March and April 2020. For Chinook Salmon, 8.2% of the run passed the window while the trap was open; this extremely low percentage was attributed mainly to the COVID-19 closure but also the weekend closures (Appendix A-3). Additional details on the trap can be found in Harmon (2003), Steinhorst et al. (2010), and USACE (2019, 2020).

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 a 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 were 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, or (for steelhead only) dorsal fin erosion were classified as ad-intact hatchery fish. The trap crew sampled fin tissue from all ad-intact steelhead (Chinook Salmon were excluded); genotyping for parentage-based tagging (PBT) analysis was conducted post hoc to further classify ad-intact hatchery steelhead (Hargrove et al. 2020). 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 (steelhead only). Information associated with previous PIT tagging events was not used to determine origin.

For all ad-intact steelhead, 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 (NRAAL). For all ad-intact steelhead, 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 steelhead 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; IPTDSW 2020). After processing, all fish were returned to the adult fish ladder to resume their upstream migration.

### **Chinook Salmon Adjustments due to COVID-19 Closure**

Chinook Salmon data collection and analysis in SY2020 faced unprecedented challenges associated with COVID-19, particularly the extended closure of the adult fish trap at LGR to follow safety policies. This trap closure occurred during the majority of the spring-summer Chinook Salmon run (Appendix A-3). Although USACE window counts for Chinook Salmon continued, estimates from limited numbers of trapped fish were deemed infeasible and, thus, we did not collect any biological samples; therefore, alternative analysis methods were developed to obtain SY2020 Chinook Salmon estimates (Appendix B-1).

### **Trap Data Management**

Since 2012, 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 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 objective was to age and genotype approximately 2,000 wild steelhead and 2,000 wild Chinook Salmon. In collaboration with our work, a second objective was to PIT tag, age, and genotype approximately 4,000 wild steelhead and 4,000 wild Chinook Salmon to estimate abundance at instream PIT detectors. We emphasize that both objectives were complimentary and not mutually exclusive, and that no wild Chinook Salmon were PIT tagged, aged, or genotyped for SY2020. While the trap was open, every ad-intact steelhead trapped at LGR was genotyped to simplify collaborative logistics and to increase accuracy and precision of abundance estimates using genetic stock identification (GSI) and PBT. All valid samples from wild steelhead were systematically subsampled if more than approximately 2,000 samples were available. The result was a pool of samples collected systematically across the spawning run and generally in constant proportion to its abundance. Hence, 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 NRAAL according to protocols detailed in Wright et al. (2015). Ages were 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 spawn year minus the total age at spawning (total age = freshwater age + saltwater age + 1). One year is added to scale age determinations for steelhead and Chinook Salmon where a visible annulus is not formed during growth but is assumed to have occurred. For steelhead, no visible annulus forms during the adult period of the lifecycle spent in freshwater over winter, when mineral deposits that form on scales are metabolized for gonadal and gamete growth (Persson et al. 1998; Witten and Huysseune 2009). For Chinook Salmon, no annulus forms during the first winter of juvenile development because they are still in the redd. Fish lacking either a freshwater or saltwater age were not used for analysis.

We validated wild steelhead 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 steelhead ages. Analysis of steelhead scales is sufficiently accurate to produce unbiased age compositions (Copeland et al. 2018; Reinhardt et al. 2022).

## **Genetics Tissue Processing and Analysis**

Detailed methods for extraction of genomic DNA from tissue samples, DNA amplification, and single nucleotide polymorphism (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) protocols at either the EFGL in Eagle, Idaho, or the Columbia River Inter-Tribal Fish Commission's genetics laboratory in Hagerman, Idaho. Steelhead were examined at a 368 SNP marker panel and Chinook Salmon are normally examined at a 343 SNP marker panel, but no biological Chinook Salmon samples were taken in SY2020. Each panel contains SNPs for PBT, GSI, and sex-determination analysis.

Parentage-based tagging involves annual sampling and genotyping of hatchery broodstock that are used to create a database of parental genotypes. Subsequently, progeny of these genotyped parents (collected either as juveniles or adults) can be assigned back to their parents via parentage analysis. Parentage assignments were performed on all ad-intact adults returning to LGR to identify hatchery fish that were phenotypically wild (unclipped/unmarked) using the program SNPPIT (Anderson 2010, available at: <https://github.com/erigande/snppit>). 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 hatchery of origin and total age (Steele et al. 2013). Parentage Based Tagging is a critical tool to differentiate hatchery fish when no other physical tags (e.g., CWT and fin clips) are present and can significantly improve escapement estimates for wild Chinook Salmon and steelhead (Hargrove et al. 2021)

Genetic stock identification is a complimentary genetic technique to PBT that seeks to identify the source of origin of wild fish. Briefly, this technique involves genotyping wild fish sampled on the landscape and using these population-level allele frequencies to assign individual fish of unknown origin (adults sampled at LGR) to reporting groups (referred henceforth as genetic stocks). 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 (Figure 1; Figure 2). Genetic stocks were 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 algorithms implemented in rubias (Moran and Anderson 2019). 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 upstream (e.g., Alpowa and Asotin creeks) and downstream (primarily Tucannon River) of 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 account for returning adults that originated from populations 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).

Phenotypic sex was not, and generally cannot, be reliably determined by personnel at the LGR trap, as most adult anadromous fish typically do not exhibit sexually dimorphic characteristics at 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 Fish Passage Center (FPC) website: <http://www.fpc.org/environment/home.asp>. Additional daily window count operation information was obtained from USACE annual fish passage reports (USACE 2019, 2020). For Chinook Salmon, the adult count was combined with the jack count to derive the total count on a daily basis.

For SY2020, we generated estimates of Chinook Salmon escapement by origin, genetic stock, and age using a combination of run reconstruction methods and previous years' data (Appendix B-1). Origin and genetic data from the past eleven years (SY2009–2019), and age data from the previous year (SY2019), were used to decompose the 2020 window counts. The age composition of the SY2019 wild adult PIT tag returns (fish tagged as juveniles) was used to break out the saltwater age-2 and -3 wild adults. To obtain brood year estimates, freshwater ages were reconstructed using the SY2014–2019 average freshwater age proportions within a saltwater age class and applying those proportions to the saltwater age estimates. We did not attempt to estimate escapement by size or sex, nor did we attempt to estimate precision (90% confidence intervals, CI).

For steelhead only, 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 SCOB I (Salmonid Composition Bootstrap Intervals) function in the SCOB I R package (<https://github.com/mackerman44/SCOB I>; R Development Core Team 2008; Steinhorst et al. 2017). SCOB I 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 ( $n \geq 100$ ) 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 3). First, the total escapement is decomposed into rearing type (ad-intact hatchery, ad-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 (B-Index), whereas small steelhead are less than 78 cm FL (A-Index), for fisheries managed under the U.S. v. Oregon Management Agreement (Joint Columbia River Management Staff 2020). 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 SAR rate for wild steelhead and Chinook Salmon, the age composition of adults at LGR was combined with estimates of emigrating wild smolt cohorts at LGR. For steelhead, we continue the SAR series that began with smolt migration year 2010. 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, we continue the SAR series that began with smolt migration year 1996. Smolt production estimates for both species were acquired from Ebel et al. (2022).

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 spring-summer 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

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

and the upper limit by

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

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

## RESULTS

### Steelhead Escapement

The USACE total window count of steelhead for SY2020 was 34,410 fish (Table 2). The LGR trap captured 7,795 of them, of which 2,349 were valid wild fish (Appendix A-5). Our estimate of wild escapement is 9,634 fish (9,337–9,933 90% CI), which comprises approximately 28% of the window count (Table 2). The remaining 24,776 fish were of hatchery origin. We estimate ad-clipped hatchery escapement was 22,453 fish (22,130–22,774 90% CI) and ad-intact hatchery escapement was 2,323 fish (2,142–2,507 90% CI). External marks, internal tags, and genetics were used to determine that 9% of the total hatchery fish and 7% of the total steelhead run were ad-intact hatchery fish. For all ad-intact steelhead, 19% were hatchery fish.

### Steelhead by Genetic Stock, Size, Sex, and Age

Relative abundance of wild steelhead by genetic stock varied greatly in SY2020, with the Grande Ronde highest at 34% and the South Fork Salmon stock lowest at 1% (Appendix D-1). Escapement estimates for each genetic stock were as follows (Figure 4; Appendix D-2): UPSALM 1,779 fish (1,641–1,922 90% CI); MFSALM 453 fish (385–521 90% CI); SFSALM 99 fish (67–133 90% CI); LOSALM 175 fish (131–223 90% CI); UPCLWR 363 fish (292–437 90% CI); SFCLWR 459 fish (379–546 90% CI); LOCLWR 476 fish (399–555 90% CI); IMNAHA 714 fish (621–810 90% CI); GRROND 3,285 fish (3,088–3,481 90% CI); and LSNAKE 1,831 fish (1,685–1,987 90% CI).

Small steelhead were most abundant across all origins (Table 2). Small wild steelhead were estimated at 9,234 fish (8,930–9,500 90% CI), small ad-clipped hatchery steelhead at 20,259 fish (19,929–20,593 90% CI), and small ad-intact hatchery steelhead at 1,452 fish (1,305–1,602 90% CI). Large wild steelhead were estimated at 400 fish (349–442 90% CI), large ad-clipped hatchery steelhead at 2,194 fish (2,028–2,363 90% CI), and large ad-intact hatchery steelhead at 871 fish (757–992 90% CI). Stock-specific estimates for wild fish by size are in Appendix D-2.

Wild steelhead were female biased, and females accounted for 65% of the overall wild return (Appendix D-3). Female escapement was estimated at 6,213 fish (5,985–6,393 90% CI) and males at 3,421 fish (3,260–3,548 90% CI). Sex ratios for each genetic stock mirrored the aggregate wild run and ranged from 53% female for Upper Clearwater River to 74% female for Lower Salmon River (Appendix D-2).

Nineteen different age classes were observed from the 1,884 wild fish that we were able to assign both a genetic stock and a total age (Appendix D-4). Total age at LGR ranged from three to eight years with freshwater age ranging from one to five years and saltwater age ranging from zero to three years. Some steelhead returned as repeat spawners.

Repeat spawning fish made up 0.5% of all wild steelhead crossing LGR. Repeat spawners were observed in most genetic stocks except for IMNAHA, SFCLWR, SFSALM, and UPCLWR. The proportions of repeat spawners slightly varied across the other genetic stocks. Repeat spawners as a proportion of the run for each genetic stock ranged from 0.2% (UPSALM) to up to 1.7% (LOSALM).

For all genetic stocks, age-5 (fish that hatched in BY2015) was the dominant total age cohort, with the exception of Lower Clearwater where age-4 (BY2016) was the dominant age cohort. We estimated that 174 (141–207 90% CI) of the returning adults were hatched in brood year (BY) 2017 and were age-3; 3,667 (3,507–3,799 90% CI) were from BY2016 and were age-4; 4,429 (4,251–4,578 90% CI) were from BY2015 and were age-5; 1,268 (1,188–1,339 90% CI) were from BY2014 and were age-6; 91 (72–107 90% CI) were from BY2013 and were age-7; and 5 (1–9 90% CI) were from BY2012 and were age-8.

The majority of the wild return, or 59%, emigrated to the ocean as freshwater age-2 and, excluding repeat spawners, 57% returned as saltwater age-1 (Appendix D-5). Saltwater age estimates were 29 (19–40 90% CI) zero-saltwater from MY2019; 5,511 (5,297–5,685 90% CI) one-saltwater from MY2018; 3,993 (3,823–4,134 90% CI) two-saltwater from MY2017; 53 (38–67 90% CI) three-saltwater from MY2016; and 48 (35–59 90% CI) repeat spawning steelhead regardless of migratory year. Furthermore, one-saltwater fish made up the vast majority of returning steelhead for six of the ten genetic stocks; the remaining four stocks (LOCLWR, SFCLWR, SFSALM, and UPCLWR) consisted mostly of two-saltwater fish (Appendix D-6). The mean fork lengths of one-saltwater and two-saltwater fish were below the 78 cm FL threshold for large steelhead (Appendix D-7).

Readers accurately determined the saltwater-age of 98% of the scale samples (n = 63) from known saltwater-age steelhead collected during SY2020 (Appendix C-1). The known saltwater-age sample was 48% one-saltwater and 52% two-saltwater. There were no three-saltwater fish, four-saltwater fish, or repeat spawners in the known saltwater-age sample.

### **Steelhead Adult-to-Adult Productivity**

Wild steelhead returning to LGR in SY2020 completed the BY2012 cohort necessary for an adult-to-adult productivity estimate. Brood year 2012 returned 22,240 adults from 39,438 parents resulting in an adult-to-adult productivity estimate of 0.56 recruits per spawner, which is below the 1.0 recruits per spawner necessary for replacement (Figure 5). A preliminary estimate of adult-to-adult productivity for the BY2013 cohort also placed it below replacement. Although unlikely to change significantly, the estimate for BY2013 is preliminary and will be completed in SY2021.

None of the ten genetic stocks had adult-to-adult productivity estimates that were above replacement (Figure 6). The recruits per spawner estimates for each stock were as follows: UPSALM 0.54, MFSALM 0.29, SFSALM 0.25, LOSALM 0.39, UPCLWR 0.60, SFCLWR 0.42, LOCLWR 0.65, IMNAHA 0.44, and GRROND 0.73. Estimates for LSSNAKE were not included because the fish from this stock recorded at LGR were only a proportion of the total returning adults; therefore, productivity estimates for LSSNAKE were not representative of the entire stock. Preliminary estimates of adult-to-adult productivity by genetic stock for BY2013 placed all genetic stocks below replacement. The estimates for BY2013 are preliminary and will be completed in SY2021.



### **Steelhead Smolt-to-Adult Return Rate**

This report continued the SAR series that began with smolt MY2010 (Table 3; Figure 7). With adult returns from SY2020, the SAR time series was complete for MY2010-2016. The most recent completed cohort, MY2016, returned 12,720 fish from 805,433 emigrants for a SAR estimate of 1.58 (1.55–1.61 95% CI). The 5-year geometric mean SAR was 2.32%.

SARs ranged from a high of 5.33 (5.29–5.38 95% CI) in MY2012 to a low of 0.56 (0.55–0.58 95% CI) in MY2015. Four of the seven 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 (2.32%) for the 2012-2016 cohorts (n = 5) was less than the target geometric mean of 4%.

The SAR estimate for the MY2016 cohort was well below the NPCC fish and wildlife program mean of 4% and minimum of 2%; however, the 5-year geometric mean just barely reached the minimum (NPCC 2009; Figure 7). 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).

### **Chinook Salmon Escapement**

The USACE total window count of Chinook Salmon for SY2020 was 34,786 fish (Table 4). Few Chinook Salmon were captured in the LGR trap due to COVID-19 safety closures, and these trap data were not suitable to use for any SY2020 estimates because they only represented a small proportion of the total run (Appendix A-3). Our estimate of wild escapement using run reconstruction was 9,774 fish (8,565 adults plus 1,209 jacks), which comprised approximately 28% of the window count (Table 4). The remaining 25,012 fish (21,564 adults plus 3,448 jacks) were of hatchery origin. We estimated ad-clipped hatchery escapement was 22,418 fish and ad-intact hatchery escapement was 2,594 fish. Ten percent of the total hatchery fish and 8% of the total Chinook Salmon run were ad-intact hatchery fish. For all ad-intact Chinook Salmon, 21% were hatchery fish. Calculations for SY2020 estimates can be found in Appendix B-1.

### **Chinook Salmon by Genetic Stock and Age**

Relative abundance of wild Chinook Salmon by genetic stock in SY2020 using run reconstruction varied greatly with HELLSC having the highest percentage of the total wild adults at 35% and TUCANO having the least at 0.5% (Appendix E-1). Of the 8,565 wild adults, escapement estimates for each genetic stock were UPSALM 1,725; MFSALM 1,486; CHMBLN 214; SFSALM 1,193; HELLSC 3,438; TUCANO 50; and FALL 459 fish (Figure 8; Appendix E-2).

Saltwater age estimates of wild Chinook Salmon were estimated to be 1,209 one-saltwater jacks from MY2019; 8,172 two-saltwater fish from MY2018; and 393 three-saltwater fish from MY2017 (Appendix E-3). The majority of the wild return (84%) returned as saltwater age-2.

### **Chinook Salmon by Size and Sex**

Abundance of wild Chinook Salmon by size and sex was not possible for SY2020 due to the COVID-19 trap closure and lack of trap samples.

### **Chinook Salmon Adult-to-Adult Productivity**

Wild Chinook Salmon returning to LGR in SY2020 completed the BY2014 cohort necessary for an adult-to-adult productivity estimate. Brood year 2014 returned 9,294 adults from 30,338 parents resulting in an adult-to-adult productivity estimate of 0.31 recruits per spawner, which is below the 1.0 recruits per spawner necessary for replacement (Figure 9). A preliminary estimate of adult-to-adult productivity for the BY2015 cohort also placed it below replacement (Figure 9). Although unlikely to change significantly, the estimate for BY2015 is preliminary and will be completed in SY2021.

Adult-to-adult productivity estimates were below replacement for all genetic stocks. Recruits per spawner of each genetic stock are as follows: UPSALM at 0.24; MFSALM at 0.24; CHMBLN at 0.25; SFSALM at 0.39; and HELLSC at 0.33 (Figure 10). Estimates for TUCANO and FALL stocks were not included because the fish from these stocks recorded at LGR were only a proportion of the total returning adults; therefore, productivity estimates for these two stocks were not representative of their entire stock. Preliminary estimates of adult-to-adult productivity by genetic stock for BY2015 also placed all genetic stocks below replacement (Figure 10). The estimates for BY2015 are preliminary and will be completed in SY2021.

### **Chinook Salmon Smolt-to-Adult Return Rate**

This report continued the SAR series that began with smolt migration year 1996 (Table 5; Figure 11). With adult returns from SY2020, the SAR time series was complete for MY1996-2016. The most recent completed cohort, MY2016, returned 9,184 fish from 1,424,036 yearling emigrants for a SAR estimate of 0.64 (0.63–0.66 95% CI). The 10-year geometric mean SAR was 1.55% and the 5-year geometric mean SAR was 1.22%.

SARs for the MY2016 cohort and both geometric means were below the NPCC fish and wildlife program mean of 4% and minimum of 2% (NPCC 2009; Figure 11). 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).

## **DISCUSSION**

Abundance of returning SY2020 wild summer steelhead and spring-summer Chinook Salmon measured at Lower Granite Dam was low. For steelhead, overall escapement (all rear types combined) counted at the LGR window in SY2020 was the lowest on record going back to at least SY1998 (Table 2). Hatchery steelhead escapement was also the lowest on record, and wild steelhead escapement was below 10,000 fish, the fifth lowest on record. Abundance of wild, natural-origin steelhead was well below IDFG's "healthy and harvestable" escapement goals and NMFS' minimum abundance thresholds (NMFS 2017; IDFG 2019; Columbia Basin Partnership Task Force 2020). Wild steelhead escapement was less than one-tenth of the proposed escapement goal of 104,500 fish, and less than half of NMFS' minimum abundance threshold of 21,000 fish, to the Snake River basin (NMFS 2017; IDFG 2019; Columbia Basin Partnership Task Force 2020). The stock-specific wild escapement estimate for the Lower Snake and Upper Salmon stocks increased significantly, whereas South Fork Salmon and Upper Clearwater stocks decreased significantly compared to SY2019, as evidenced by non-overlapping 90% CIs (Figure 4). The remaining genetic stocks did not change significantly from last year. Despite the presence or absence of statistical significance, the 5-year trend in point estimates suggests a continued decline for all stocks.

Unfortunately, large wild, large hatchery ad-clipped, and large hatchery ad-intact steelhead escapement all decreased significantly from SY2019 to SY2020 (Table 2). Additionally, the mean length-at-age for two-saltwater steelhead was below the length cutoff for the B-run size classification. Steelhead and fall Chinook Salmon fisheries in the Columbia and Snake rivers are partially constrained by the abundance of large steelhead, often called B-run steelhead in fisheries regulations, counted at Bonneville and Lower Granite dams. B-run steelhead are defined as fish  $\geq 78$  cm in fork length and are often associated with a two-saltwater age. A-run steelhead can also have two-saltwater fish returning, but are typically smaller in size than the B-run dominated stocks. In SY2020, two-saltwater returns were on average 2.8 cm smaller than SY2019 two-saltwater fish and 7.5 cm smaller than the 78 cm length requirement (Appendix D-7). The reduced length-at-age is not novel or restricted to this spawn year, but a continuation of a developing trend, and poor growth and survival in the ocean may be a contributing factor (Bowersox et al. 2019). The depressed returns of populations that typically produce larger two- and three-saltwater fish, particularly, the Upper Clearwater, South Fork Clearwater, Middle Fork Salmon, and South Fork Salmon river wild populations and the Dworshak hatchery stock, contributed to the apparent return of smaller steelhead. Total two-saltwater wild steelhead returns in SY2020 were also the second lowest on record going back to at least SY2009. Idaho fisheries were restricted during the fall of 2019 in attempt to ensure adequate broodstock to Dworshak National Fish Hatchery and to keep impacts on wild fish within limits. The declining average length of two-saltwater steelhead poses a challenge to fisheries managers because it has impacted fishing regulations and public perception of fewer returning B-run steelhead (Copeland et al. 2017; Bowersox et al. 2019).

We observed some changes in the sex composition in the SY2020 steelhead run compared to previous years. Wild steelhead stocks continue to be female biased, and historically the Upper Clearwater stock was the most female biased; however, this year it is the lowest percentage female among all stocks. Sex composition is likely driven by relative saltwater age composition of one-saltwater and two-saltwater fish, creating a cohort effect. Generally, returning one-saltwater fish tend to be mostly males; females benefit from remaining in the ocean longer by growing larger to increase their fecundity (Hendry et al. 2004). In previous years, whenever the Upper Clearwater stock showed an increase in the percentage of one-saltwater fish, there appeared to also be a slight increase in the percentage of males. The Upper Clearwater stock in SY2020 followed the same trend with a relative increase in both one-saltwater fish and males, which could explain the lower relative abundance of females. Although the sex and age composition of steelhead cohorts may vary from year to year, the overall abundance of steelhead stocks in SY2020 was low.

Chinook Salmon returns in SY2020 were also low. Although overall escapement counted at the LGR window in SY2020 was higher than SY2019, it was the fifth lowest escapement recorded going back to at least SY1998 (Table 4). Hatchery Chinook Salmon escapement was also the fifth lowest on record, and wild Chinook Salmon escapement was below 10,000 fish. Abundance of wild- and natural-origin Chinook Salmon was well below IDFG's "healthy and harvestable" escapement goals and NMFS' minimum abundance thresholds. Wild Chinook Salmon escapement was less than one-twelfth of the proposed escapement goal of 127,000 fish, and less than one-third of NMFS' minimum abundance threshold of 31,500 fish, to the Snake River basin (NMFS 2017; IDFG 2019; Columbia Basin Partnership Task Force 2020). The stock-specific wild escapement estimate for all stocks (except FALL) increased compared to SY2019 (Figure 8). There was an also improvement in two-saltwater returns in SY2020, likely due to the increased number of returning wild jacks and hatchery jacks in SY2019 (Lawry et al. 2020). Despite the increases in abundance among stocks and two-saltwater returns, the 5-year trend in point estimates suggests a continued decline for all stocks.

Considering the challenges of SY2020 Chinook Salmon data analyses associated with COVID-19 closures, our reported estimates reflect averages of previous years and we need to exercise caution when interpreting these data. Decomposition estimates were needed for the purposes of forecasting for fisheries planning and to continue the productivity and SAR time series. We are confident these data are adequate for those purposes; however, we do not want to further speculate or overanalyze fine-scale stock-specific trends based on these estimates.

In this report, we omitted the productivity estimates for three genetic stocks that 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 from downstream of LGR. The LSSNAKE (steelhead) and TUCANO (Chinook Salmon) stocks contain the Tucannon River population located downstream of LGR. Some returning adults born in the Tucannon River overshoot their natal stream and stray upstream of LGR. Without abundance information from the Tucannon River for each species, estimates for the LSSNAKE 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 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 a small amount (<30 PIT-tagged fish in any given year) of 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 downstream of LGR after successfully crossing to the upstream side. A portion of these fallback fish re-ascend the LGR ladder, essentially being counted twice at the window, while others stay downstream of LGR. Furthermore, the window is not counted 24 hours a day throughout the season (USACE 2019, 2020). 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). Currently a different method for adult escapement estimates at LGR is under development 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 report summarized the abundance and composition of wild adult steelhead and spring-summer Chinook Salmon returning to LGR during spawn year 2020 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 over the past five years.

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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). Extirpated populations are shaded.

<b>Snake River steelhead DPS</b>	
<b>Major population group</b>	<b>Population name</b>
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
Salmon River	13. South Fork Clearwater 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.

<b>Snake River spring-summer Chinook Salmon ESU</b>	
<b>Major population group</b>	<b>Population name</b>
Lower Snake River	1. Tucannon River
	2. Asotin Creek (extirpated) <sup>a</sup>
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) <sup>a</sup>
	10. Lookingglass Creek (extirpated) <sup>a</sup>
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) <sup>a</sup>	
Dry Clearwater River (extirpated) <sup>a</sup>	33. Potlatch River (extirpated) <sup>a</sup>
	34. Lapwai Creek (extirpated) <sup>a</sup>
	35. Lawyer Creek (extirpated) <sup>a</sup>
	36. Upper South Fork Clearwater River (extirpated) <sup>a</sup>
Wet Clearwater River (extirpated) <sup>a</sup>	37. Lower North Fork Clearwater River (extirpated)
	38. Upper North Fork Clearwater River (extirpated)
	39. Lolo Creek (extirpated) <sup>a</sup>
	40. Lochsa River (extirpated) <sup>a</sup>
	41. Meadow Creek (extirpated) <sup>a</sup>
	42. Moose Creek (extirpated) <sup>a</sup>
	43. Upper Selway River (extirpated) <sup>a</sup>

<sup>a</sup> Reintroduced fish exist in extirpated areas except the North Fork Clearwater River basin upstream of Dworshak Dam.

Table 2. Estimated annual escapement, by fish size and origin, of steelhead, spawn years 1998–2020. Large fish were greater than or equal to 78 cm fork length (FL) and small fish were 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; Lawry et al. 2020; present study).

Spawn year <sup>(a)</sup>	LGR window count	Estimated number of steelhead at LGR that were:							Total hatchery	Total wild
		Large wild	Large hatchery ad-clipped	Large hatchery ad-intact	Small wild	Small hatchery ad-clipped	Small hatchery ad-intact			
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 <sup>(b)</sup>	31,574	4,118 <sup>(b)</sup>	34,549 <sup>(b)</sup>	110,750	17,721 <sup>(b)</sup>	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	
2020	34,410	400	2,194	871	9,234	20,259	1,452	24,776	9,634	

<sup>a</sup> 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.

<sup>b</sup> Spawn year 2011 was the first year of adult PBT returns used to adjust wild and hatchery ad-intact fish estimates.

Table 3. 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. Included in parentheses are 95% confidence intervals for SARs.

Smolt migration year	Estimated number of smolts <sup>(a)</sup>	Adults returning to Lower Granite Dam					%SAR (95% CI)
		by saltwater age			Repeat spawners		
		1	2	3			
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	805,433	8,498	4,169	53	48	1.58 (1.55–1.61)	
2017 <sup>(b)</sup>	908,556	3,804	3,993	-	-	0.86 (0.84–0.88)	
2018 <sup>(c)</sup>	949,098	5,511	-	-	-	0.58 (0.57–0.60)	

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

<sup>b</sup> Preliminary SAR until saltwater age-3 is added (SY2021).

<sup>c</sup> Preliminary SAR until saltwater age-2 and age-3 are added (SY2022).



Table 4. Estimated annual escapement, by origin and saltwater age, of Chinook Salmon, spawn years 1998–2020. Jacks were saltwater age-1 and include saltwater age-0 mini-jacks; adults were 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; Lawry et al. 2020; present study). Spawn year 2020 estimates were generated using LGR window count data and run reconstruction methods.

Spawn year <sup>(a)</sup>	Window count	Estimated number of Chinook Salmon at Lower Granite Dam that were:							
		Wild adults <sup>(b)</sup>	Wild jacks <sup>(b)</sup>	Total wild	Hatchery adults <sup>(b)</sup>	Hatchery jacks <sup>(b)</sup>	Total hatchery	Total adults <sup>(b)</sup>	Total jacks <sup>(b)</sup>
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
2020 <sup>(c)</sup>	34,786	8,565	1,209	9,774	21,564	3,448	25,012	30,129	4,657

<sup>a</sup> Spring-summer Chinook Salmon at Lower Granite Dam are considered fish passing March 1 through August 17.

<sup>b</sup> 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. No scale samples were taken during SY2020 due to COVID-19 trap closures, therefore adults and jacks were estimated using length at the LGR counting window (adult ≥57 cm, FL; jack <57 cm, FL). 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.

<sup>c</sup> Window count, total adult, and total jack numbers for SY2020 are from actual LGR window count data. All other SY2020 estimates were calculated using run reconstruction methods.

Table 5. 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 2005–2019 (below the dashed line). SAR 95% confidence intervals are in parentheses.

Smolt migration year	Estimated number of smolts <sup>(a)</sup>	Adults returning to Lower Granite Dam by saltwater age					%SAR (95% CI)
		0 <sup>(b)</sup>	1	2	3	4	
1996	419,826	n/a	n/a <sup>(c)</sup>	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 (0.73–0.77)
2016	1,424,036	47	1,651	6,530	956	0	0.64 (0.63–0.66)
2017 <sup>(d)</sup>	1,171,926	34	490	3,191	393	-	0.35 (0.34–0.36)
2018 <sup>(e)</sup>	1,437,312	29	992	8,172	-	-	0.64 (0.62–0.66)
2019 <sup>(f)</sup>	794,695	18	1,209	-	-	-	0.15 (0.14–0.17)
2020 <sup>(g)</sup>	n/a <sup>(h)</sup>	0	-	-	-	-	-

<sup>a</sup> Smolt abundance for 2010-2019 derived from SCRAPI program (Camacho et al. 2018b, 2019b; Ebel et al. 2022).

<sup>b</sup> 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 2005-2019.

<sup>c</sup> 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.

<sup>d</sup> Preliminary SAR until saltwater age-4 is added (SY2021).

<sup>e</sup> Preliminary SAR until saltwater age-3 and age-4 are added (SY2022).

<sup>f</sup> Preliminary SAR until saltwater age-2 through age-4 are added (SY2023).

<sup>g</sup> Preliminary SAR until saltwater age-1 through age-4 are added (SY2024).

<sup>h</sup> MY2020 smolt estimate not available (n/a) due to COVID-19 safety closures.

## FIGURES

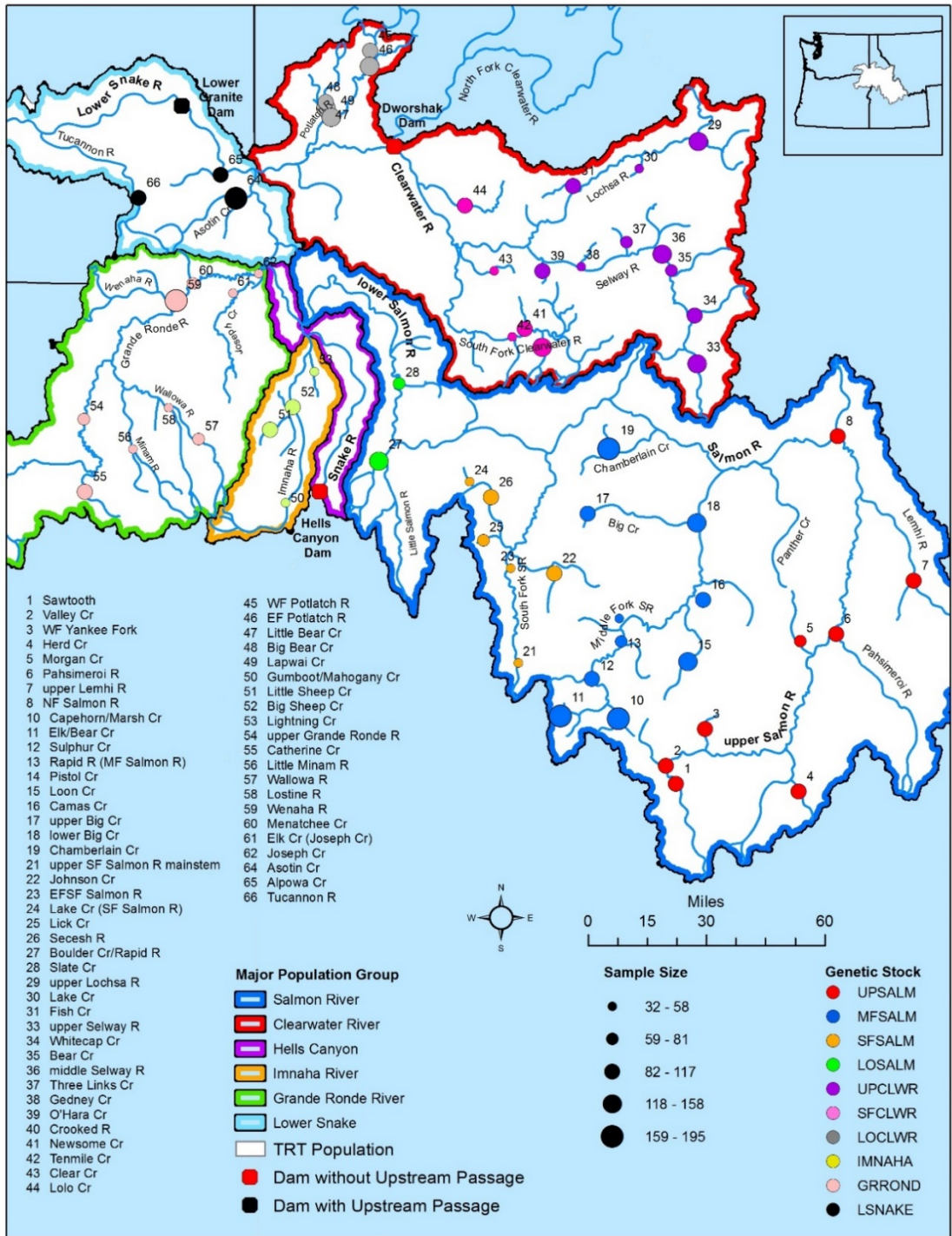


Figure 1. Map of steelhead genetic stocks and sample collections included in the Snake River basin SNP baseline version 3.1 (Powell et al. 2018) used for genetic stock identification at Lower Granite Dam. A detailed description of collections can be found in Hargrove et al. (2021). The Hells Canyon Tributaries major population group does not support independent populations and is considered extirpated (NMFS 2016). See Genetic Tissue Processing and Analysis section for genetic stock abbreviations.

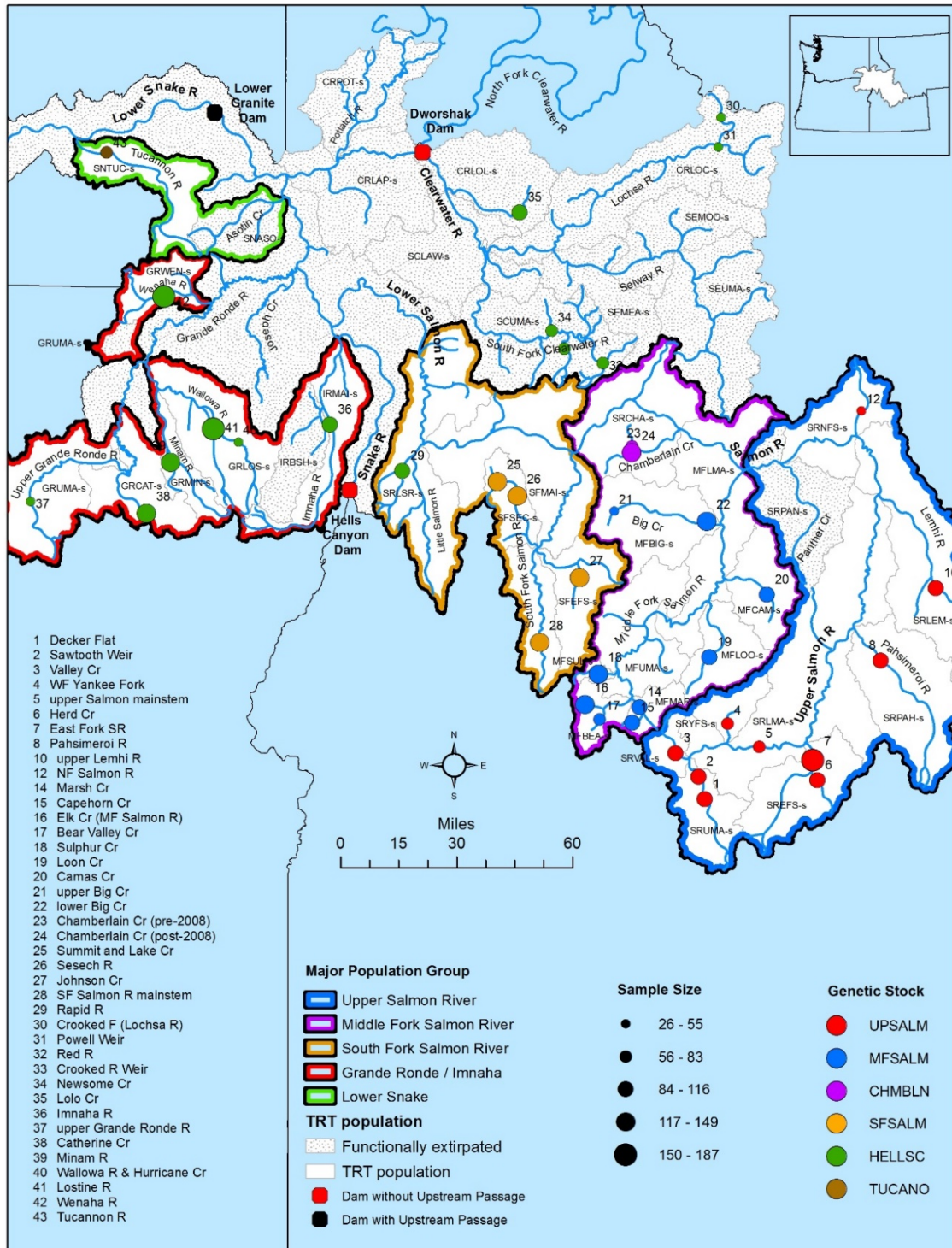


Figure 2. Map of Chinook Salmon genetic stocks and sample collections included in the Snake River basin SNP baseline version 3.1 (Powell et al. 2018) used for genetic stock identification at Lower Granite Dam. A detailed description of collections can be found in Hargrove et al. (2022). Reintroduced fish exist in functionally extirpated TRT populations as mapped. See Genetic Tissue Processing and Analysis section for genetic stock abbreviations.



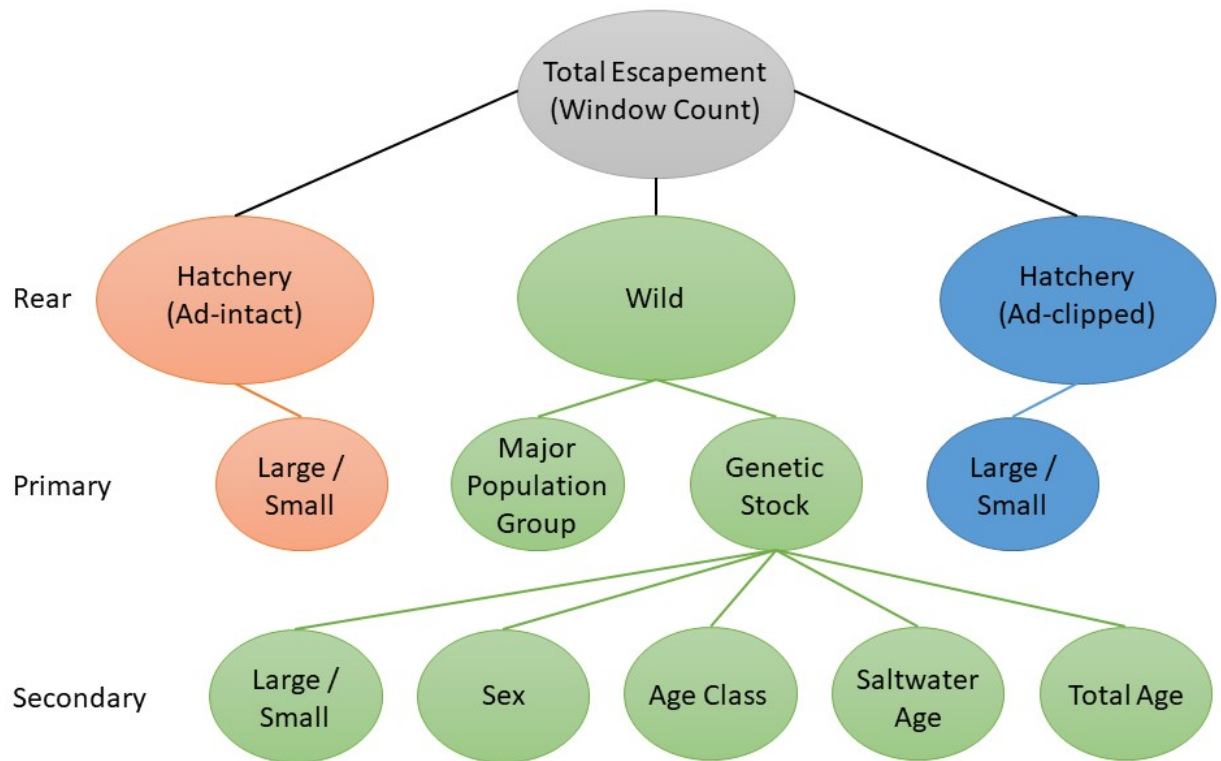


Figure 3. Schematic of the Salmonid Compositional Bootstrap Intervals (SCOBI) Lower Granite Dam decomposition model. Large/Small refer the fork length designations for Chinook Salmon large ( $\geq 57$  cm, fork length [FL]) and small ( $< 57$  cm, FL) and steelhead large ( $\geq 78$  cm, FL) and small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

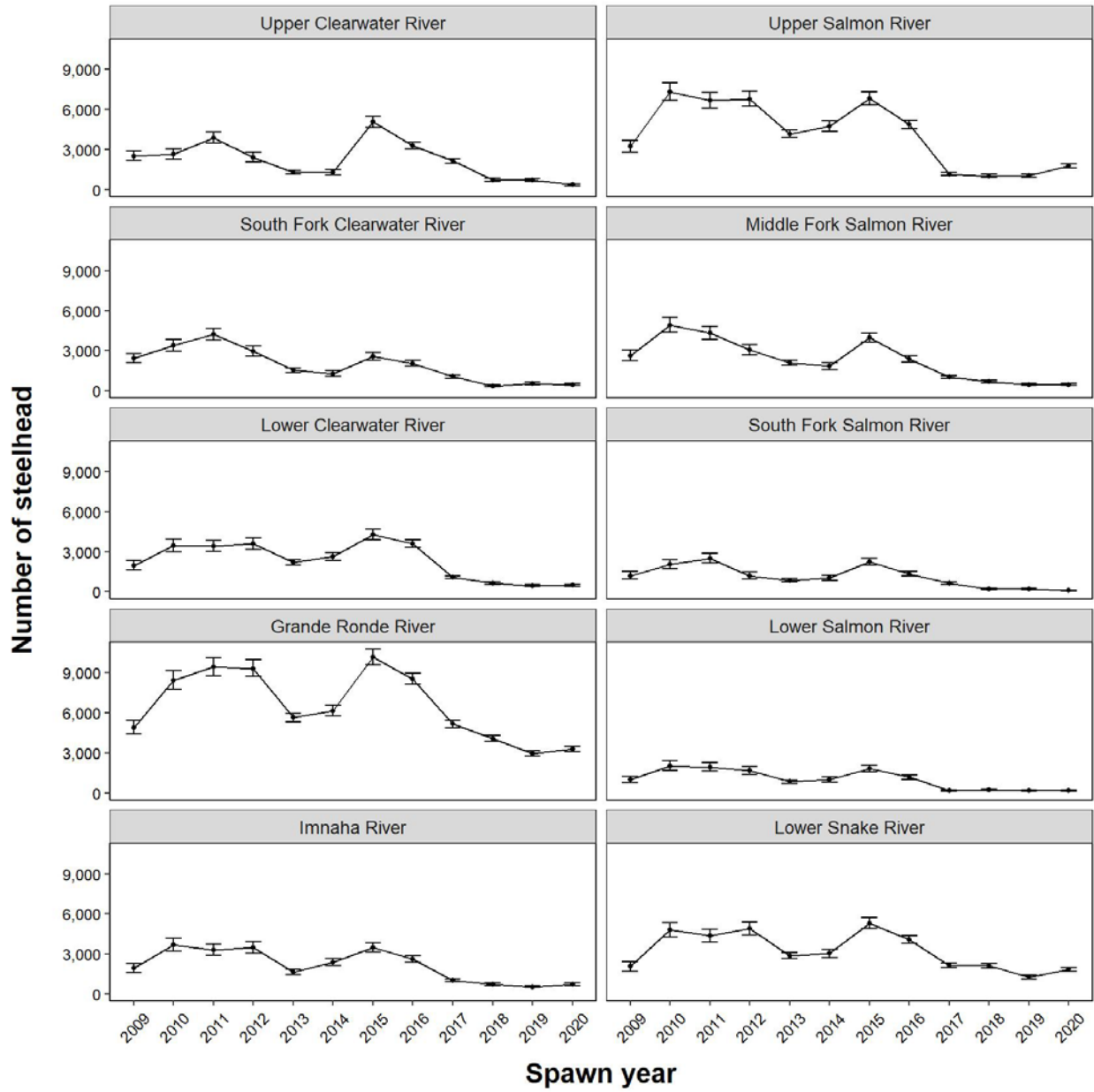


Figure 4. Estimated escapement by genetic stock of wild steelhead at Lower Granite Dam for spawn years 2009–2020. Confidence intervals are at 90%.

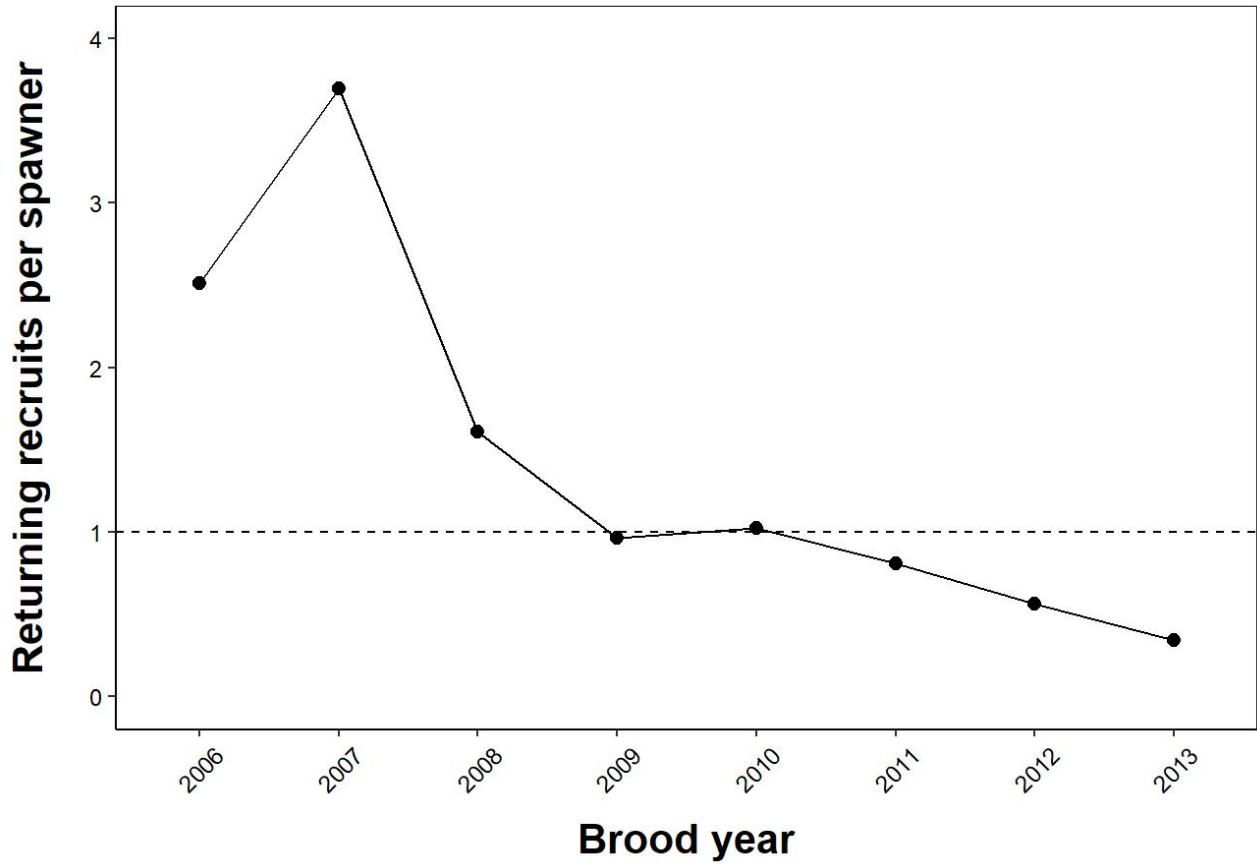


Figure 5. Adult-to-adult productivity (returning recruits per parent spawner) of wild steelhead at Lower Granite Dam. The dashed line at 1.0 recruits per spawner represents replacement. Spawn year 2020 completed brood year 2012. Note brood year 2013 was shown for reference, but represents a preliminary result that will be completed in SY2021.



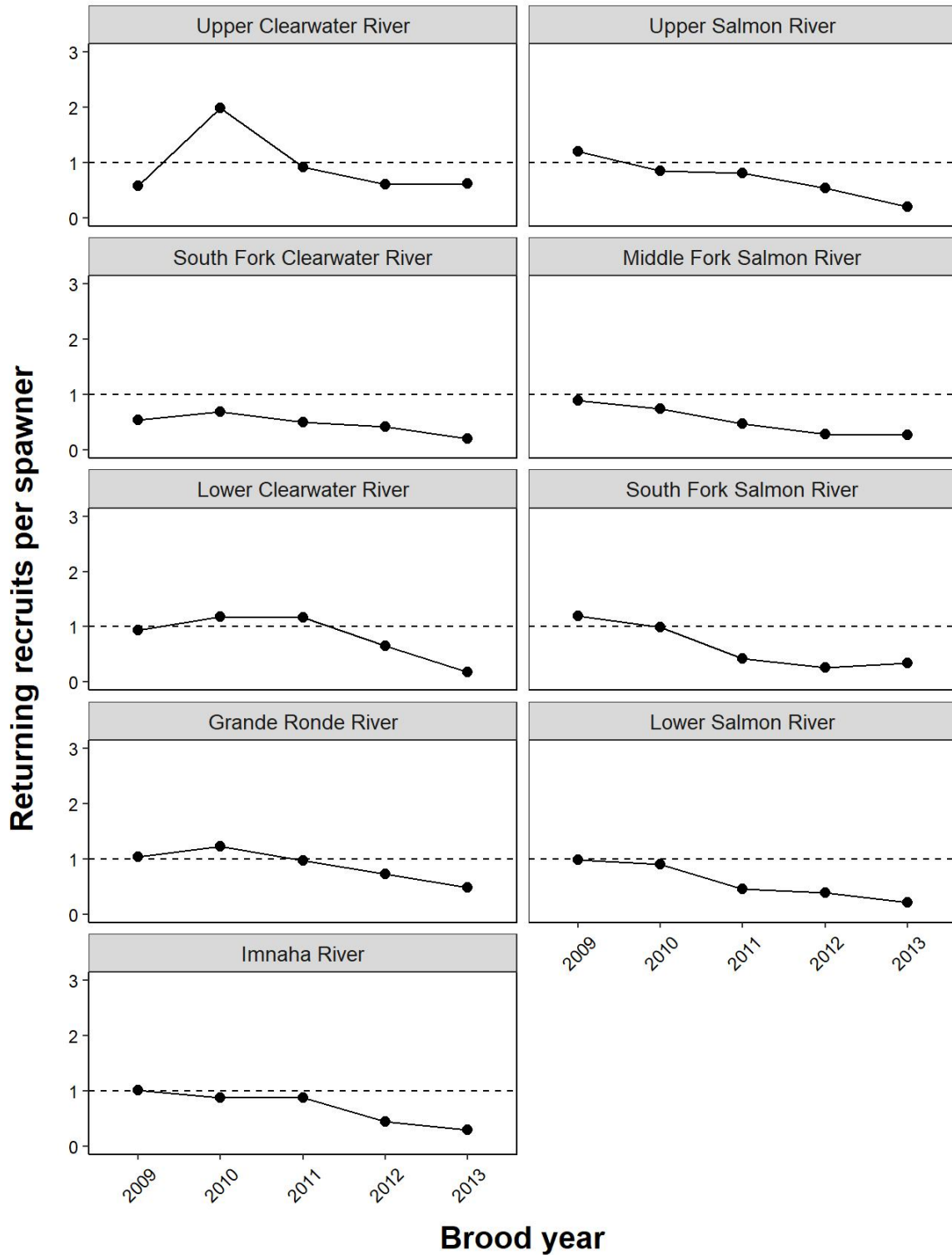


Figure 6. Adult-to-adult productivity (returning recruits per parent spawner) for each genetic stock of wild steelhead at Lower Granite Dam. The dashed line at 1.0 recruits per spawner represents replacement. Spawn year 2020 completed brood year 2012. Note brood year 2013 was shown for reference, but represents a preliminary result that will be completed in SY2021.

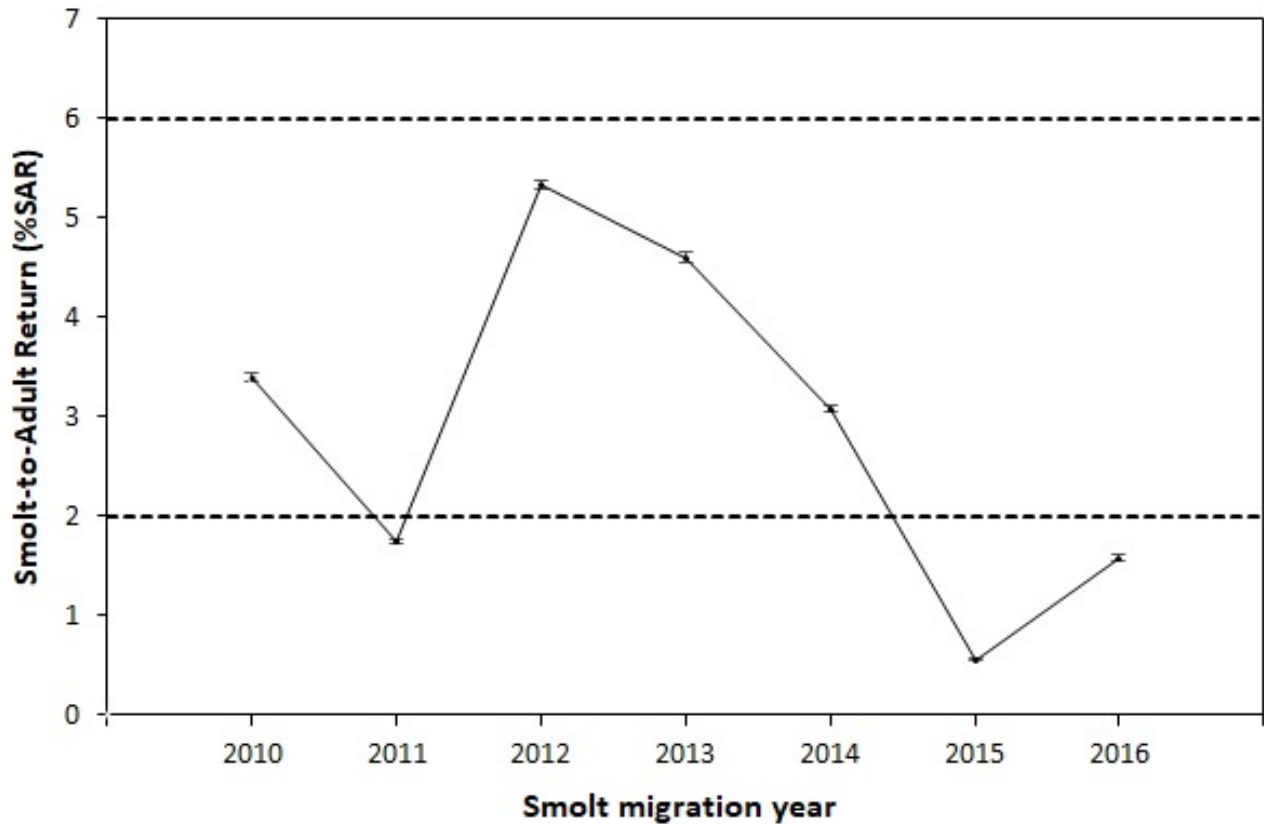


Figure 7. Estimated wild steelhead smolt-to-adult return (%SAR) rate of emigrant smolts and adult returns to Lower Granite Dam for smolt migration years 2010-2016. Confidence intervals are at 95%. The dashed lines represent the lower and upper range SAR objectives for wild steelhead established by the Northwest Power and Conservation Council (NPCC 2009). See Table 3 for numbers.

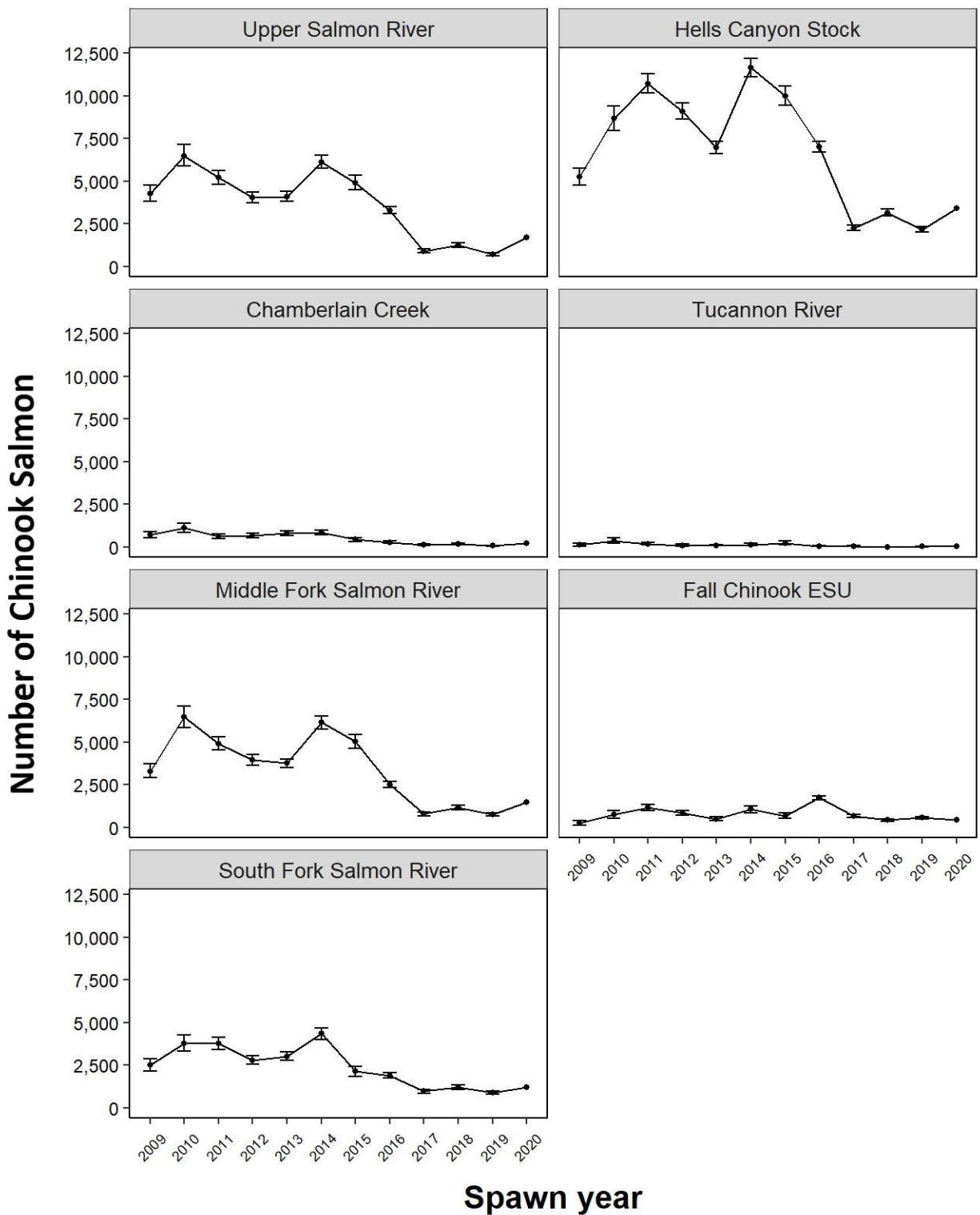


Figure 8. Estimated escapement by genetic stock of wild Chinook Salmon at Lower Granite Dam for spawn years 2009–2020. Confidence intervals, when shown, are at 90%. Spawn year 2020 estimates were generated using run reconstruction and does not include jacks or have confidence intervals.

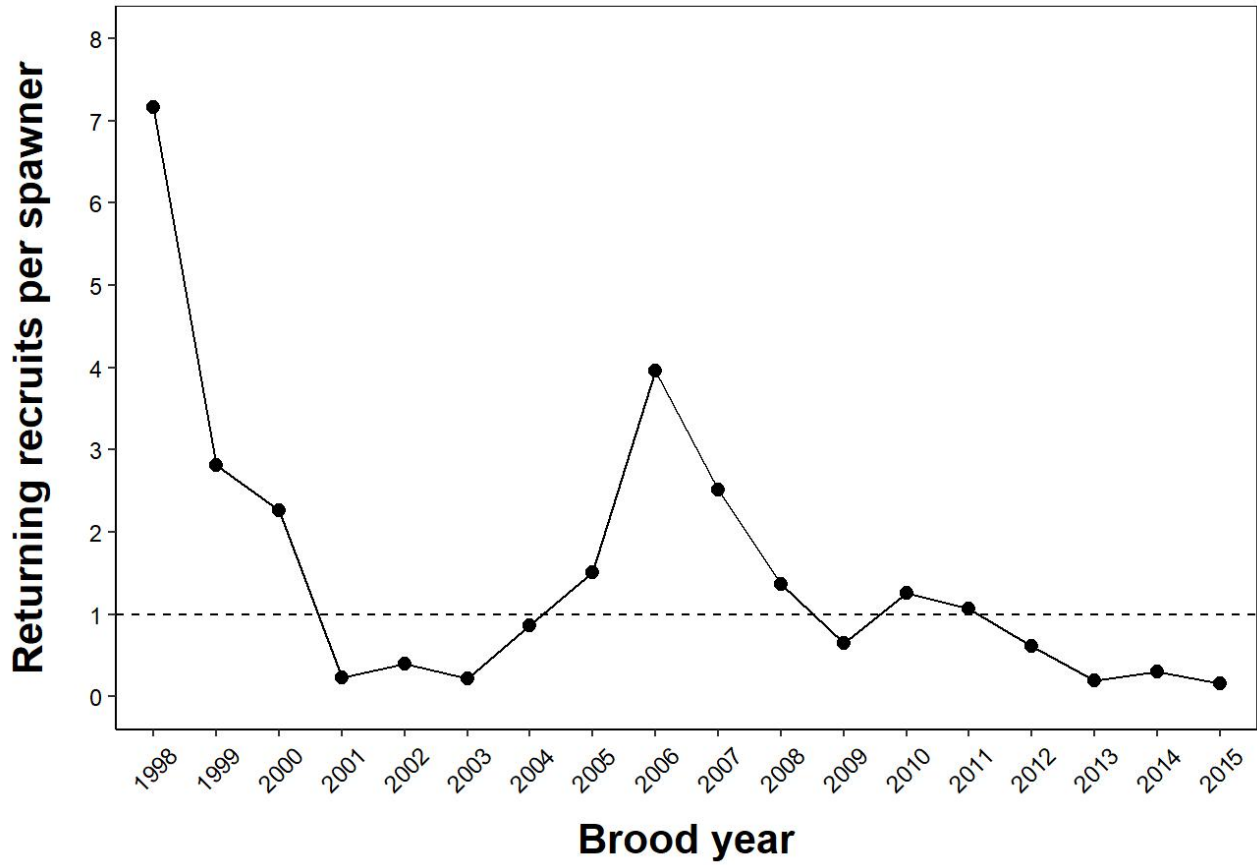


Figure 9. Adult-to-adult productivity (returning recruits per parent spawner) of wild Chinook Salmon at Lower Granite Dam. The dashed line at 1.0 recruits per spawner represents replacement. Spawn year 2020 completed brood year 2014. Note brood year 2015 was shown for reference, but represents a preliminary result that will be completed in SY2021.

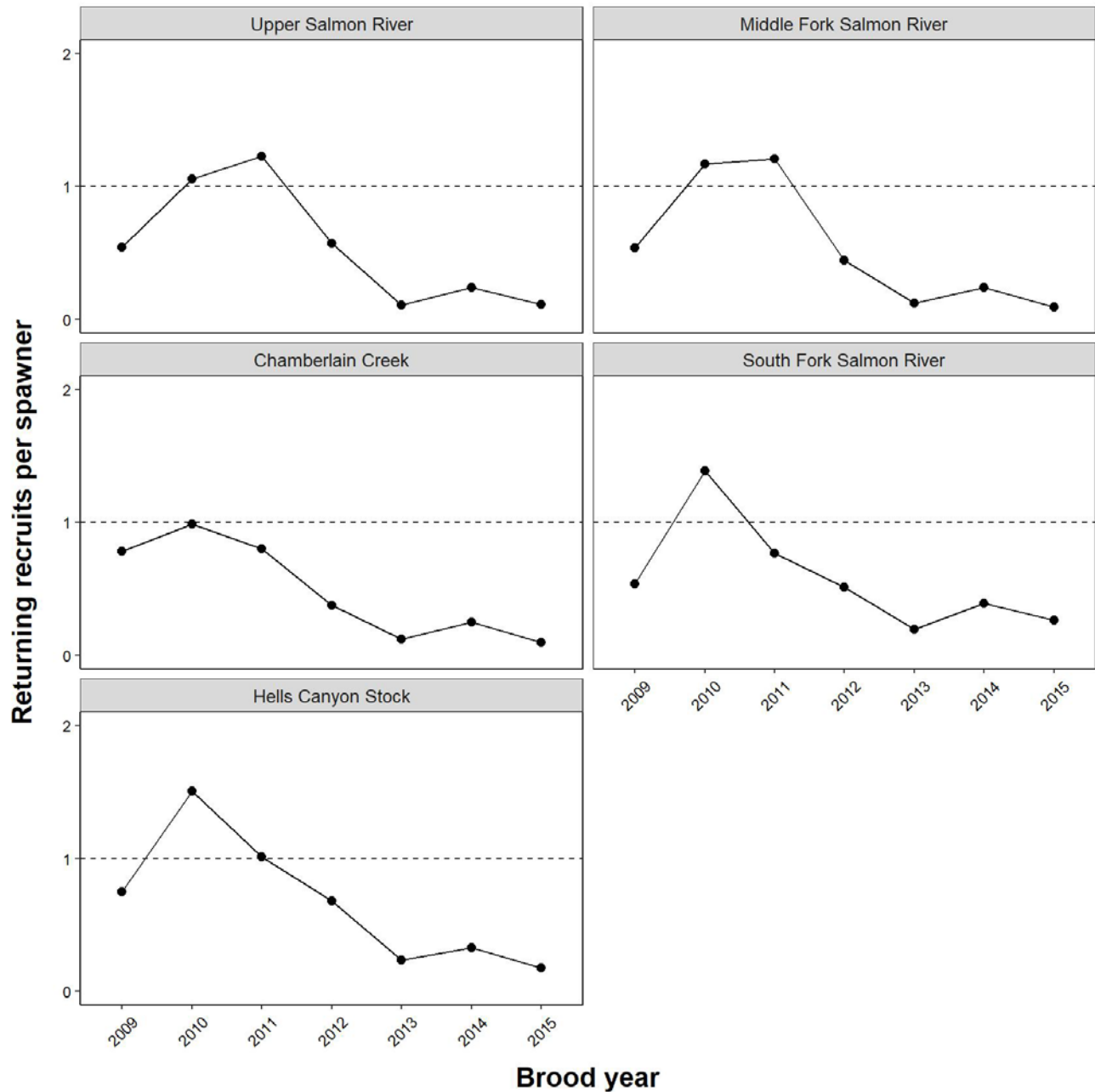


Figure 10. Adult-to-adult productivity (returning recruits per parent spawner) for each genetic stock of wild Chinook Salmon at Lower Granite Dam. The dashed line at 1.0 recruits per spawner replacement. Spawn year 2020 completed brood year 2014. Note brood year 2015 was shown for reference, but represents a preliminary result that will be completed in SY2021.

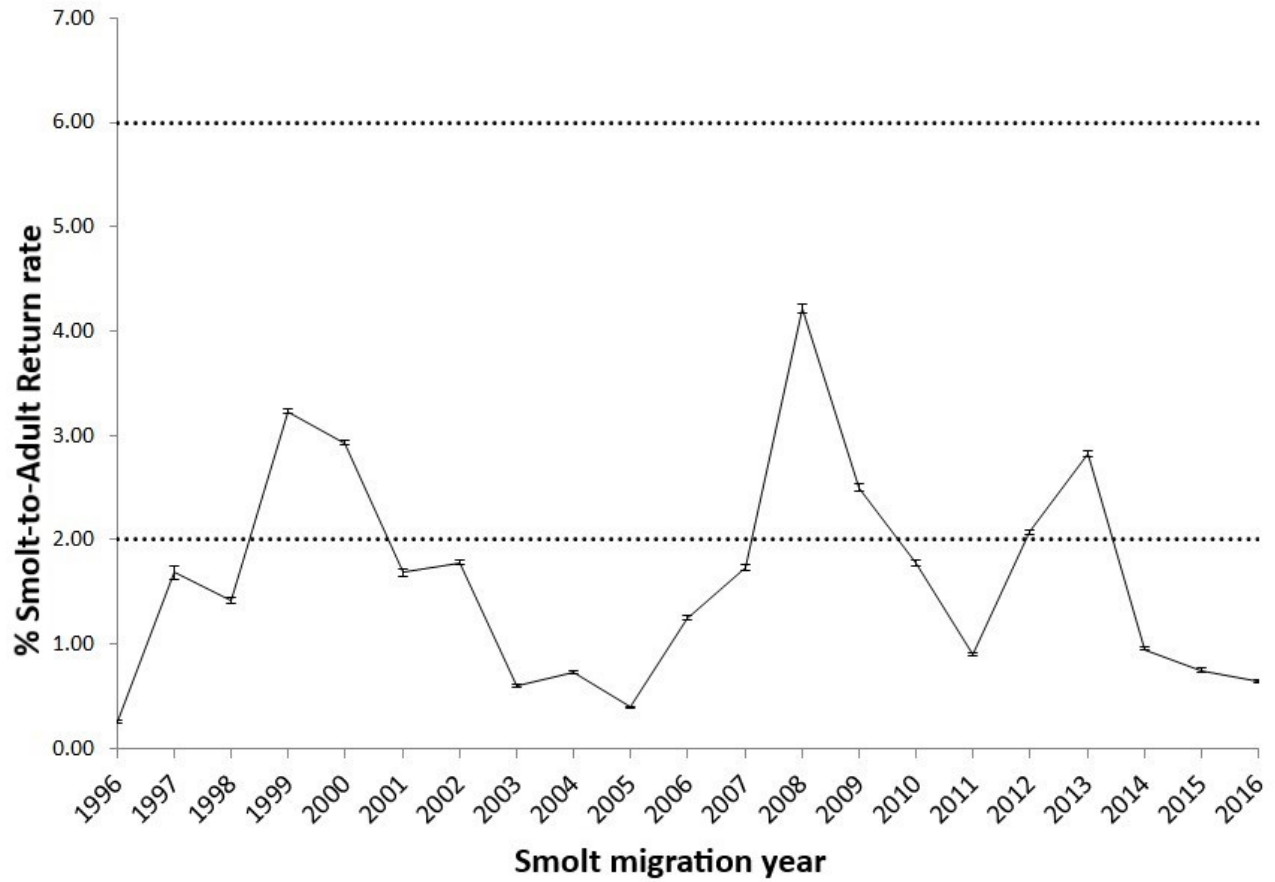


Figure 11. Estimated wild Chinook Salmon smolt-to-adult return (SAR) rate of emigrant smolts and adult returns to Lower Granite Dam. Confidence intervals are at 95%. The dashed lines represent the lower and upper range SAR objectives for wild Chinook Salmon established by the Northwest Power and Conservation Council (NPCC 2009). See Table 5 for numbers.

## **APPENDICES**

Appendix A: Annual Lower Granite Dam trapping operations, 2019–2020.



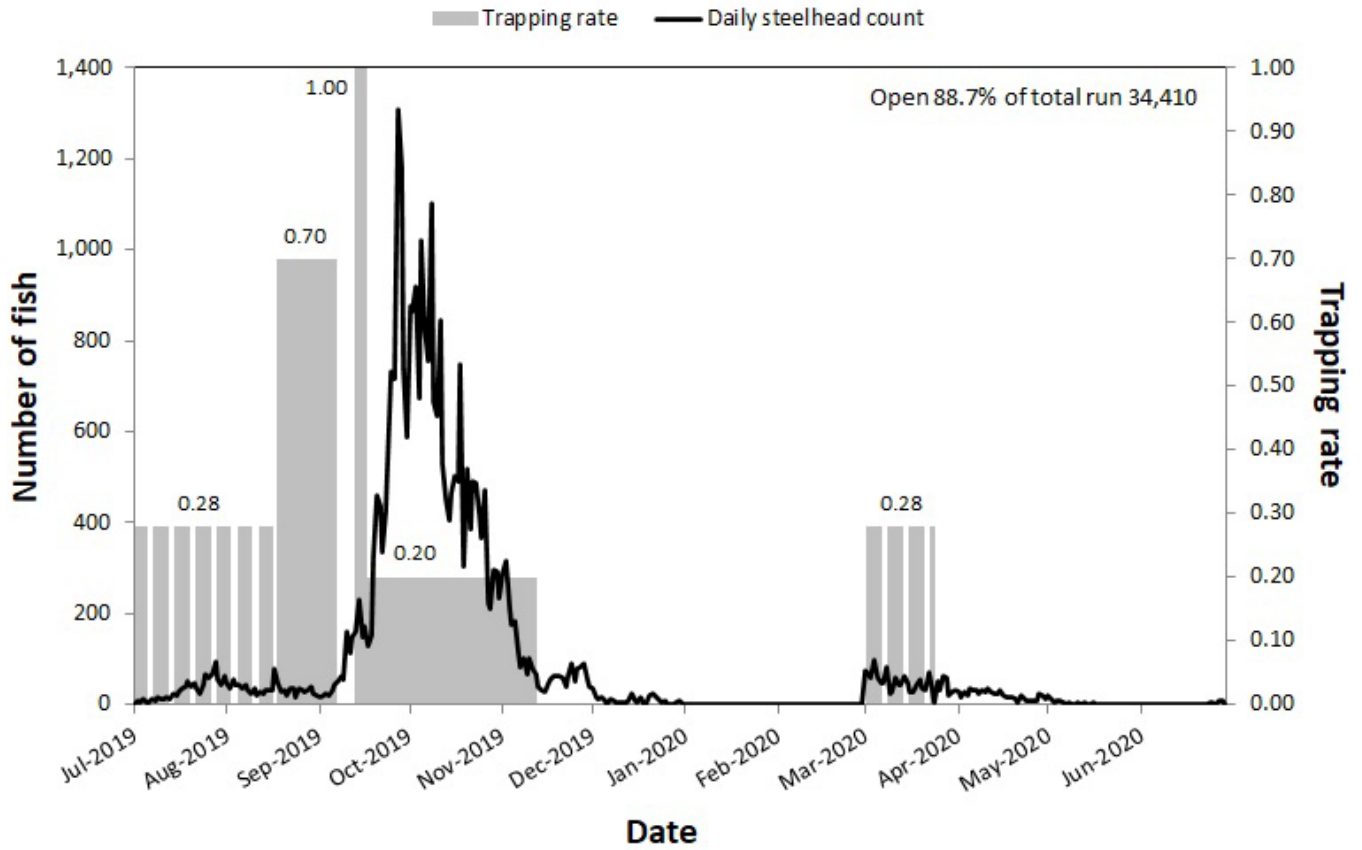
Appendix A-1. Annual Lower Granite Dam trapping operations, 2019–2020. Shaded areas were outside the 2020 spawn year (July 1, 2019 to June 30, 2020 for steelhead and March 1 to August 17, 2020 for Chinook Salmon).

Calendar date	Trap operation	Comments
<i>Calendar year 2019</i>		
January 1–April 4	Closed	Winter closure; anesthesia disposal and water supply problems
April 5–August 17	5 days/week, 28% Daily Rate	
August 18–September 6	7 days/week, 70% Daily Rate <sup>(a)</sup>	
September 7–12	Closed	Hot water closure
September 13–16	7 days/week, 100% Daily Rate <sup>(a)</sup>	
September 17–November 12	7 days/week, 20% Daily Rate	
November 13–December 31	Closed	Winter closure
<i>Calendar year 2020</i>		
January 1–March 1	Closed	Winter closure
March 2–24	5 days/week, 28% Daily Rate	
March 25–July 1	Closed <sup>(b)</sup>	COVID-19 closure
July 2–August 2	5 days/week, 28% Daily Rate	
August 3–17	5 days/week, 25% Daily Rate	
August 18–September 1	7 days/week, 80% Daily Rate <sup>(a)</sup>	
September 2–November 12	7 days/week, 18% Daily Rate	
November 13–December 31	Closed	Winter closure

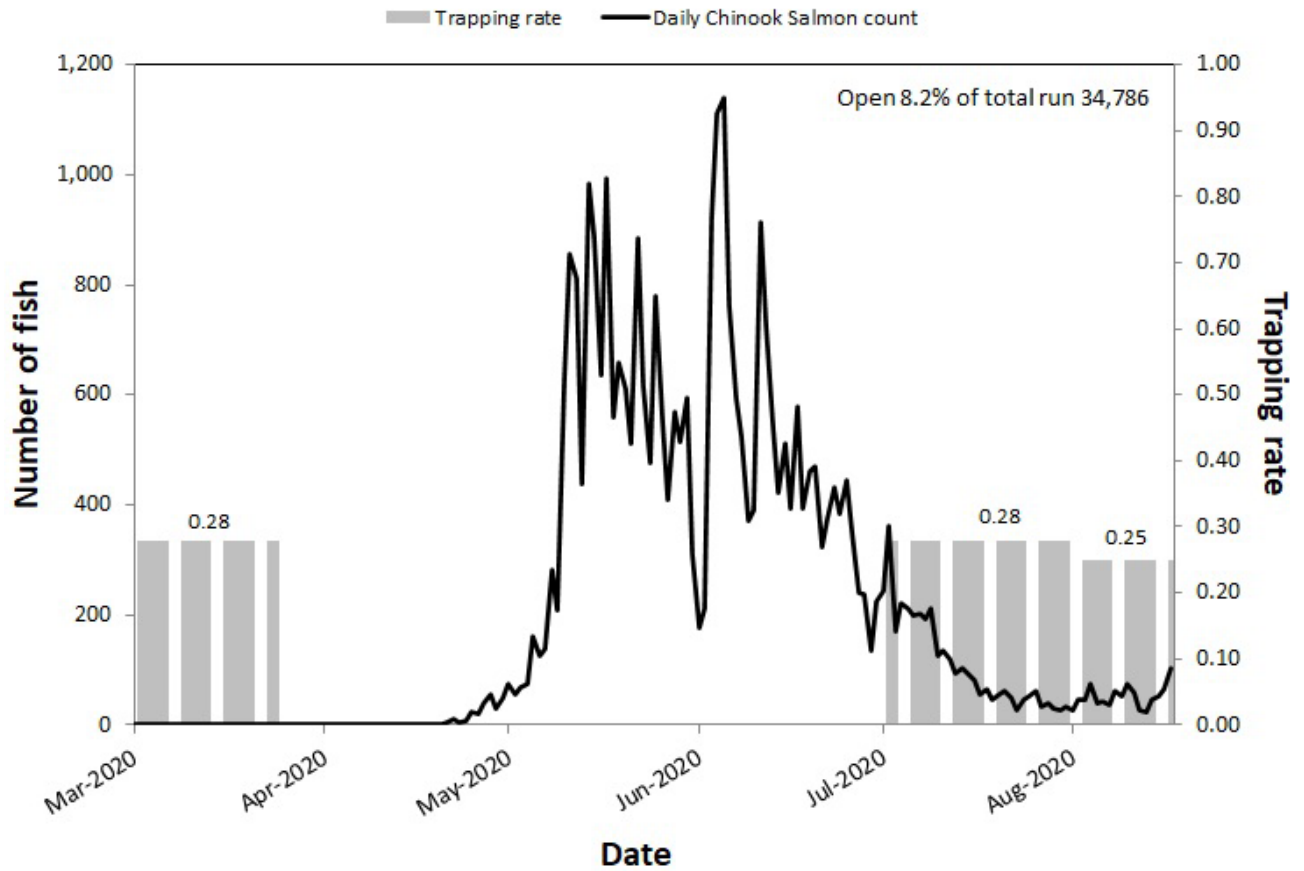
<sup>a</sup> Trap rate exceeded co-manager agreement for a trap rate maximum of 20% (7 days/week) to accommodate fall-run Chinook Salmon broodstock collection at the LGR trap.

<sup>b</sup> Trap operations were shut down due to COVID-19 safety policies.

Appendix A-2. Daily number of steelhead counted at the Lower Granite Dam window, spawn year 2020. Vertical gray bars indicate when the trap was open and daily trapping rate. 88.7% of the steelhead passed LGR when the trap was open. See Appendix A-1 and text for explanation of various trap closures.



Appendix A-3. Daily number of Chinook Salmon counted at the Lower Granite Dam window, spawn year 2020. Vertical gray bars indicate when the trap was open and daily trapping rate. 8.2% of the Chinook Salmon passed LGR when the trap was open. See Appendix A-1 and text for explanation of various trap closures.



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 2009–2020. Only fish failing to meet criteria were considered wild.

<b>If the LGR mark or tag is:</b>	<b>Then the origin at window is:</b>	<b>Then the origin at trap is:</b>	<b>And the final origin is:</b>
Adipose fin clip	Hatchery	Hatchery	Hatchery
Coded wire tag (CWT)	N/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 <sup>(a)</sup>
Passive integrated transponder (PIT)	N/A	N/A	N/A <sup>(b)</sup>

<sup>a</sup> Started in SY2011 with complete coverage by SY2013.

<sup>b</sup> Minor discrepancies occurred 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 2020. Data were summarized by weekly strata for analysis using the Salmonid Composition Bootstrap Intervals (SCOBI) method.

Time strata	Statistical week <sup>(a)</sup>	Sampling period	Number of days	Days trap open <sup>(b)</sup>	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
<i>Fall 2019</i>											
1	27A - 36	7/1 - 9/8	70	55	2,283	805	486	482	482	482	367
2	37-38	9/9 - 9/22	14	10	3,021	1,179	426	425	425	425	355
3	39	9/23 - 9/29	7	7	5,730	1,235	371	371	371	371	301
4	40	9/30 - 10/6	7	7	5,772	1,265	302	302	302	302	256
5	41	10/7 - 10/13	7	7	4,979	1,046	233	233	233	233	189
6	42	10/14 - 10/20	7	7	3,426	742	162	162	162	162	121
7	43	10/21 - 10/27	7	7	2,839	661	157	156	156	156	130
8	44	10/28 - 11/3	7	7	1,852	407	107	106	106	106	91
9	45 - 53 <sup>(c)</sup>	11/4 - 12/31	58	9	2,294	204	48	47	47	47	40
<i>Spring 2020</i>											
10	9 - 27B <sup>(c)</sup>	3/1 - 6/30	122	17	2,214	251	57	54	54	54	34
Total:			306	133	34,410	7,795	2,349	2,338	2,338	2,338	1,884

<sup>a</sup> Statistical weeks are grouped to try to provide a minimum sample size of 100 valid fish with a genotype and age.

<sup>b</sup> See Appendix A-1 for trapping operation details.

<sup>c</sup> Includes a partial week.

Appendix B: Run reconstruction methods used for spring-summer Chinook Salmon estimates, spawn year 2020.

## Appendix B-1. Methodology for spring-summer Chinook Salmon run reconstruction at Lower Granite Dam, spawn year 2020.

Unprecedented changes and interruptions to normal workflows occurred during 2020 due to COVID-19. The adult fish trap at Lower Granite Dam (LGR) was not operated during the majority of the spring-summer Chinook Salmon run and therefore biological sampling of returning fish did not occur. With a lack of sampling and genetic data, we employed the following alternative methodologies to reconstruct the spring-summer Chinook Salmon return at Lower Granite Dam for spawn year 2020. The results from this analysis are shown in Table B-1.

Window counts were obtained from the U.S. Army Corps of Engineers (USACE) for the spring and summer management periods at Lower Granite Dam. Available data included ad-clipped and ad-intact counts for adults and an aggregate count for jacks that was not separated by adipose fin status. We parsed out the window counts into finer-scale estimates using a combination of methods (Figure B-1) which are described below.

### **ADULTS**

#### **Ad-Clipped Hatchery Adults**

We estimated age-specific returns of ad-clipped hatchery (H) adults using traditional run reconstruction which is the summation of harvest + hatchery trap returns + below/above weir escapement. For hatchery trap returns, we assumed fish <83 cm FL were two-saltwater adults and fish ≥83 cm FL were three-saltwater adults. We applied the age composition of the hatchery trap returns to the harvest and escapement estimates for the same release group. We determined the composition of the entire pool of H adults using traditional run reconstruction, then applied that composition to the total ad-clipped adult window count to obtain final age- and release site-specific estimates of H adults.

#### **Ad-Intact Hatchery Adults**

Ad-intact adults were separated into wild (W) and ad-intact hatchery (HNC) adults using historic data. The composition of the total adult hatchery (H + HNC) has remained consistent from 2014–2019, so we used that information to estimate the adult HNC Chinook Salmon for SY2020. Window counts identified total number of H adults that passed LGR in 2020. The mean proportion (2014–2019) of all HNC adults (9.96%; Table B-2) was applied to the H adult count in 2020. The total number of HNC adults were estimated using the following formula:

$$\begin{aligned} HNC \text{ adults} &= \frac{H \text{ adult window count}}{1 - \% \text{ of total HNC adults}} - H \text{ adult window count} \\ HNC \text{ adults} &= \frac{19,417}{1 - 0.0996} - 19,417 \\ HNC \text{ adults} &= 2,147 \end{aligned}$$

#### **Wild Adults**

We estimated the W adult estimate by subtracting the HNC adult estimate (see above) from the total ad-intact adult window count:

$$\begin{aligned}
 W \text{ adults} &= \text{total ad intact adult window count} - \text{HNC adults} \\
 W \text{ adults} &= 10,712 - 2,147 \\
 W \text{ adults} &= 8,565
 \end{aligned}$$

The W adult estimate was parsed out to the genetic stock-level using genetic data from samples collected from 2009–2019 at LGR. We estimated stock-level escapement to LGR by multiplying the W adult estimate by the average proportion of each genetic stock from 2009–2019 (Table B-3). We separated the W adult estimate into two- and three-saltwater fish using PIT tag detections of wild adults that were PIT tagged as juveniles and were detected as adults at LGR in 2020.

## JACKS

Jacks represented the most complex group to reconstruct because the USACE window counts for jacks were not separated by adipose fin status. We applied the adult ad-clipped rate observed in 2020 based on the window count (64.4%) to the aggregate jack window count to separate ad-clipped and ad-intact jacks. Data from 2014–2019 show that the adult and jack ad-clipped rates were similar among years (Table B-2).

### Ad-Clipped Hatchery Jacks

We applied the adult ad-clipped rate based on the window count (64.4%) to the aggregate jack window count to estimate the number of ad-clipped hatchery (H) jacks using the following formula:

$$\begin{aligned}
 H \text{ jacks} &= \text{jack window count} \times \text{adult clip rate} \\
 H \text{ jacks} &= 4,657 \times 0.644 \\
 H \text{ jacks} &= 3,001
 \end{aligned}$$

### Ad-Intact Jacks

The total number of ad-intact jacks was calculated by subtracting the number of H jacks estimated above from the total jack window count:

$$\begin{aligned}
 \text{total ad intact jacks} &= \text{jack window count} - H \text{ jacks} \\
 \text{total ad intact jacks} &= 4,657 - 3,001 \\
 \text{total ad intact jacks} &= 1,656
 \end{aligned}$$

The total ad-intact jacks were separated into W and HNC jacks using previous years' data. Similar to adults, the composition of the total hatchery jacks (H + HNC) has remained consistent from 2014-2019 (Table B-2), so we used that information to estimate the number of HNC jack Chinook Salmon. We applied the proportion of all HNC jacks (12.96%) to the H jack estimate, to estimate the total number of HNC jacks using the following formula:

$$\begin{aligned}
 HNC \text{ jacks} &= \frac{H \text{ jacks}}{1 - \% \text{ of total HNC jacks}} - H \text{ jacks} \\
 HNC \text{ jacks} &= \frac{3,001}{1 - 0.1296} - 3,001 \\
 HNC \text{ jacks} &= 447
 \end{aligned}$$



### **Wild Jacks**

We calculated the W jack estimate by subtracting the HNC jack estimate (see above) from the total ad-intact jack estimate:

$$W \text{ jacks} = \text{total ad intact jacks} - \text{HNC jacks}$$

$$W \text{ jacks} = 1,656 - 447$$

$$W \text{ jacks} = 1,209$$

Table B-1. Summary of escapement estimates of spring-summer Chinook Salmon at Lower Granite Dam in spawn year 2020.

<b>Saltwater age</b>	<b>Hatchery ad-clipped</b>	<b>Hatchery ad-intact<sup>1</sup></b>	<b>Total hatchery</b>	<b>Wild<sup>2</sup></b>	<b>All returns</b>
0-saltwater	0	0	0	0	0
1-saltwater	3,001	447	3,448	1,209	4,657
2-saltwater	18,924	2,092	21,016	8,172	29,189
3-saltwater	493	55	548	393	941
4-saltwater	0	0	0	0	0
<b>Total</b>	<b>22,418</b>	<b>2,594</b>	<b>25,012</b>	<b>9,774</b>	<b>34,786</b>

<sup>1</sup> Used age composition of ad-clipped adults to parse out age of ad-intact hatchery adults.

<sup>2</sup> Used age composition from wild PIT tag detections @ LGR to parse out age of wild adults.

Table B-2. Escapement estimates of Chinook Salmon at Lower Granite Dam from spawn year 2014–2019.

Spawn year	Origin	Escapement at LGR <sup>(a)</sup>				% of HNC Chinook Salmon			Percent of total that are ad-clipped	Adult clip rate	Jack clip rate	
		Total Chinook	Adults	Jacks <sup>(b)</sup>	Un-assigned	All Chinook	Adults	Jacks				
2019	H	22,339	17,542	4,666	131	8.7%	9.6%	4.7%	75.4%	74.4%	79.2%	
2019	HNC	2,116	1,869	231	16							
2019	W	5,162	4,152	992								
2018	H	31,040	27,689	2,506	845	10.9%	10.8%	15.3%	73.5%	73.1%	72.7%	
2018	HNC	3,810	3,337	451	22							
2018	W	7,382	6,863	490								
2017	H	38,438	27,545	10,774	119	9.3%	8.5%	11.6%	79.8%	80.5%	77.9%	
2017	HNC	3,961	2,545	1,410	6							
2017	W	5,793	4,108	1,651								
2016	H	57,187	50,738	5,959	490	12.0%	11.9%	11.6%	70.0%	69.0%	79.4%	
2016	HNC	7,814	6,840	783	191							
2016	W	16,752	15,939	766								
2015	H	98,864	87,309	10,855	700	9.3%	8.6%	15.0%	74.7%	74.6%	74.0%	
2015	HNC	10,159	8,228	1,922								
2015	W	23,409	21,499	1,894								
2014	H	74,153	56,800	14,745	2,608	12.1%	10.4%	19.6%	64.7%	63.3%	66.3%	
2014	HNC	10,182	6,592	3,590								
2014	W	30,338	26,351	3,921								
Average								9.96%	12.96%		72.5%	74.9%

<sup>a</sup> See Lawry et al. 2020 for methodology used to derive these estimates.

<sup>b</sup> Jack count does not include saltwater age-0 minijacks.

Table B-3. Genetic stock proportions of entire adult Chinook Salmon wild run at Lower Granite Dam, spawn years 2009–2019. Average stock proportions were used to decompose stock-specific estimates for adult Chinook Salmon in SY2020; jacks were not included in these data.

Stock	Proportion of each genetic stock in entire adult Chinook Salmon wild run per spawn year											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Average
UPSALM	0.28	0.24	0.20	0.19	0.22	0.20	0.22	0.20	0.16	0.16	0.14	0.20
CHMBLN	0.03	0.04	0.02	0.03	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.03
MFSALM	0.19	0.24	0.17	0.18	0.17	0.20	0.22	0.15	0.12	0.16	0.12	0.17
SFSALM	0.16	0.14	0.14	0.13	0.14	0.15	0.09	0.11	0.14	0.17	0.16	0.14
HELLSC	0.31	0.31	0.42	0.43	0.40	0.39	0.42	0.43	0.40	0.44	0.44	0.40
TUCANO	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01
FALL	0.02	0.02	0.04	0.03	0.02	0.03	0.02	0.09	0.15	0.05	0.12	0.05

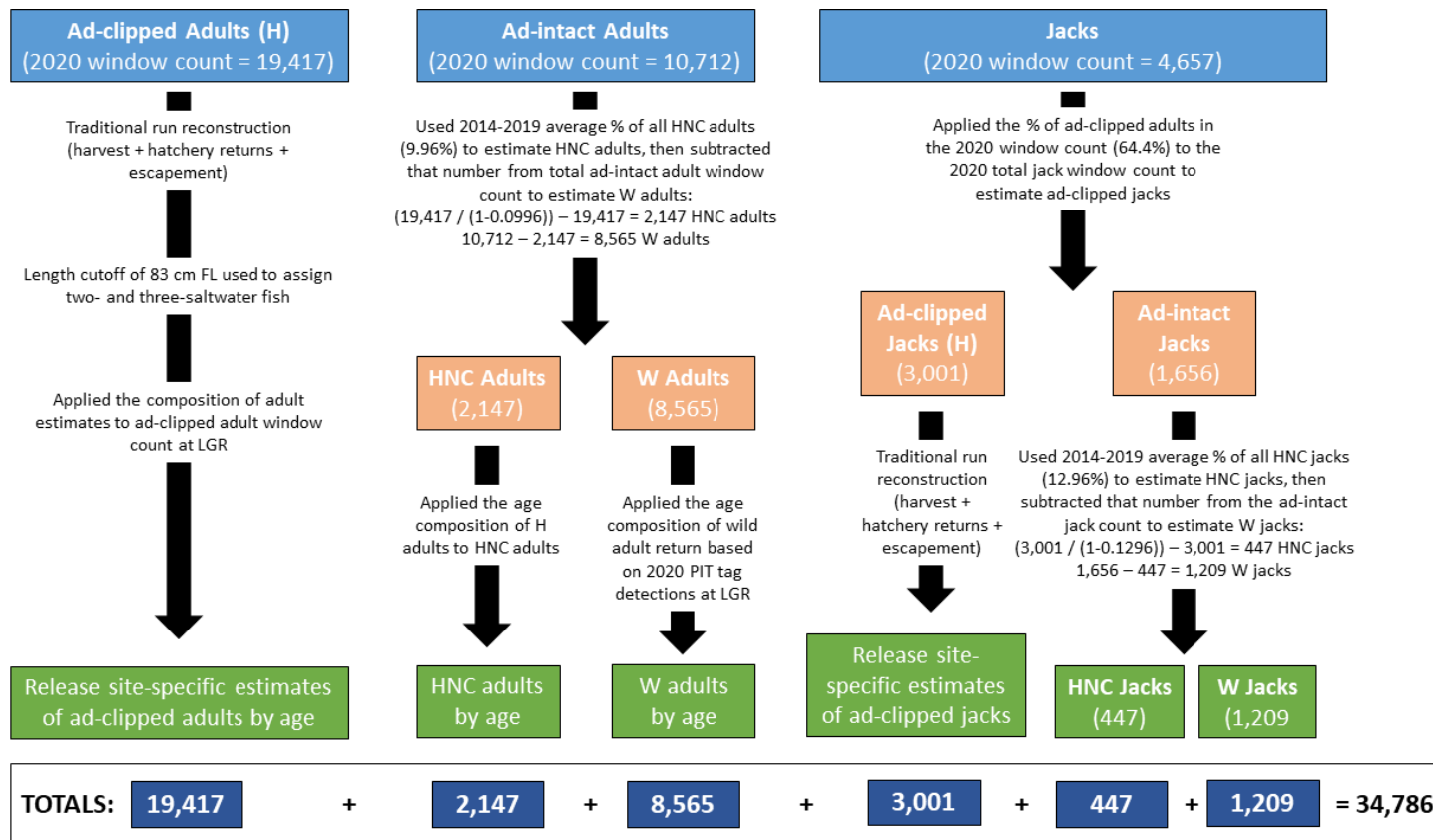
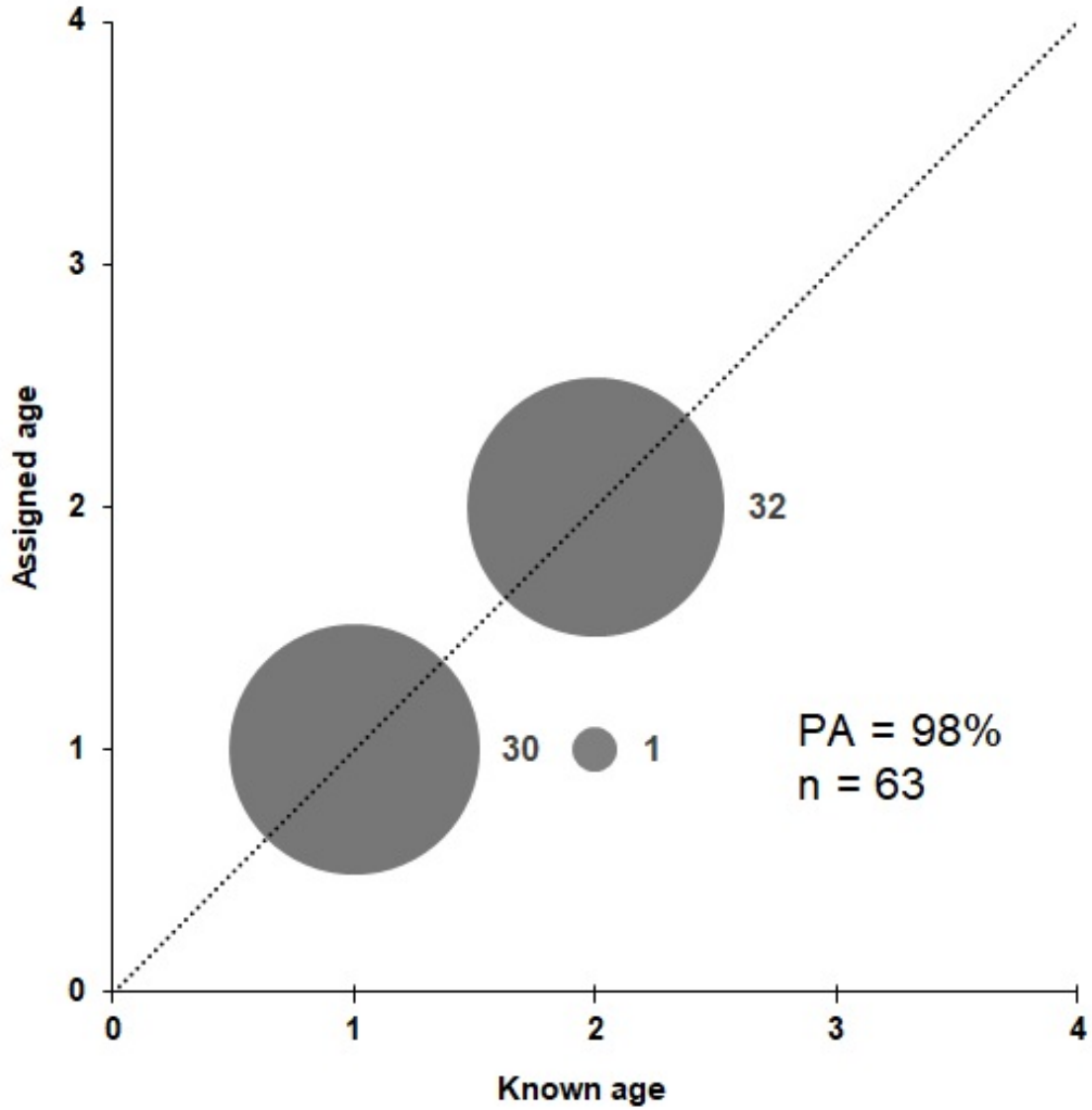


Figure B-1. Schematic describing the calculations for spring-summer Chinook Salmon run reconstruction at Lower Granite Dam in spawn year 2020.

Appendix C: Steelhead age validation.

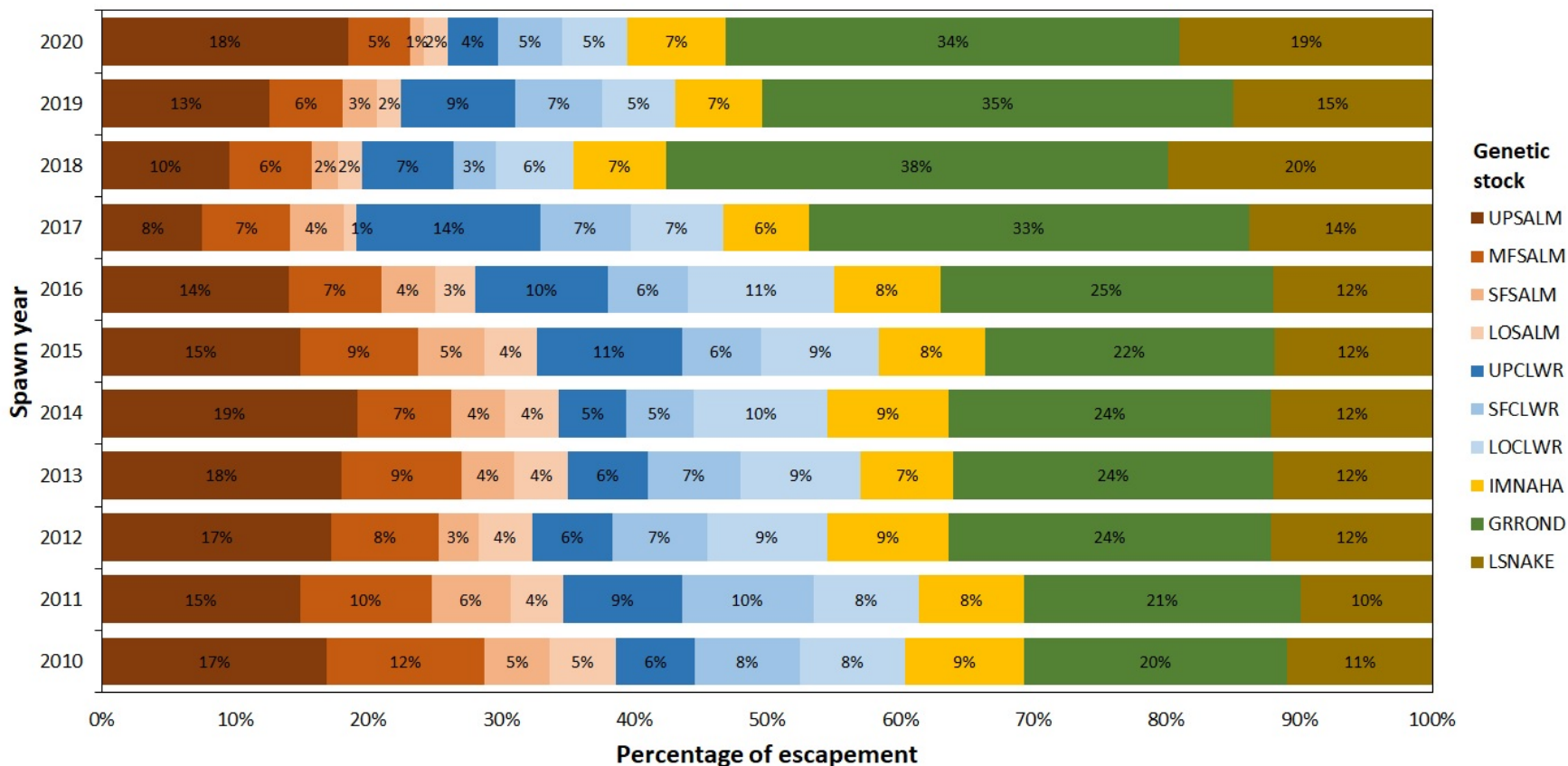
Appendix C-1. Age bias plot illustrating pairwise comparisons of scale assigned saltwater-age with known age for steelhead at Lower Granite Dam, spawn year 2020 (NRAAL, scale data; PTAGIS, PIT-tag data). Dashed line represents the 1:1 relationship. PA = percent agreement.



Appendix D: Wild steelhead at Lower Granite Dam, spawn year 2020.



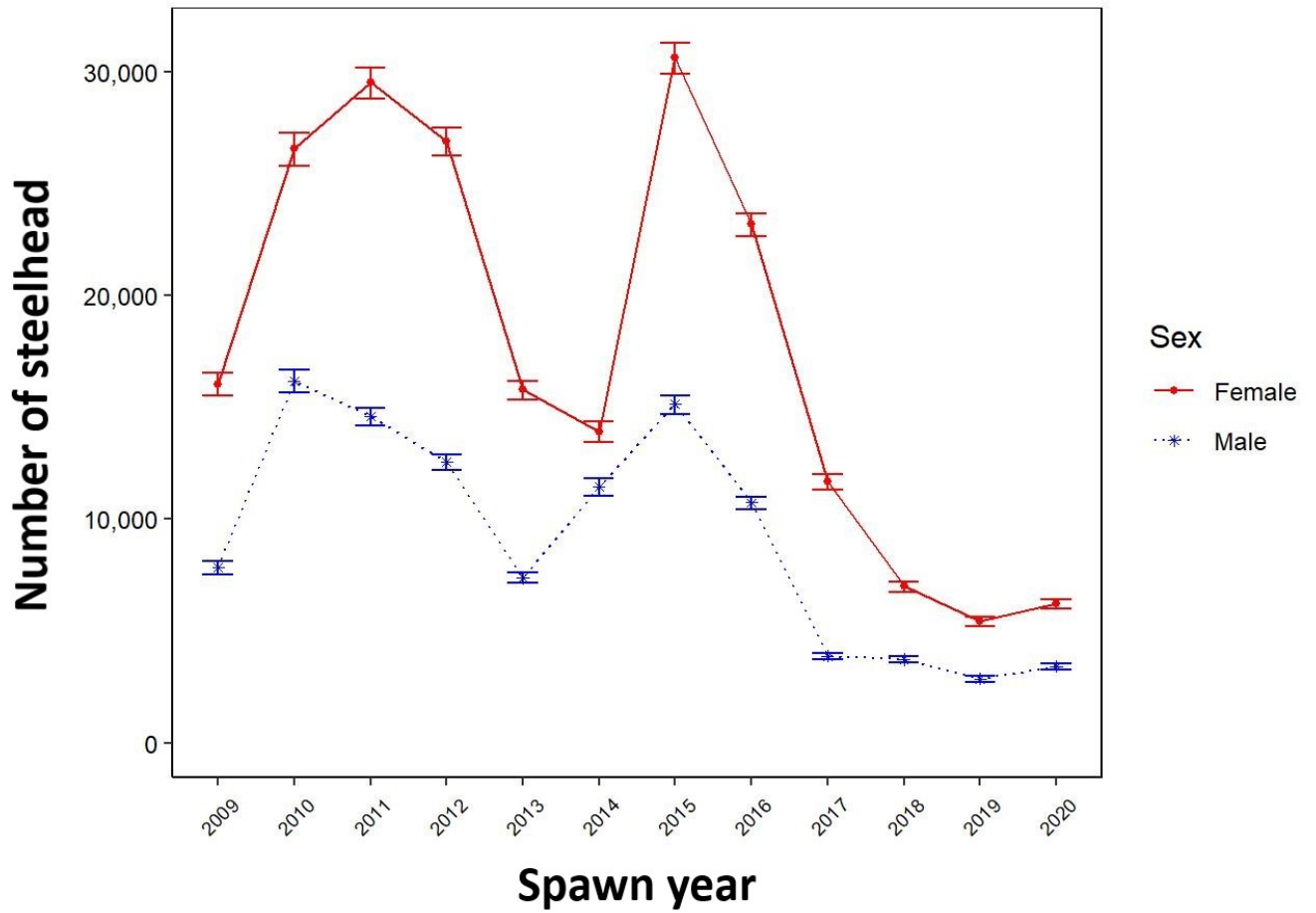
Appendix D-1. Percentage of the estimated escapement of wild steelhead by genetic stock to the overall estimated wild escapement at Lower Granite Dam, spawn years 2010–2020. See Genetic Tissue Processing and Analysis section for stock abbreviations.



Appendix D-2. Estimated escapement of wild steelhead at Lower Granite Dam by sex and by size for each genetic stock, spawn year 2020. L = lower bound and U = upper bound of 90% confidence intervals. See Genetic Tissue Processing and Analysis section 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	1,105	1,009	1,198	674	608	738	49	36	64	1,730	1,589	1,868	1,779	1,641	1,922
MFSALM	328	274	380	125	99	150	5	1	9	448	381	517	453	385	521
SFSALM	72	46	98	27	13	40	28	14	42	71	45	96	99	67	133
LOSALM	129	92	167	46	29	63	9	3	16	166	122	210	175	131	223
UPCLWR	192	151	233	171	125	218	84	62	106	279	215	341	363	292	437
SFCLWR	254	205	302	205	157	253	115	86	145	344	279	408	459	379	546
LOCLWR	336	274	394	140	110	170	28	15	42	448	374	524	476	399	555
IMNAHA	463	395	528	251	207	293	9	4	15	705	612	797	714	621	810
GRROND	2,104	1,971	2,231	1,181	1,093	1,267	40	29	51	3,245	3,046	3,435	3,285	3,088	3,481
LSNAKE	1,230	1,126	1,332	601	535	668	33	23	43	1,798	1,653	1,945	1,831	1,685	1,987
Total	6,213	5,985	6,393	3,421	3,260	3,548	400	349	442	9,234	8,930	9,500	9,634	9,337	9,933

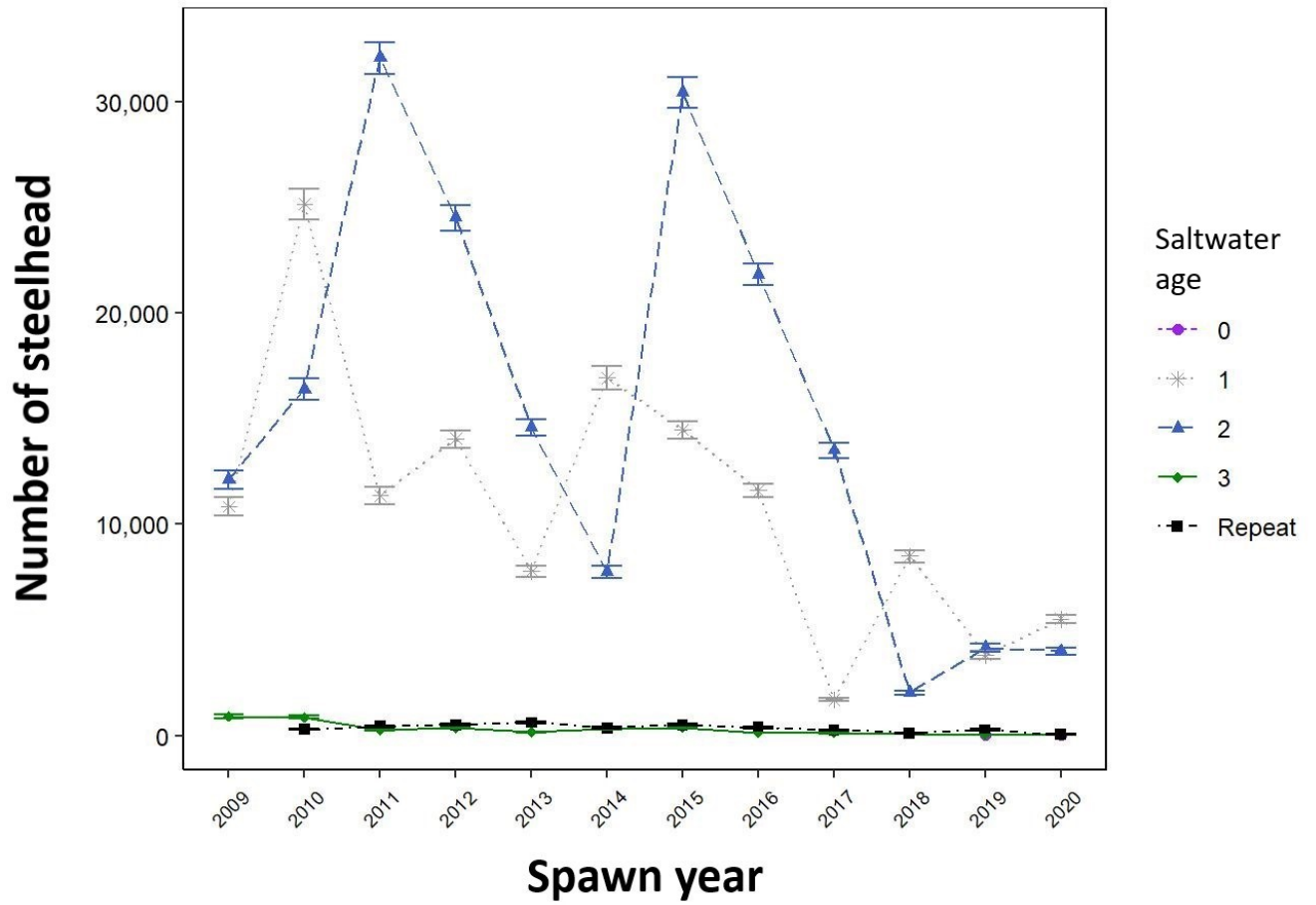
Appendix D-3. Estimated escapement by sex of wild steelhead at Lower Granite Dam, spawn years 2009–2020. Confidence intervals are at 90%.



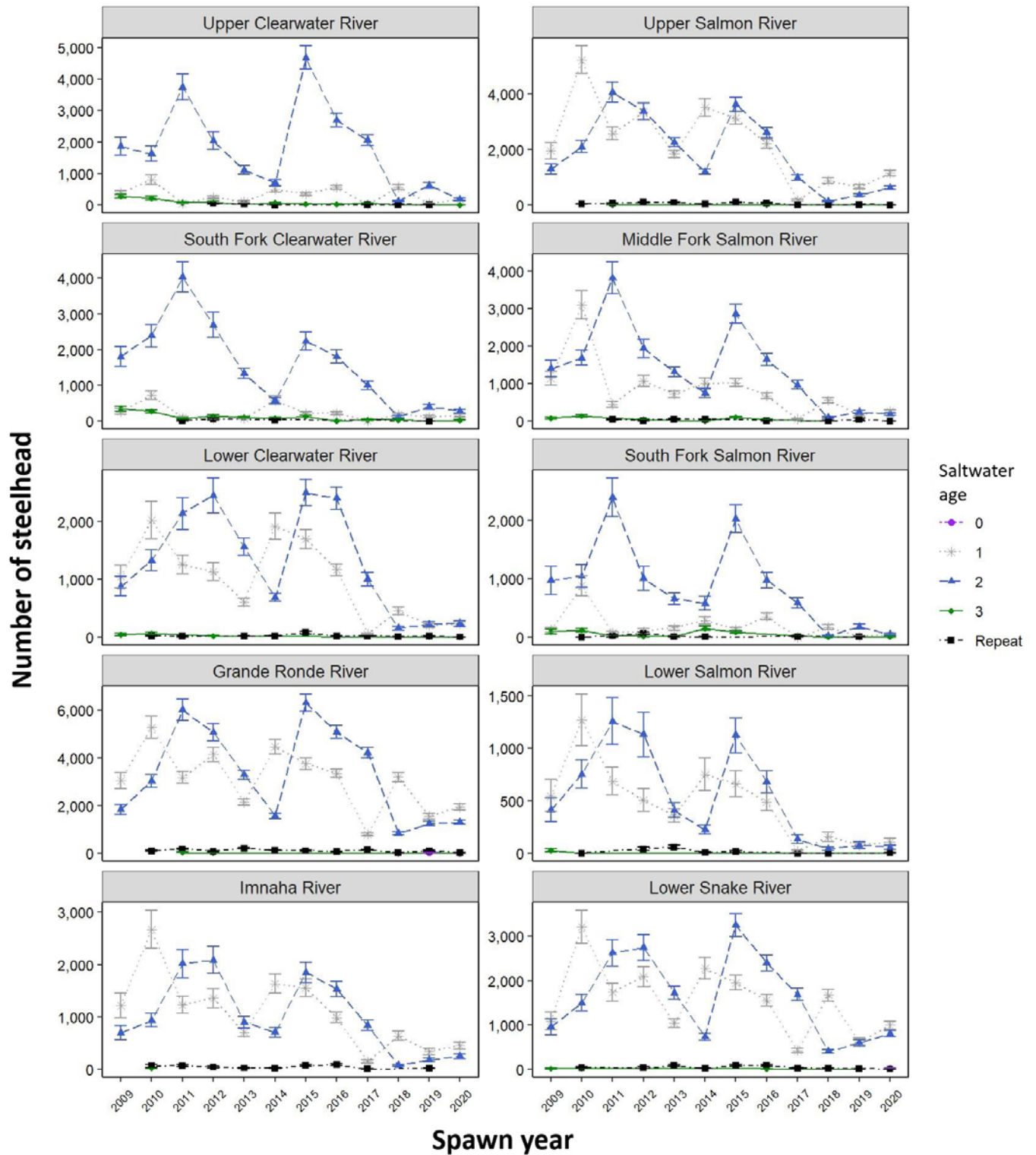
Appendix D-4. Estimated escapement of wild steelhead at Lower Granite Dam by smolt migration year (MY), brood year (BY), and age class for each genetic stock, spawn year 2020. Only individual fish that had both a total age and an assigned stock were used (n = 1,884). Age class format is European: freshwater age.saltwater age. R represents consecutive year repeat spawners who spawned two years in a row, and R1 represents skip spawners who spent one year in saltwater between spawning years. See Genetic Tissue Processing and Analysis section for stock abbreviations.

Smolt migration year (MY), brood year (BY), and age class																				
Genetic stock	MY16						MY17							MY18				MY19		Total wild
	<u>BY13</u>	<u>BY13</u>	<u>BY14</u>	<u>BY14</u>	<u>BY14</u>	<u>BY15</u>	<u>BY12</u>	<u>BY13</u>	<u>BY13</u>	<u>BY14</u>	<u>BY14</u>	<u>BY15</u>	<u>BY16</u>	<u>BY14</u>	<u>BY15</u>	<u>BY16</u>	<u>BY17</u>	<u>BY16</u>	<u>BY17</u>	
	3.1R1	3.3	2.1R1	2.2R	2.3	1.3	5.2	4.1R	4.2	3.1R	3.2	2.2	1.2	4.1	3.1	2.1	1.1	3.0	2.0	
UPSALM	4	0	0	0	5	0	0	0	9	0	126	418	71	19	413	690	24	0	0	1,779
MFSALM	0	0	0	3	0	0	5	0	13	0	124	48	0	8	217	35	0	0	0	453
SFSALM	0	5	0	0	0	0	0	0	4	0	27	20	0	0	30	13	0	0	0	99
LOSALM	0	0	0	0	5	0	0	0	0	3	14	40	5	4	38	66	0	0	0	175
UPCLWR	0	0	0	0	6	0	0	0	5	0	40	113	25	0	120	54	0	0	0	363
SFCLWR	0	5	0	0	16	6	0	0	0	0	91	154	34	0	23	105	25	0	0	459
LOCLWR	0	0	0	0	0	0	0	4	0	0	21	177	42	4	41	187	0	0	0	476
IMNAHA	0	0	0	0	0	0	0	0	11	0	72	155	16	9	152	283	16	0	0	714
GRROND	19	0	0	9	5	0	0	0	6	0	366	773	158	70	636	1,194	40	5	4	3,285
LSNAKE	0	0	6	0	0	0	0	0	6	0	205	532	67	10	323	597	65	20	0	1,831
Total	23	10	6	12	37	6	5	4	54	3	1,086	2,430	418	124	1,993	3,224	170	25	4	9,634

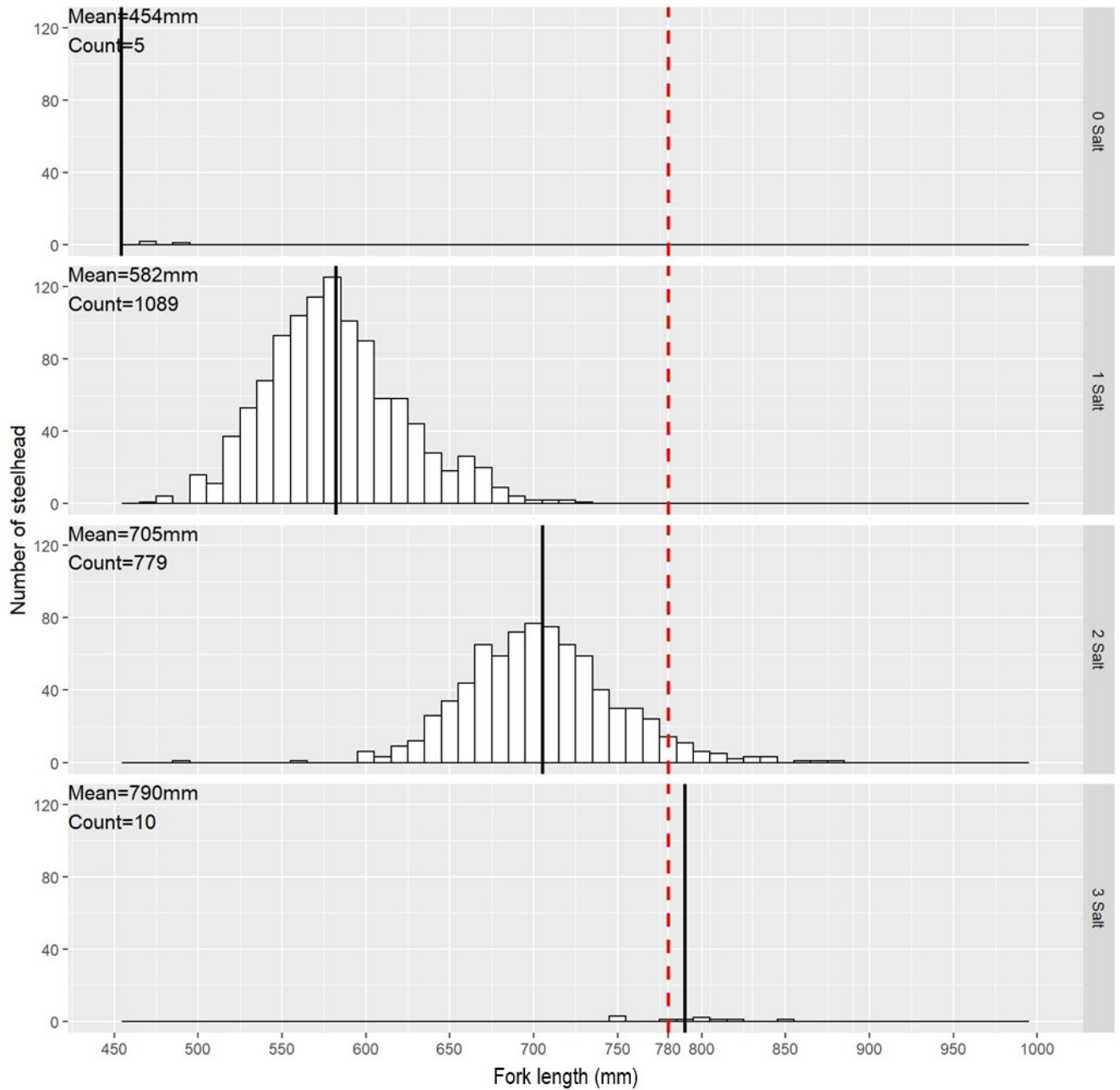
Appendix D-5. Estimated escapement by saltwater age of wild steelhead at Lower Granite Dam, spawn years 2009–2020. Confidence intervals are at 90%. Repeat refers to steelhead showing evidence of previous spawning events.



Appendix D-6. Estimated escapement by genetic stock and saltwater age of wild steelhead at Lower Granite Dam, spawn years 2009–2020. Confidence intervals are at 90%. Repeat refers to steelhead showing evidence of previous spawning events.



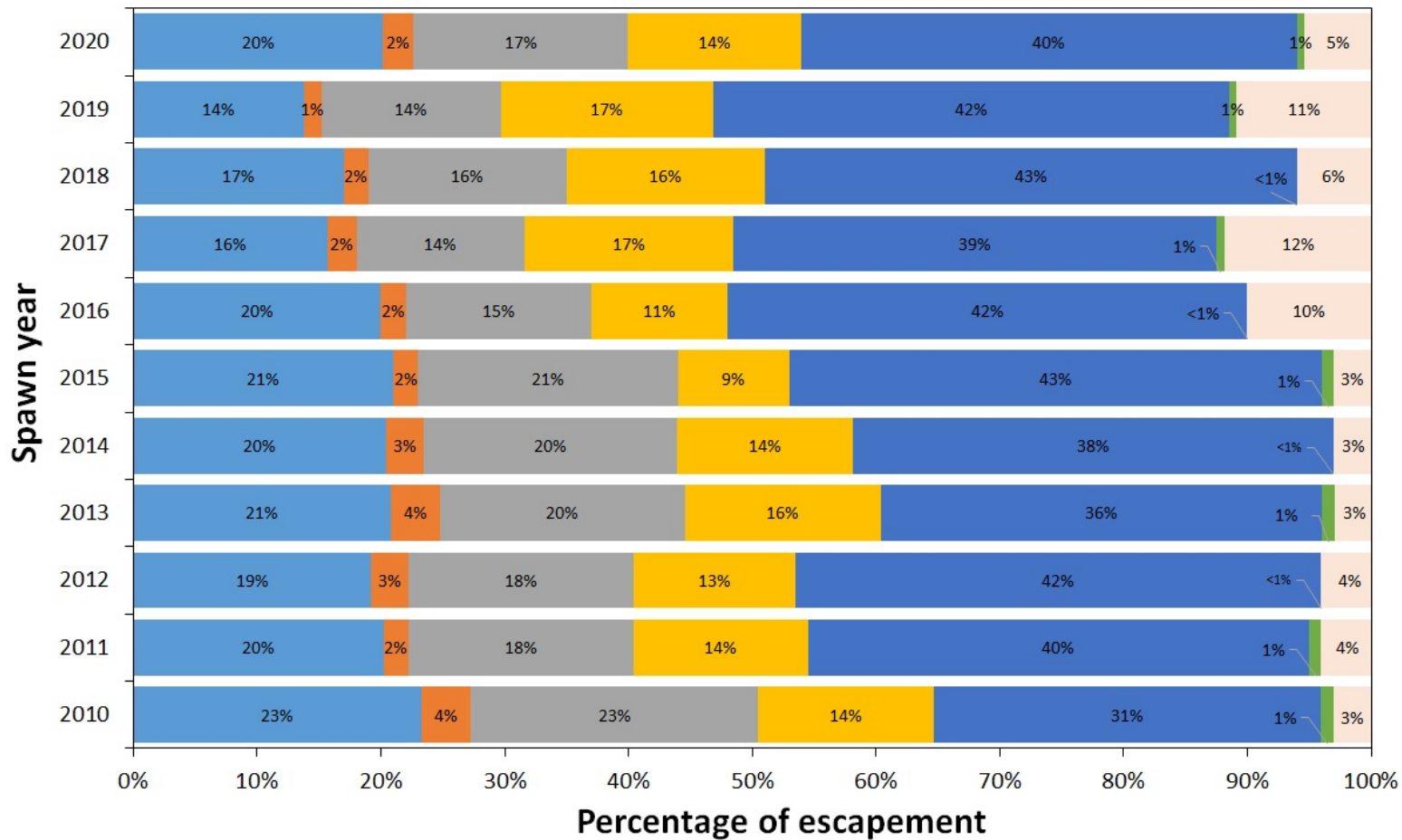
Appendix D-7. Length frequency distribution by saltwater age of wild steelhead trapped at Lower Granite Dam, spawn year 2020. Solid black vertical line represents mean fork length (FL) at saltwater age. Dashed vertical red line represents the 780 mm (FL) cutoff for determining large-sized steelhead.



Appendix E: Wild Chinook Salmon at Lower Granite Dam, spawn year 2020.



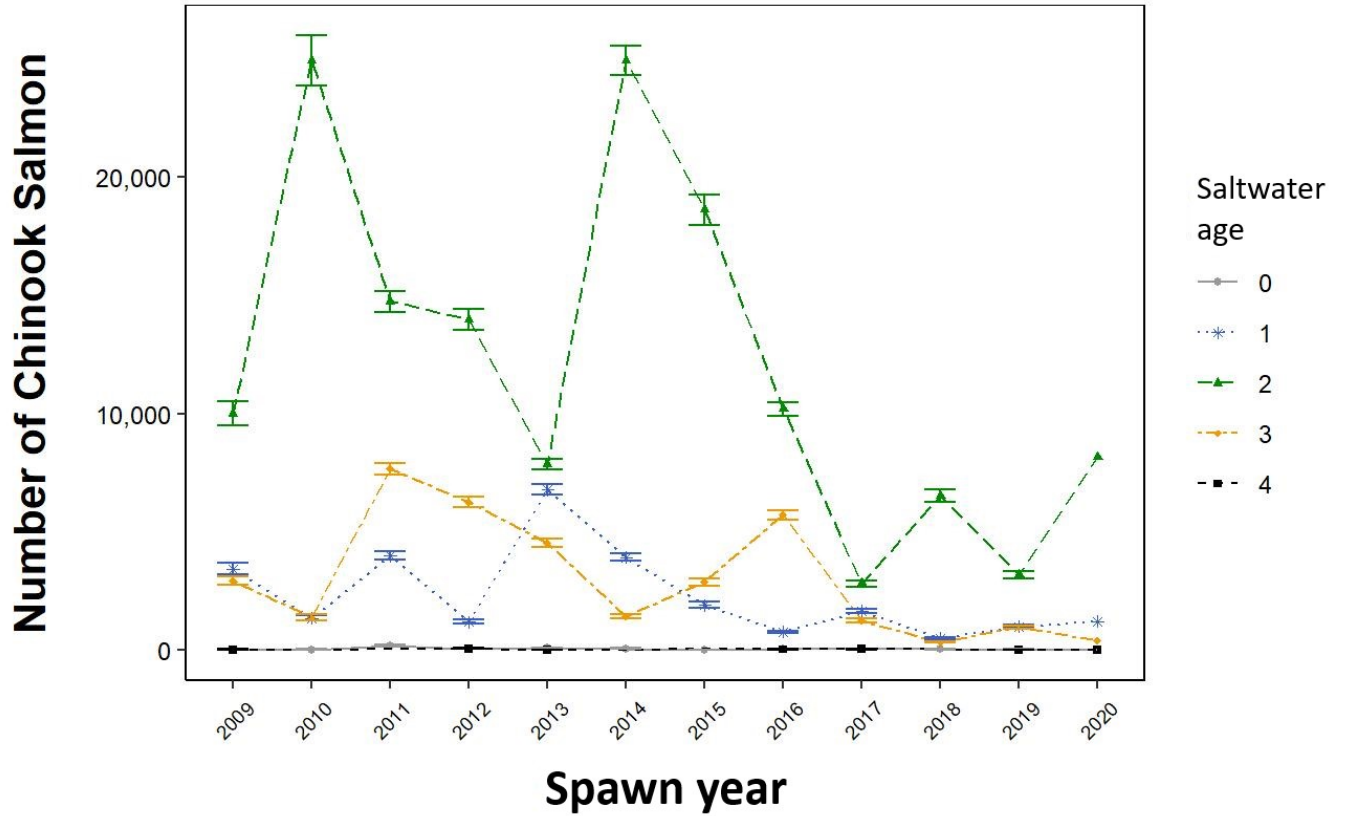
Appendix E-1. Percentage of the estimated escapement of wild Chinook Salmon by genetic stock to the overall estimated wild escapement at Lower Granite Dam, spawn years 2010–2020. Spawn year 2020 stock-specific estimates were generated using run reconstruction methods and do not include jacks in the total wild count. See Genetic Tissue Processing and Analysis section for stock abbreviations.



Appendix E-2. Estimated escapement of wild adult Chinook Salmon at Lower Granite Dam using run reconstruction and historic data, spawn year 2020. Stock-specific estimates do not include jacks. See Genetic Tissue Processing and Analysis section for stock abbreviations.

<b>Genetic stock</b>	<b>Wild adult estimate</b>
UPSALM	1,725
CHMBLN	214
MFSALM	1,486
SFSALM	1,193
HELLSC	3,438
TUCANO	50
FALL	459
Total	8,565

Appendix E-3. Estimated escapement by saltwater age of wild Chinook Salmon at Lower Granite Dam, spawn years 2009-2020. Confidence intervals, when present, are at 90%. Spawn year 2020 saltwater age estimates were generated using run reconstruction methods and do not have confidence intervals.



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