FISHERY RESEARCH

IDAHO NATURAL PRODUCTION MONITORING AND EVALUATION

ANNUAL PROGRESS REPORT
February 1, 2012—January 31, 2013

Prepared by:
Patrick Kennedy, Senior Fishery Research Biologist
Kimberly A. Apperson, Regional Fisheries Biologist
Jon Flinders, Regional Fisheries Biologist
Matthew Corsi, Regional Fisheries Biologist
June Johnson, Senior Fishery Technician
Robert Hand, Regional Fisheries Biologist
Jordan Messner, Regional Fisheries Biologist

IDFG Report Number 13-12
July 2013

IDAHO NATURAL PRODUCTION MONITORING AND EVALUATION

Project Progress Report

2012 Annual Report

Part 1—Project Overview
Part 2—Monitoring relative abundance and age composition of spring-summer Chinook salmon on the spawning grounds in Idaho
Part 3—Monitoring age composition of wild adult spring-summer Chinook salmon in the Snake River basin to estimate smolt-to-adult return rates
Part 4—The stock-recruitment relationship for wild/natural spring-summer Chinook salmon in the Snake River basin
Part 5— Wild Chinook salmon and steelhead juvenile density and spatial structure

By

Patrick Kennedy
Kimberly A. Apperson
Jon Flinders
Matthew Corsi
June Johnson
Robert Hand
Jordan Messner

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

To

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

Project Number 1991-073-00
Contract Number 59833

IDFG Report Number 13-12
July 2013

ABBREVIATIONS AND ACRONYMS

BH	Beverton-Holt
BPA	Bonneville Power Administration
BY	Brood Year
CI	Confidence Interval
COE	U.S. Army Corps of Engineers
CWT	Coded Wire Tag
DPS	Distinct Population Segment
EFSF	East Fork South Fork Salmon River
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FANR	Females Available for Natural Reproduction
FL	Fork Length
GPM	General Parr Monitoring
GSI	Genetic Stock Identification
HOR	Hatchery Origin
ICBTRT	Interior Columbia Basin Technical Recovery Team
IDFG	Idaho Department of Fish and Game
INPMEP	Idaho Natural Production Monitoring and Evaluation Project
ISMES	Idaho Steelhead Monitoring and Evaluation Studies
LGR	Lower Granite Dam
MPG	Major Population Group
NOAAF	National Oceanic and Atmospheric Administration Fisheries
NOR	Natural Origin
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
PIT	Passive Integrated Transponder
RPA	Reasonable and Prudent Alternatives
SAR	Smolt to Adult Return Rate
SY	Smolt Year
VSP	Viable Salmonid Population

TABLE OF CONTENTS

Page

ABBREVIATIONS AND ACRONYMS i
PART 1—PROJECT OVERVIEW 1
PROJECT OBJECTIVES 2
REPORT TOPICS 2
LITERATURE CITED 4
PART 2— MONITORING RELATIVE ABUNDANCE AND AGE COMPOSITION OF SPRING-SUMMER CHINOOK SALMON ON THE SPAWNING GROUNDS IN IDAHO 8
ABSTRACT 8
INTRODUCTION 9
METHODS 9
Redd Surveys 9
Carcass Surveys 10
Carcass Age Composition 10
RESULTS 11
Redd Surveys 11
Carcass Surveys 11
Carcass Age Composition 11
DISCUSSION 12
RECOMMENDATIONS 14
ACKNOWLEDGEMENTS 15
LITERATURE CITED 16
PART 3— MONITORING AGE COMPOSTION OF WILD ADULT SPRING-SUMMER CHINOOK SALMON IN THE SNAKE RIVER BASIN TO ESTIMATE SMOLT-TO-ADULT RETURN RATES 25
ABSTRACT 25
INTRODUCTION 26
METHODS 26
RESULTS 27
DISCUSSION 27
ACKNOWLEDGEMENTS 29
LITERATURE CITED 30
PART 4—THE STOCK-RECRUITMENT RELATIONSHIP FOR WILD/NATURAL SPRING-SUMMER CHINOOK SALMON IN the SNAKE RIVER BASIN 34
ABSTRACT 34
INTRODUCTION 35
METHODS 35
Females Available for Natural Reproduction 35
Stock-Recruit Model 36

Table of Contents, continued.

Page

RESULTS 37
Females Available for Natural Reproduction 37
Stock-Recruit Model 37
DISCUSSION 37
ACKNOWLEDGEMENTS 38
LITERATURE CITED 39
PART 5— WILD CHINOOK SALMON AND STEELHEAD JUVENILE DENSITY AND SPATIAL STRUCTURE 45
ABSTRACT 45
INTRODUCTION 46
METHODS 46
Core and Non-core Trend Surveys 47
Extensive Panel Surveys 48
Intensive Panel Surveys 48
Detection Probability 48
RESULTS 48
Core and Non-core Trend Surveys 49
Extensive Panel Surveys 50
Intensive Panel Surveys 51
Detection Probability 52
DISCUSSION 52
RECOMMENDATIONS 53
ACKNOWLEDGEMENTS 54
LITERATURE CITED 55
APPENDICES 78
LITERATURE CITED 91

LIST OF TABLES

Page

Table 1. Transect name and target dates for redd surveys used to index wild Chinook salmon abundance by major population group and independent population. 18

Table 2. Wild Chinook salmon redds counted in Idaho trend transects in the Salmon River and Clearwater River subbasins during the years 2009-2012 by major population group and independent population. 20

Table 3. Brood year and age class frequencies of wild Chinook salmon carcasses sampled from Idaho spawning grounds during 2012. Freshwater age was assumed to be one year. Frequencies of all carcasses, hatchery origin (HOR) and natural origin (NOR), recovered during surveys, from the BioSamples database and the Spawning Ground Survey database are summed. 21

Table 4. Mean length (cm) for wild Chinook salmon by ocean-age, major population group, and spawn year. Confidence intervals (alpha = 0.95) are given in parentheses. 24

Table 5. Escapement, aging method used, and ocean age proportion of wild Chinook salmon at Lower Granite Dam by adult return year 1998-2012. 32

Table 6. Estimated number of wild Chinook salmon smolts at Lower Granite Dam, number of adults at Lower Granite Dam by ocean-age, and percent smolt-to-adult return rate (SAR). 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 2005-2012 (below the dashed line). SAR confidence intervals are at 95% and are given in parentheses. 33

Table 7. Estimated adult Chinook salmon females available for natural reproduction (FANR) for 2012, estimated from percentage of females based on hatchery sex ratios applied to the total run at Lower Granite Dam, and accounting for adult females removed by harvest and at hatchery weirs. Harvest was increased by 10% to account for incidental hooking mortality. 42

Table 8. Abundance of Snake River spring-summer Chinook salmon females available for natural reproduction (FANR), and the number of wild smolts estimated at Lower Granite Dam by brood year and smolt year used to construct the Beverton-Holt stock-recruit model. The result of the model estimated the number of smolts-per-female over the 21 year time series. 42

Table 9. Candidate hypotheses explaining density dependence observed in smolt production of Snake River spring-summer Chinook salmon populations during 1990-2012. 43

Table 10. IDFG core trend snorkel survey transects ($n = 218$) by Snake River steelhead major and independent population. 57

Table 11. Densities (fish/100 m^2) of salmonids observed at core trend transects snorkeled in the Salmon River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. 61

List of Tables, continued.

Page

Table 12. Densities (fish/100 m^2) of salmonids observed at non-core trend transects snorkeled in the Salmon River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. 63

Table 13. Densities (fish/100 m^2) of salmonids observed at core trend transects snorkeled in the Clearwater River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. 64

Table 14. Densities (fish/100 m^2) of salmonids observed at non-core trend transects snorkeled in the Clearwater River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. 66

Table 15. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Potlatch River drainage in the Clearwater lower main-stem steelhead population, from May 25 to July 11, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 67

Table 16. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the South Fork Clearwater River drainage in the Clearwater River steelhead population, June 24-26 and July 6-10, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 69

Table 17. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Camas Creek Drainage in the Middle Fork Salmon River steelhead population, July 6 to August 7, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 70

Table 18. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Rapid River drainage in the lower main-stem Salmon River steelhead population, August 1 to August 8, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 71

Table 19. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Upper Middle Fork Salmon River Drainage in the Middle Fork Salmon River steelhead population, July 10 to August 20, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 72

Table 20. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Crooked Fork Creek drainage, in the Lochsa River steelhead population, July 19-25, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 73

List of Tables, continued.

Page

Table 21. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Crooked River drainage in the South Fork Clearwater steelhead population, July 5-12, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.....74

Table 22. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Fish Creek drainage in the South Fork Clearwater steelhead population from July 18-25, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.....75

Table 23. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Marsh Creek drainage in the Middle Fork Salmon upper main-stem steelhead population from July 18-24, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species. 76

Table 24. Steelhead trout detection probabilities from mark-resight studies in 2012. Fish were marked with an upper caudal clip in the main transect and resighted during a subsequent snorkel survey. Asterisks indicate that juvenile cutthroat trout were included in the number marked.....77

LIST OF FIGURES

Page

Figure 1. Spring-summer Chinook salmon populations and major population groups (MPGs) in the Snake River evolutionary significant unit (ESU).....6

Figure 2. Summer steelhead populations and major population groups (MPGs) in the Snake River distinct population segment (DPS). 7

Figure 3. Spawning ground survey locations where wild Snake River spring-summer Chinook salmon carcasses were collected in 2012. 22

Figure 4. Length distribution by ocean-age of wild Snake River spring-summer Chinook salmon carcasses collected on the spawning grounds in 2012. Ages were determined from fin ray analysis (*n* = 1,399).....23

Figure 5. Comparison of observed smolt abundance at Lower Granite Dam and females available for natural reproduction for brood years 1990-2010, to model predictions in 2011 and 2012 from the Snake River spring-summer Chinook salmon Beverton-Holt stock-recruit model. 44

LIST OF APPENDICES

Appendix A. Data Used to Calculate Wild Adult Snake River Spring-Summer Chinook Salmon Age Proportions at Lower Granite Dam from 1998-2004.....79

Appendix B. Data Collected By INPMEP During 2012 Relevant To VSP Criteria 93

Appendix C. Other Project Accomplishments 95

PART 1—PROJECT OVERVIEW

Populations of Chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *O. mykiss* 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 then 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. The increase has been dominated by hatchery fish, while the returns of naturally produced Chinook salmon and steelhead trout remain critically low. As a result, Snake River spring-summer Chinook salmon (hereafter Chinook salmon) was classified as threatened in 1992 under the Endangered Species Act (ESA). Within the Snake River spring-summer Chinook salmon evolutionarily significant unit (ESU; Figure 1), there are seven major population groups (MPGs): Lower Snake River, Grande Ronde/Imnaha Rivers, South Fork Salmon River, Middle Fork Salmon River, Upper Salmon River, Dry Clearwater River, and the Wet Clearwater River. However, the Dry Clearwater River and the Wet Clearwater River MPGs are considered to have been extirpated and re-established with stocks from other MPGs. A total of 28 extant demographically independent populations have been identified. Snake River steelhead trout (hereafter steelhead) was classified as threatened under the ESA in 1997. Within the Snake River steelhead distinct population segment (DPS; Figure 2), there are six MPGs: Lower Snake River, Grande Ronde River, Imnaha River, Clearwater River, Salmon River, and Hells Canyon Tributaries (ICBTRT 2003, 2005; NMFS 2011). The Hells Canyon MPG is considered to have been extirpated. A total of 24 extant populations have been identified.

The purpose of the Idaho Natural Production Monitoring and Evaluation Project (INPMEP) is to provide information for monitoring the status of Idaho's wild Chinook salmon and steelhead populations with respect to the viable salmonid population (VSP) criteria defined by McElhany et al. (2000). In the 1950s, IDFG developed a program to index annual spawning escapement by enumerating Chinook salmon redds in selected areas with the intent to describe population trends over time. The total area and number of streams surveyed represents a large portion of wild Chinook salmon spawning habitat in Idaho (Hassemer 1993a). The number of redds counted in these areas provide an index of the annual wild adult Chinook salmon spawner abundance at the independent population scale (see ICBTRT 2003 for population delineations). For adult Chinook salmon, 2012 data were collected in selected spawning tributaries in the Clearwater River and Salmon River subbasins to describe population-specific abundance, productivity, spatial structure, and diversity. For juvenile Chinook salmon and steelhead, we assessed spatial structure and productivity during 2012.

The INPMEP monitors the Idaho portion of the Snake River spring-summer Chinook salmon ESU (hereafter the aggregate) above LGR. The aggregate escapement of Snake River Chinook salmon and steelhead is measured at LGR, with the exception of the Tucannon River, Washington, population. Some wild fish are migrating to Washington or Oregon tributaries to spawn, but the majority is destined for Idaho. Age data collected at LGR are used to assign returning adults to specific brood years (BYs), for cohort analysis, and to estimate productivity and survival rates (Copeland et al. 2007, 2009, 2011, 2012; Copeland and Putnam 2009; Copeland and Roberts 2010; Kennedy et al. 2011, 2012; Schrader et al. 2011, 2012). 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. Escapement and composition of wild spring/summer Chinook salmon at LGR are

detailed in a separate report (Schrader et al. in preparation). Here, we report the aggregate stock-recruit model, methods which are unchanged from past reports. Also, we provide a final version of aggregate Chinook salmon age composition at LGR for estimating smolt-to-adult survival return rates.

Information presented in this report is summarized according to the VSP criteria mentioned above. The data reported will be population-specific where possible. Population-specific redd survey data were added in the 2010 proposal to address the Reasonable and Prudent Alternatives (RPAs) 50 and 63, defined in the 2008 Federal Columbia River Power System Biological Opinion (http://www.nwr.noaa.gov/hydropower/fcrps_opinion/federal_columbia_river_power_system.html). We address RPA 50 to produce data relevant to Chinook salmon and steelhead population status assessments and will also provide data on hatchery fraction for Chinook salmon carcasses recovered on the spawning grounds. The fraction of hatchery Chinook salmon contributing to natural spawning is relevant to RPA 63.

PROJECT OBJECTIVES

Project tasks are grouped into four objectives. The purpose of each objective involves enumerating or describing individuals within the various life stages of wild Chinook salmon and steelhead. By understanding the transitions between life stages and associated controlling factors, we hope to achieve a mechanistic understanding of stock-specific population dynamics that will aide mitigation and population recovery efforts.

Objective 1. Estimate 2012 adult abundance and composition of returning wild adult Chinook salmon passing LGR. In collaboration with the Chinook and Steelhead Genotyping for Genetic Stock Identification (GSI) at Lower Granite Dam (Bonneville Power Administration [BPA] project #2010-026-00), we will decompose the aggregate estimates into major population groups and, in some cases, populations. Over time, productivity will be assessed. These results are reported in a separate document (Schrader et al. in preparation).

Objective 2. Estimate population-specific abundance, hatchery fraction, and composition of wild Chinook salmon from information obtained on the spawning grounds in the Salmon River and Clearwater River subbasins.

Objective 3. Estimate lifecycle survival and the freshwater productivity of the Snake River Chinook salmon ESU. There are two components: update and refine a stock-recruit model and estimate aggregate smolt-to-adult survival rates.

Objective 4. Estimate the distribution and abundance of wild Chinook salmon and steelhead parr in tributaries of the Salmon River and Clearwater River subbasins in coordination with the Idaho Steelhead Monitoring and Evaluation Studies (ISMES; BPA project #1990-055-00). Estimate spatial structure and productivity.

REPORT TOPICS

In this annual progress report, we present technical results for work conducted during 2012. Part 2 contains results collated from Chinook salmon spawning ground surveys, including the number of redds counted in trend monitoring transects and the ages and production type of

Chinook salmon carcasses (Objective 2). Part 3 contains detailed results from aging wild Chinook salmon from Lower Granite Dam and the estimation of smolt-to-adult return rates for the Snake River ESU (Objective 3). A one-time reporting of the data used to generate the aggregate age composition for adult return years 1996-2004 is included in Appendix A. Part 4 is a report on the ongoing development of a stock-recruit model for the freshwater phase of wild Chinook salmon in the Snake River ESU (Objective 3). Part 5 is a summary of the parr density and juvenile salmonid spatial structure data collected in 2012 (Objective 4). In Appendix B, we summarize the data collected during 2012 that are applicable to the VSP criteria (McElhany et al. 2000) for each spring-summer Chinook salmon (Table B-1) and steelhead population (Table B-2) in Idaho. Finally, other project accomplishments during 2012 (e.g., professional presentations) are also summarized in Appendix C.

LITERATURE CITED

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Wauneta, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27.

Copeland, T., J. Johnson, S. Kraft, and P. R. Bunn. 2007. Idaho natural production monitoring and evaluation, 2006 annual report. Idaho Department of Fish and Game Report 07-31. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, K. A. Apperson, J. M. Flinders, and R. Hand. 2009. Idaho natural production monitoring and evaluation project. Idaho Department of Fish and Game Report 09-06. 2008 annual report to the U.S. Department of Energy, Bonneville Power Administration. Contract 36423, Project 199107300. Idaho Department of Fish and Game, Boise.

Copeland, T., and S. Putnam. 2009. Idaho steelhead monitoring and evaluation studies. Idaho Department of Fish and Game Report 09-05. Annual report 2008, BPA Project 1990-055-00.

Copeland, T., and R. V. Roberts. 2010. Idaho steelhead monitoring and evaluation studies. Idaho Department of Fish and Game Report 10-08. Annual report 2009, BPA Project 1990-055-00.

Copeland, T., R. V. Roberts, and K. A. Apperson. 2011. Idaho steelhead monitoring and evaluation studies. Idaho Department of Fish and Game Report 11-09. Annual report 2010, BPA Project 1990-055-00.

Copeland, T., R. V. Roberts, and K. A. Apperson. 2012. Idaho steelhead monitoring and evaluation studies. Idaho Department of Fish and Game Report 12-04. Annual report 2011, BPA Project 1990-055-00.

Hassemer, P. 1993a. Salmon spawning ground surveys, 1989-1992. Idaho Department of Fish and Game. Project F-73-R-15. Pacific Salmon Treaty Program Award No. NA17FP0168-02. 32 p. plus appendices.

ICBTRT (Interior Columbia Basin Technical Recovery Team). 2003. Independent populations of Chinook, steelhead, and sockeye for listed Columbia basin ESUs. ICBTRT draft report July 2003.

ICBTRT (Interior Columbia Basin Technical Recovery Team). 2005. Updated population delineation in the interior Columbia basin. Memo to NMFS Northwest Regional Office May 11, 2005.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, and R. Hand. 2011. Idaho Natural Production Monitoring and Evaluation, 2009-2010 annual progress report. Idaho Department of Fish and Game Report 11-23. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand, and M. Corsi. 2012. Idaho Natural Production Monitoring and Evaluation, 2011 annual progress report. Idaho Department of Fish and Game Report 12-18. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonids populations and the recovery of evolutionarily significant units. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-42.

NMFS (National Marine Fisheries Service). 2011. Five-year review: summary and evaluation of Snake River sockeye, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River basin steelhead. NMFS, Northwest Region.

Raymond, H. L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer Chinook salmon and steelhead in the Columba River basin. North American Journal of Fisheries Management 8:1-24.

Schrader, W. C., T. Copeland, M. W. Ackerman, K. Ellsworth, and M. R. Campbell. 2011. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, spawn year 2009. Idaho Department of Fish and Game Report 11-24. Annual report 2009, BPA Projects 1990-055-00, 1991-073-00, 2010-026-00.

Schrader, W. C., T. Copeland, P. Kennedy, M. W. Ackerman, K. K. Wright, and M. R. Campbell. 2012. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, spawn year 2010. Idaho Department of Fish and Game Report 12-16. Annual report 2010, BPA Projects 1990-055-00, 1991-073-00, 2010-026-00.

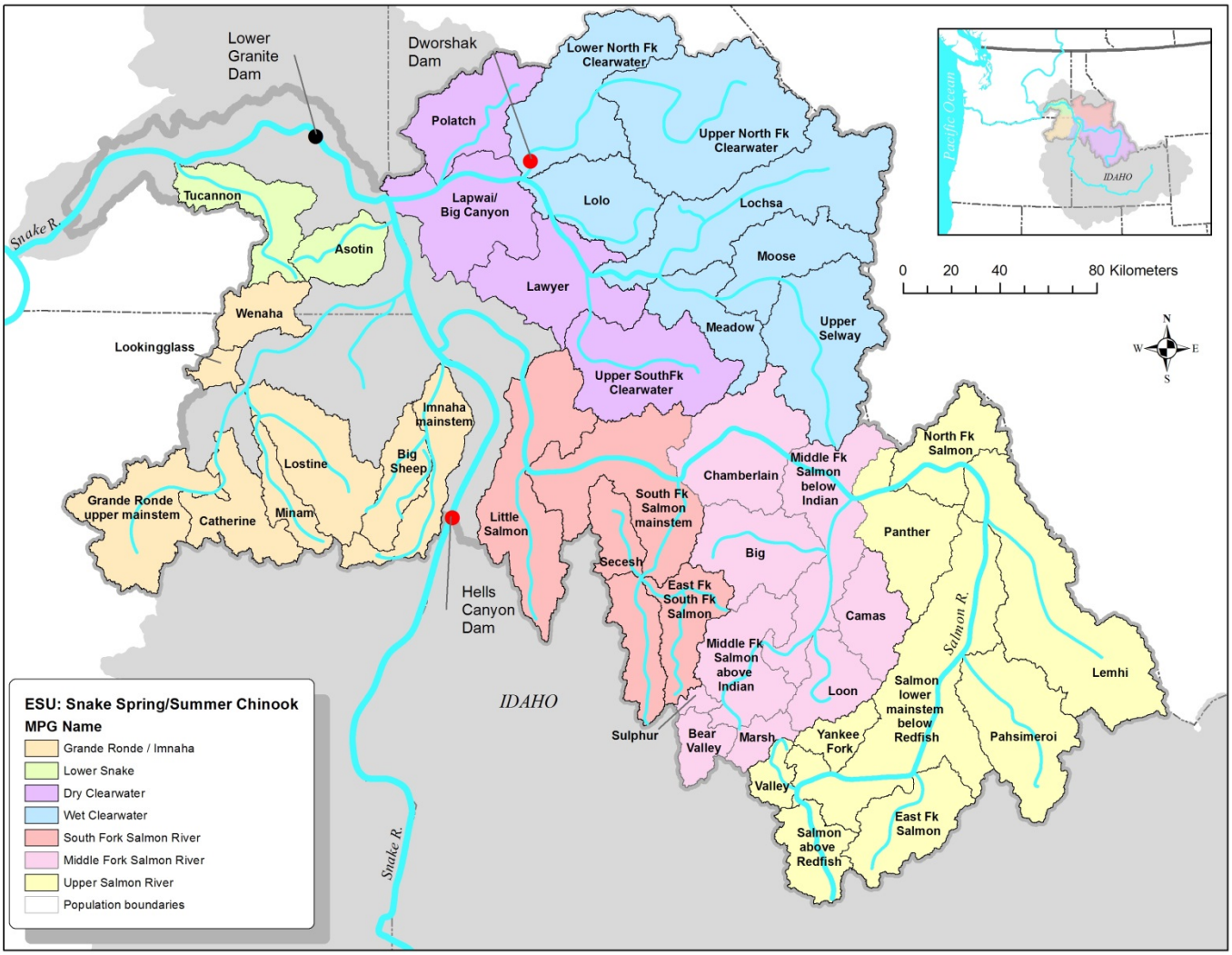

Figure 1. Spring-summer Chinook salmon populations and major population groups (MPGs) in the Snake River evolutionary significant unit (ESU).

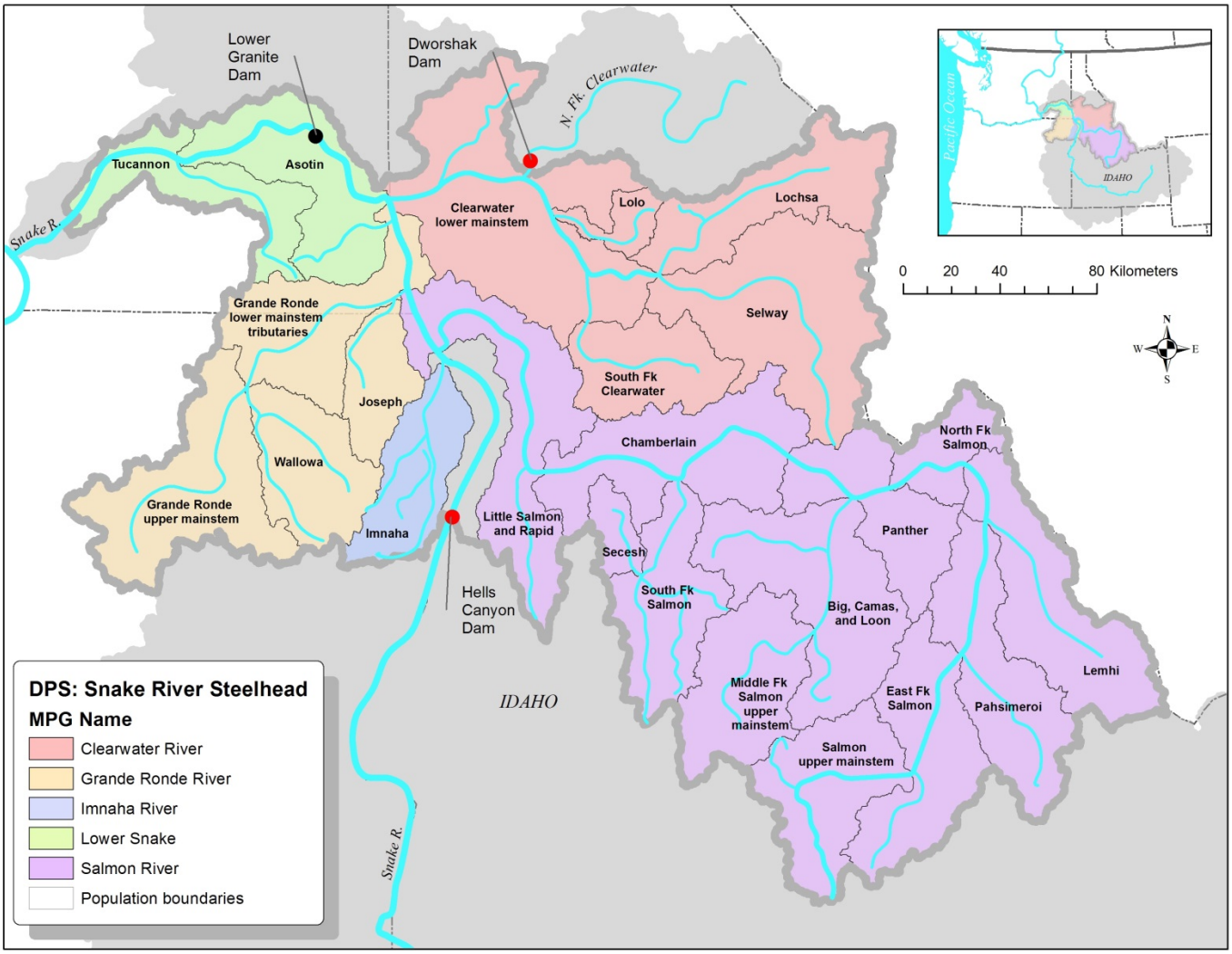

Figure 2. Summer steelhead populations and major population groups (MPGs) in the Snake River distinct population segment (DPS).

PART 2— MONITORING RELATIVE ABUNDANCE AND AGE COMPOSITION OF SPRING-SUMMER CHINOOK SALMON ON THE SPAWNING GROUNDS IN IDAHO

ABSTRACT

The Idaho Natural Production Monitoring and Evaluation Project monitors the status of wild Snake River spring-summer Chinook salmon populations in the Salmon River and Clearwater River subbasins. In this part of the report, we detail results from the 2012 Chinook salmon spawning ground surveys. We summarize redd surveys for Idaho trend transects, carcass surveys, and the length-at-age results. During spawn year 2012, Idaho Department of Fish and Game surveyed 847 redds in the South Fork Salmon River Major Population Group (MPG), 937 redds in the Middle Fork Salmon River MPG, 947 redds in the Upper Salmon River MPG, 160 redds in the Dry Clearwater River MPG, and 42 redds in the Wet Clearwater River MPG. We aged 1,399 Chinook salmon carcasses using dorsal fin rays in 2012; 383 from the South Fork Salmon River MPG, 384 from the Middle Fork Salmon River MPG, 525 from the Upper Salmon River MPG, 91 from the Dry Clearwater River MPG, and 16 from the Wet Clearwater River MPG. For Chinook salmon in Idaho, aggregate estimates of mean length-at-age from 2009-2012 generally decreased for one-, two-, and three-ocean fish and increased for four-ocean fish. Estimating ocean ages of spawning Chinook salmon using fin rays continues to be the preferred method for population-specific age composition; accuracy is estimated at 97.8%.

Authors:

Patrick Kennedy
Senior Fishery Research Biologist

June Johnson
Senior Fishery Technician

Kimberly A. Apperson
Regional Fisheries Biologist

Jon Flinders
Regional Fisheries Biologist

Matthew Corsi
Regional Fisheries Biologist

INTRODUCTION

Management of Snake River spring-summer Chinook salmon *Oncorhynchus tshawytscha* (hereafter Chinook salmon) requires the monitoring of adult abundance and escapement to spawning habitat. In Idaho, it is difficult to census all salmon returning to each population due to the large geographic area and difficult access in remote wilderness areas used by spawning Chinook salmon. In lieu of estimating abundance, the Idaho Department of Fish and Game (IDFG) developed a program to index annual spawning abundance by counting salmon redds in selected transects. The core transects surveyed annually are hereafter referred to as "trend surveys" (Table 1). The use of annual trend surveys to index spawner abundance continues to be the most efficient method to monitor these populations (Gallagher et al. 2010). The sum of all trend transect area surveyed represents a large portion of Chinook salmon spawning habitat in Idaho (Pirtle 1956). The number of redds counted during surveys in these trend transects provide an index used to measure annual relative adult spawner abundance. Time series trends in adult abundance can be assessed from these redd survey data. Redd and carcass data are also used to derive point estimates of natural spawner abundance, smolt-to-adult survival, and recruitment-per-spawner estimates (ICBTRT 2005).

Chinook salmon redd surveys in Idaho were made as early as 1947. However, consistent trend surveys date back to 1957. The redd survey program incorporated additional spawning areas to support expanded monitoring activities and management requirements as necessary.

Chinook salmon carcass surveys were included when redd surveys were conducted from the ground. Carcass surveys provide information used to estimate population-specific length, age, sex ratios, and proportion of hatchery and wild fish on the spawning grounds. Prior to 1993, adipose fin-clips indicated the presence of a coded-wire-tag (CWT). Since 1993, most hatchery origin Chinook salmon released in the Snake River basin had an external mark, usually an adipose fin-clip, regardless of whether they have a CWT.

In 2004, the Interior Columbia Basin Technical Recovery Team (ICBTRT) was formed at the urging of the National Oceanic and Atmospheric Administration Fisheries (NOAAF) to refine the recovery monitoring process for the Endangered Species Act (ESA) status assessments. The ICBTRT identified three different scales of population structure for both Chinook salmon and steelhead. Within the Snake River spring-summer Chinook salmon evolutionarily significant unit (ESU), there are seven MPGs and 29 extant demographically independent populations (Figure 1; ICBTRT 2003, 2005; NMFS 2011).

This section contains redd survey data used for trend analysis by managers and researchers along with fin-ray ages, frequencies of hatchery/wild fish, and average length-at-age of Chinook salmon on the spawning grounds by major population group (MPG).

METHODS

Redd Surveys

During 2012, redd survey methods were the same as past years using standardized procedures described in Hassemer (1993b). Trend transect boundaries and target dates have generally remained constant and were described in Hassemer (1993a). Redd survey trend transect names and target dates are listed by population in Table 1. Single-pass, peak-count

surveys were made over each trend transect each year. Each survey was originally timed to coincide with the period of maximum spawning activity on a particular stream, based on historic observations, and assigned a target count-time window. The method chosen for each redd survey was dependent on the best visual technique for each trend area and ability to maximize the number of river miles surveyed. Methods included low-flying helicopter or single-pass ground surveys conducted on foot. Currently no redd survey trend transects are identified for the following populations: Little Salmon River, Upper Middle Fork Salmon River, Lapwai/Big Canyon Creeks, Potlatch River, Lawyer Creek, and Meadow Creek. Trend surveys in the East Fork South Fork Salmon River have been discontinued due to low escapement of wild fish and to reduce redundancy since the Nez Perce Tribal Fisheries Department conducts annual redd and carcass surveys there.

Carcass Surveys

Carcasses were sampled from spawning areas throughout the Idaho portion of the study area (Figure 3) consistent with methods in Copeland et al. 2004. Reaches were a subset of the redd survey transects described in Hassemer (1993a). Not all redd survey transects were surveyed from the ground; therefore, carcasses were not available for all populations. Because age composition, sex ratios, and hatchery/wild fraction can vary widely among populations, we have a minimum goal of 100 carcass samples from each population.

Each carcass was thoroughly scanned to determine origin. Hatchery origin was identified visually by the presence of external marks, such as an adipose fin clip. Handheld CWT wands and Passive Integrated Transponder (PIT) tag readers were used to scan each carcass for the presence of internal tags; the presence of which could identify hatchery origin.

Carcass Age Composition

Fin ray analysis techniques were consistent with Copeland et al. 2007. Fin rays were dried, set in epoxy resin, cut into cross-sections with a bone saw, and mounted on microscope slides. All samples were aged independently by two technicians. Personnel were trained with reference fin rays and were required to demonstrate 90% accuracy in an aging test before they were allowed to begin aging new samples. If there was disagreement in age determination or the age did not match what was expected for fish length, then fins were aged again in a referee session. A referee session requires that three personnel observed the fin together and arrived at a consensus age. In some cases, a consensus could not be achieved and the fin ray was removed from the sample.

Hatchery personnel also collected dorsal fins from known-age (PIT or CWT) hatchery adults at Rapid River, Sawtooth, Clearwater, Pahsimeroi, and McCall hatcheries. The known-age samples were collected from Chinook salmon tagged as juveniles with PIT tags or CWTs and recovered as returning adults. The known-age samples were randomly included with the wild samples to assess aging accuracy and train new personnel in growth patterns specific to the years being analyzed. Chinook salmon with a fork length (FL) less than 45 cm were removed from the sample due to the possibility that they were mini-jacks.

We summarized carcass survey data in three ways: 1) 2012 length-frequency distribution determined by fin ray analysis was used to describe the aggregate population above LGR. Point estimates and 95% confidence intervals for length-at-age were also estimated by MPG for years 2009-2012. 2) The number of carcasses collected was summarized by age for each population for each year; and 3) the frequencies of hatchery production and natural

production carcasses were summed between the BioSamples and the Spawning Ground Survey databases for each MPG.

RESULTS

Redd Surveys

We surveyed 2,933 Chinook salmon redds in trend transects in 2012 (Table 2). A total of 2,731 redds were in the Salmon River subbasin. There were 847 redds in the South Fork Salmon MPG, of which most or 467 were in the South Fork Salmon River population. The Middle Fork Salmon River MPG had 937 redds of which most or 497 were in the Bear Valley/Elk Creek population. There were 947 redds in the Upper Salmon River MPG of which most or 348 redds were in the Upper Salmon River main-stem population (above Redfish Lake Creek). There were no surveys conducted in the Yankee Fork population. Partial surveys were conducted in the Big Creek and Valley Creek populations.

A total of 202 redds were observed in the Clearwater River subbasin (Table 2). There were 160 redds in the Dry Clearwater MPG and 42 redds in the Wet Clearwater MPG. Most Clearwater River redds were in the South Fork Clearwater River population, which was only partially surveyed. Trend surveys were not conducted in the Lolo Creek, Moose Creek, and the Upper Selway River populations.

Carcass Surveys

During 2012, we sampled 2,520 wild Chinook salmon carcasses on Idaho spawning grounds (Table 3, Figure 3). A total of 593 hatchery origin and 2,025 natural origin carcasses were recorded in the databases.

Carcass Age Composition

During 2012, we assigned ages to 1,399 fin rays (Table 3). Of the assigned ages, 1.7% were brood year (BY) 2009, 53.6% were BY 2008, 43.9% were BY 2007, and 0.8% were BY 2006. Freshwater age was assumed to be one year for all fin rays.

For the South Fork Salmon River MPG, 2.6% of carcasses were BY 2009, 63.2% were BY 2008, 33.9% were BY 2007, and 0.3% were BY 2006 (n = 383; Table 3). For the Middle Fork Salmon River MPG, 2.3% were BY 2009, 43.2% were BY 2008, 53.7% were BY 2007, and 0.8% were BY 2006 (n = 384). For the Upper Salmon River MPG, 0.8% were BY 2009, 49.8% were BY 2008, 48.1% were BY 2007, and 1.3% were BY 2006 (n = 526). For the Dry Clearwater MPG, 1.1% were BY 2009, 74.7% were BY 2008, and 24.2% were BY 2007 (n = 91). For the Wet Clearwater MPG, 81.2% were BY 2008, and 18.8% were BY 2007 (n = 16).

Of the 138 known ocean-age fin rays assigned ages, 97.8% were aged correctly. Overall, there were 23 known-age samples from BY 2009, 87 from BY 2008, and 28 from BY 2007.

The Idaho aggregated length distributions of one-ocean and two-ocean groups overlapped by 19 cm (Figure 4). The overlap between two- and three-ocean length distributions was 20 cm. The length distribution for four-ocean fish was within the three-ocean length distribution. Mean length-at-age for the Idaho aggregate decreased by 3.4 cm for one-ocean

fish, decreased by 4.9 cm for two-ocean fish, decreased by 0.7 cm for three-ocean fish, and increased by 0.7 cm for four-ocean fish from 2009 to 2012 (Table 4).

In the Salmon River drainage, mean length-at-age for wild Chinook salmon varied by year and by MPG. Comparisons of annual mean length-at-age in years 2009 through 2012 showed that the South Fork Salmon River MPG decreased by 4.6 cm for one-ocean fish, decreased by 4.7 cm for two-ocean fish, decreased by 3.6 cm for three-ocean fish, and increased by 2.0 cm for four-ocean fish (Table 4). For the Middle Fork Salmon River MPG, mean length-at-age decreased by 1.0 cm for one-ocean fish, decreased by 3.6 cm for two-ocean fish, and increased by 0.5 cm for three-ocean fish. The sample size was insufficient to estimate mean length-at-age in the Middle Fork Salmon River MPG for four-ocean fish. For the Upper Salmon River MPG, mean length-at-age decreased by 3.6 cm for one-ocean fish, decreased by 5.1 cm for two-ocean fish, increased by 0.5 cm for three-ocean fish, and decreased by 11.5 cm for four-ocean fish.

In the Clearwater River drainage, mean length-at-age for years 2009-2012 in the Dry Clearwater MPG decreased by 9.6 cm for one-ocean fish, decreased by 0.7 cm for two-ocean fish, and decreased by 3.4 cm for three-ocean fish. In the Wet Clearwater MPG, mean length-at-age decreased by 3.3 cm in two-ocean fish. There were not enough samples to estimate mean length-at-age for four-ocean fish in the Dry Clearwater MPG and one-, three-, and four-ocean fish in the Wet Clearwater MPG.

DISCUSSION

The IDFG Chinook salmon spawning ground survey data are a key element in Idaho's Chinook salmon management. These data are used in annual forecasting which contribute to setting the Lower Columbia River fisheries before the Chinook salmon ever migrate into Idaho. Furthermore, hatchery Chinook salmon harvest rates and incidental take of wild catch-and-release fish are set according to the number of wild or natural adults.

The Chinook salmon information presented in this section was acquired during spawning ground surveys, which typically include both redd and carcass surveys. For monitoring wild Chinook salmon abundance, redd surveys account for a large proportion of the available spawning habitat in Idaho. In contrast to the redd surveys, the spatial and temporal distribution of carcass surveys could be improved (Figure 3). Increased effort or spatially balanced sampling would benefit the analysis and interpretation of the biological data used to monitor these wild populations. However, the importance and utility of maintaining the long-term redd trend survey dataset is a higher priority than restructuring our current carcass survey design. Because most spring and summer Chinook salmon spawn during such a narrow time period, we have very little flexibility in altering our carcass survey design.

Currently, population-specific adult Chinook salmon abundances are indexed using redd surveys in most populations. The IDFG redd survey dataset is extensive and has recently been improved to be easily accessed and accommodate survey data from a variety of projects. Therefore, not all redd surveys conducted in Idaho were presented in this report.

The abundance of wild adult spawning spring-summer Chinook salmon in Idaho continues to be very low compared to historical estimates (Ford et al. 2010). In general, Idaho populations do not meet viability criteria, and therefore they continue to be listed under the ESA as threatened. Furthermore, the trend in relative abundance indicates substantial declines from

historical abundances, though the past two years were periods of growth in relative abundance (Table 2). Trends in spatial distribution follow trends in abundance. Adult spawner abundance is low in comparison to the vast area of habitat that Idaho has available for Chinook salmon to spawn in, which resulted in patchy and disjunct spatial structure of spawning Chinook salmon that are not well dispersed over the available habitat.

Biological data from carcass surveys provide estimates of length-at-age, age composition, sex composition, and hatchery fraction at the population scale with a resolution not currently available using data collected at LGR. Hatchery fraction of the population can only be measured on the spawning grounds. These metrics were also used to estimate the productivity of each population (ICBTRT 2005; Ford et al. 2010). Tissue samples obtained from carcasses also contribute to the genetic stock index baseline used to estimate the proportions of returning adults by population for harvest management and abundance monitoring (Ackerman et al. 2012).

Population-specific age composition was reported as frequencies or percentages of fish sampled from the spawning grounds (Table 3). We considered the frequencies to be representative of the population's age composition when sample sizes were approximately equal to 100 (Gerritsen and McGrath 2007).

Frequencies of hatchery and natural origin carcasses were reported as encountered; thus the reported ratio should be indicative of the hatchery/wild spawning fraction for Idaho populations. Most carcass surveys conducted by IDFG were within areas of controlled escapement such as natural production areas above hatchery weirs, or areas designed to monitor supplementation. For some supplemented populations (e.g., South Fork Salmon River) estimates of hatchery fraction may be biased high or low depending on the transect. For example, surveys conducted above a hatchery weir will identify natural fish almost exclusively. Surveys immediately downstream from a hatchery weir will have a greater proportion of hatchery spawners. For other populations with no history of hatchery supplementation (e.g., Middle Fork Salmon River MPG), we assume this bias does not exist. Thus, frequencies of fish encountered by production type provided an accurate estimate of hatchery fraction on the spawning grounds. In general, the frequency of hatchery carcasses encountered on the spawning grounds varied among MPGs, populations, and years.

Length-at-age varies by MPG and year. Table 4 describes the annual variability in length-at-age from 2009-2012. Overlapping confidence intervals in many years for three- and four-ocean fish show that visual determinations of fish ages based on length are not accurate. There were not enough carcasses in each age group to estimate population specific length-at-age which resulted in samples aggregated to the next highest population scale for each MPG. For population-specific variability in length-at-age, see Copeland et al. 2004. Though comparisons of mean length-at-age between the years 2009 and 2012 showed decreases in most classes, there were a few years where mean length-at-age increased for a year or two in some age classes. Mean length-at-age of two-ocean fish decreased most consistently. There are far fewer samples available for four-ocean fish, which is evidence that this age class is not well represented on the spawning grounds. Trends of decreasing length-at-age have recently been recognized in other Chinook salmon populations as well (Kendall and Quinn 2011). Sampling complications in the Clearwater River drainage have resulted in small sample sizes that reduce our ability to draw inferences from spawning ground survey results.

The status of population diversity can be monitored using genetic diversity, and the trends can be monitored using spawn timing, age distributions, fecundity, and sex ratios

(Crawford and Rumsey 2011). Genetic diversity is estimated by the Genotyping for Genetic Stock Identification (GSI) project at Lower Granite Dam (Bonneville Power Administration [BPA] project #2010-026-00; see Ackerman et al. 2012, Table 2). For the shorter-term trends, however, little information is available on spawn timing and fecundity. Estimating spawn timing is difficult using single-pass redd surveys. Currently, fecundity is not measured during IDFG carcass surveys because eggs and milt are already spent and not available to quantify. Population-specific sex ratios and age distributions are monitored on the spawning grounds annually. However, those data vary widely between years and among populations making trends difficult to detect (compare Table 3 to results in Kennedy et al. 2011, 2012). Sex ratios estimated from spawning ground data are negatively biased against males because male precocial Chinook salmon are rarely encountered due to their small size (Zhou 2002) and potential for iteroparity (Unwin et al. 1999). Also, the timing of IDFG trend surveys is based on redds created by females, which likely results in a negative bias against jack Chinook salmon carcass recovery since they generally return slightly later (Anderson and Beer 2009; Bracis and Anderson 2013).

RECOMMENDATIONS

1. Continue to refine and improve spawning ground survey data management, from quality assurance in the field to quality control of the Spawning Ground Survey database output; to ensure timely and accurate summaries for managers.

2. Publish protocols for redd surveys and carcass surveys to ensure standardized methods are used.

3. Maintain the IDFG trend surveys. Spatial and temporal changes to these surveys should be resisted unless well justified (e.g., evaluated change in peak spawn timing).

4. Assess the accuracy of the target survey dates for the trend surveys in at least one population per year.

5. Conduct power analyses to estimate the number of carcasses needed from each population to estimate age composition relative to the 10-year geometric mean of abundance.

6. Increase monitoring of wild or natural adult spawners in the Clearwater drainages to better understand those populations.

7. Expand previously reported length-at-age (Copeland et al. 2004) analyses through current years.

ACKNOWLEDGEMENTS

We are grateful to the Bonneville Power Administration and Susan Offerdal, our contracting officer's technical representative, for support and funding of this research. The Nez Perce Tribe, the Shoshone-Bannock Tribe, the University of Idaho, and many IDFG regional staff contributed to the spawning ground survey data. The majority of the spawning ground survey data was provided by the Idaho Supplementation Studies project (Bonneville Power Administration project #1989-098-00). The Middle Fork Salmon River redd surveys were provided by Russ Thurow (U.S. Forest Service). Emanuel Ziolkowski provided quality control for the spawning ground survey data. IDFG Information Systems Bureau, particularly Evan Brown and Chris Harrington, provided database management and technical oversight for the entire trend data set. Fin ray analyses were conducted by Laura Kurpiers and Ross Gay. Paul Bunn coordinated BioSamples database management and created the carcass survey map for this report. This section benefited from reviews by Bill Schrader and Lance Hebdon. Cheryl Zink helped format and edit the document.

LITERATURE CITED

Ackerman, M. W., J. McCane, C. A. Steele, M. R. Campbell, A. P. Matala, J. E. Hess, and S. R. Narum. 2012. Chinook salmon and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam. Idaho Department of Fish and Game Report 12-15. Annual Report, BPA Project 2010-026.

Anderson, J. J., W. N. Beer. 2009. Oceanic, riverine, and genetic influences on spring Chinook salmon migration timing. Ecological Applications 19(8):1989-2003.

Bracis, C., and J. J. Anderson. 2013. Inferring the relative oceanic distribution of salmon from patterns in age-specific arrival timing. Transactions of the American Fisheries Society 142:556-567.

Copeland, T., J. Johnson, and P. R. Bunn. 2004. Idaho natural production monitoring and evaluation. Idaho Department of Fish and Game Report 04-47. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, S. Kraft, and P. R. Bunn. 2007. Idaho natural production monitoring and evaluation, 2006 annual report. Idaho Department of Fish and Game Report 07-31. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Crawford B. A. and S. M. Rumsey. 2011. Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act. National Marine Fisheries Service, NW Region. Seattle.

Ford M. J. (ed.), T. Cooney, P. McElhany, N. Sands, L. Weitkamp, J. Hard, M. McClure, R. Kope, J. Myers, A. Albaugh, K. Barnas, D. Teel, P. Moran, and J. Cowen. 2010. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Northwest. Draft U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NWFSC-XXX.

Gallagher, S., P. Adams, D. Wright, and B. Collins. 2010. Performance of Spawner Survey Techniques at Low Abundance Levels. North American Journal of Fisheries Management 30:1086-1097.

Gerritsen, H. D. and D. McGrath. 2007. Precision estimates and suggested sample sizes for length-frequency data. Fisheries Bulletin 106:116-120.

Hassemer, P. 1993a. Salmon spawning ground surveys, 1989-1992. Idaho Department of Fish and Game. Project F-73-R-15. Pacific Salmon Treaty Program Award No. NA17FP0168-02. 32 p. plus appendices.

Hassemer, P. 1993b. Draft manual of standardized procedures for counting Chinook salmon redds. Idaho Department of Fish and Game, Boise.

ICBTRT (Interior Columbia Basin Technical Recovery Team). 2003. Independent populations of Chinook, steelhead, and sockeye for listed Columbia basin ESUs. ICBTRT draft report July 2003.

ICBTRT (Interior Columbia Basin Technical Recovery Team). 2005. Updated population delineation in the interior Columbia Basin. Memo to NMFS Northwest Regional Office May 11, 2005.

Kendall, N. W. and T. P. Quinn. 2011. Length and Age Trends of Chinook salmon in the Nushagak River, Alaska, Related to Commercial and Recreational Fishery Selection and Exploitation, Transactions of the American Fisheries Society 140:3, 611-622.

Kennedy P, T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand. 2011. Idaho Natural Production Monitoring and Evaluation, 2009-2010 annual progress report. Idaho Department of Fish and Game Report 11-23. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kennedy P, T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand. M. Corsi. 2012. Idaho Natural Production Monitoring and Evaluation, 2011 annual progress report. Idaho Department of Fish and Game Report 12-18. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2011. Five-year review: summary and evaluation of Snake River sockeye, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River basin steelhead. NMFS, Northwest Region.

Pirtle, R. B. 1956. Field Studies to Estimate the Size and Timing of Runs of Anadromous Species of Fish in the Columbia and Snake River and Their Tributaries Above the Confluence of the Snake River. Idaho Department of Fish and Game, Boise.

Unwin, M. J., M. T. Kinnison, and T. P. Quinn. 1999. Exceptions to semelparity: postmaturation survival, morphology, and energetics of male Chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences 56:1172–1181.

Zhou, S. 2002. Size-dependent recovery of Chinook salmon in carcass surveys. Transactions of the American Fisheries Society 131(6):1194-1202.

Table 1. Transect name and target dates for redd surveys used to index wild Chinook salmon abundance by major population group and independent population.

Major Population Group and Population	**Transect Name**	**Target Survey Date**
South Fork Salmon River		
Little Salmon River	n/t[a]	n/t
South Fork Salmon River	NS-26	9/5
	NS-27	9/5
	NS-28	9/5
	NS-29	9/5
Secesh River	WS-16	8/25-9/1
	WS-17	8/25-9/1
	WS-18	8/25
	WS-19	8/25
East Fork South Fork Salmon River	NS-30	9/1-9/5
	NS-31	9/1-9/5
	NS-32	9/1-9/5
Middle Fork Salmon River		
Chamberlain Creek	WS-1	8/25
	WS-1a	8/25
Big Creek	WS-13	9/5
	WS-14a	9/5
	WS-14b	9/5
	WS-14c	9/5
	WS-14d	9/5
Lower Middle Fork Salmon	WS-15	9/8
Camas Creek	WS-8	8/25-9/5
Loon Creek	WS-6	8/25-9/5
	WS-7	8/25-9/5
Sulphur Creek	OS-4	8/21
	WS-12	8/21
Bear Valley Creek	WS-9a	8/27
	WS-9b	8/27
	WS-9c	8/27
	WS-9d	8/27
	WS-10a	8/27
	WS-10b	8/27
	WS-11a	8/27
	WS-11b	8/27
	WS-11c	8/27
Marsh Creek	WS-2a	8/15-8/20
	WS-2b	8/15-8/20
	WS-3	8/15-8/20
	WS-4	8/15-8/20
	WS-5	8/15-8/20
Upper Middle Fork Salmon	n/t	n/t
Upper Salmon River		
North Fork Salmon River	NS-25a	9/8
	NS-25b	9/8
	NS-25c	9/8
Lemhi River	NS-9	9/8
	NS-10	9/8
Pahsimeroi River	NS-33a	9/8
Lower Salmon River	NS-17	9/8
	NS-18	9/8
	NS-19	9/8
	NS-20	9/8
	NS-21	9/8
	NS-22	9/8

Table 1. Continued.

Major Population Group and Population	**Transect Name**	**Target Survey Date**
Lower Salmon River	NS-23	9/8
	NS-24	9/8
East Fork Salmon River	NS-1a	9/8
	NS-1b	9/8
	NS-2a	9/8
	NS-2b	9/8
Yankee Fork River	NS-5	9/8
	NS-6	9/8
	NS-7	9/8
	NS-8	9/8
Valley Creek	NS-3a	9/8
	NS-3b	9/8
	NS-4	9/8
Upper Salmon River	NS-15a	9/8
	NS-15b	9/8
	NS-15c	9/8
	NS-16	9/8
	NS-12	8/31-9/5
	NS-13a	9/8
	NS-13b	9/8
	OS-1	8/31-9/5
	OS-2	8/31-9/5
	OS-3	8/31-9/5
	OS-5	9/8
	OS-6	9/8
Panther Creek	NS-11	9/8
Dry Clearwater		
Lapwai/Big Canyon Creeks	n/t	n/t
Potlatch River	n/t	n/t
Lawyer Creek	n/t	n/t
South Fork Clearwater	NC-1	9/3
	NC-2a	9/3
	NC-2b	9/3
	NC-3	9/3
	NC-4	9/1-9/5
	NC-6	9/3
	NC-8	9/3
Wet Clearwater		
Lolo Creek	NC-14	9/3
Lochsa River	NC-10	9/3
	NC-11	9/3
	NC-13	9/8
Meadow Creek	n/t	n/t
Moose Creek	WC-3a	9/8
	WC-3b	9/8
Upper Selway River	WC-1	9/8
	WC-2	9/8
	WC-4a	9/8
	WC-4b	9/8
	WC-5	9/8
	WC-6	9/8
	WC-7	9/8
	WC-8	9/8
	WC-9	9/8

[a] n/t = No trend monitoring transects have been identified within these populations.

Table 2. Wild Chinook salmon redds counted in Idaho trend transects in the Salmon River and Clearwater River subbasins during the years 2009-2012 by major population group and independent population.

Major Population Group and Population		2009	2010	2011	2012
South Fork Salmon River					
Little Salmon River		n/t[a]	n/t	n/t	n/t
South Fork Salmon River		459	244[b]	750	467
Secesh River		380	299[b]	242	207
East Fork South Fork Salmon River		160[b]	n/c[c]	n/c	n/c
	MPG total	999	543	992	847
Middle Fork Salmon River					
Chamberlain Creek		63	78[b]	114[b]	96
Big Creek		124	92[b]	96[b]	111[b]
Lower Middle Fork Salmon		1	1	0	0
Camas Creek		12	17	3	22
Loon Creek		28	20	15	34
Sulphur Creek		23	52	79	19
Bear Valley/Elk Creek		265	418	400	497
Marsh Creek		64	243	259	158
Upper Middle Fork Salmon		n/t	n/t	n/t	n/t
	MPG total	580	921	966	937
Upper Salmon River					
North Fork Salmon River		28	39	46	42
Lemhi River		61	79	99	63
Pahsimeroi River		42	47	56	74
Lower Salmon River		48	63[b]	119	95
East Fork Salmon River		59	289	224	201
Yankee Fork River		363	4[b]	9	n/c
Valley Creek		43	68	42	110[b]
Upper Salmon River		240	279	222[b]	348
Panther Creek		11	1	0	14
	MPG total	895	869	817	947
Dry Clearwater					
Lapwai/Big Canyon Creeks		n/t	n/t	n/t	n/t
Potlatch River		n/t	n/t	n/t	n/t
Lawyer Creek		n/t	n/t	n/t	n/t
South Fork Clearwater		193	144[b]	264[b]	160[b]
	MPG total	193	144	264	160
Wet Clearwater					
Lolo Creek		n/c	n/c	n/c	n/c
Lochsa River		51	50	69	36[b]
Meadow Creek		n/t	n/t	n/t	n/t
Moose Creek		n/c	n/c	n/c	n/c
Upper Selway River		8[b]	23[b]	15[b]	6[b]
	MPG total	59	73	84	42
	Idaho total	2,726	2,550	3,123	2,933

[a] n/t = No trend monitoring transects have been identified.
[b] Indicates partial survey of the trend transects for a population.
[c] n/c = No trend survey conducted.

Table 3. Brood year and age class frequencies of wild Chinook salmon carcasses sampled from Idaho spawning grounds during 2012. Freshwater age was assumed to be one year. Frequencies of all carcasses, hatchery origin (HOR) and natural origin (NOR), recovered during surveys, from the BioSamples database and the Spawning Ground Survey database are summed.

	Brood year and age class					All Carcasses	
	2009	2008	2007	2006	Total		
Major Population Group and Population	1.1	1.2	1.3	1.4	Aged	HOR	NOR
South Fork Salmon River							
Little Salmon River	-	-	-	-	0	-	-
South Fork Salmon River	-	46	51	-	97	18	158
Secesh River	4	123	31	-	158	0	159
East Fork South Fork Salmon River	6	73	48	1	128	0	130
MPG total	10	242	130	1	383	18	447
Middle Fork Salmon River							
Chamberlain Creek	-	9	3	-	12	0	13
Big Creek	4	63	38	-	105	0	106
Lower Middle Fork Salmon	-	-	-	-	0	-	-
Camas Creek	-	-	-	-	0	-	-
Loon Creek	-	-	-	-	0	-	-
Sulphur Creek	-	5	4	-	9	1	9
Bear Valley Creek	3	49	94	2	148	0	365
Marsh Creek	2	37	66	1	106	3	123
Upper Middle Fork Salmon		3	1		4	0	4
MPG total	9	166	206	3	384	4	620
Upper Salmon River							
North Fork Salmon River	-	6	8	-	14	0	15
Lemhi River	-	12	7	2	21	0	24
Pahsimeroi River	-	-	-	-	0	0	10
Lower Salmon River	1	35	40	1	77	21	112
East Fork Salmon River	-	19	77	1	97	0	100
Yankee Fork	-	-	-	-	0	0	5
Valley Creek	-	65	48	1	114	10	124
Upper Salmon River[a]	3	124	73	2	202	143	362
Panther Creek	-	-	-	-	0	-	-
MPG total	4	261	253	7	525	174	752
Dry Clearwater							
Lapwai/Big Canyon Creeks	-	-	-	-	0	-	-
Potlatch River	-	-	-	-	0	-	-
Lawyer Creek	-	-	-	-	0	-	-
South Fork Clearwater	1	68	22		91	369	157
MPG total	1	68	22	0	91	369	157
Wet Clearwater							
Lolo Creek	-	-	-	-	0	-	-
Lochsa River	-	13	3	-	16	28	41
Meadow Creek	-	-	-	-	0	-	-
Moose Creek	-	-	-	-	0	-	-
Upper Selway River	-	-	-	-	0	0	8
MPG total	0	13	3	0	16	28	49
Idaho total	24	750	614	11	1,399	593	2,025

[a] Includes surveys above and below the Sawtooth Hatchery weir.

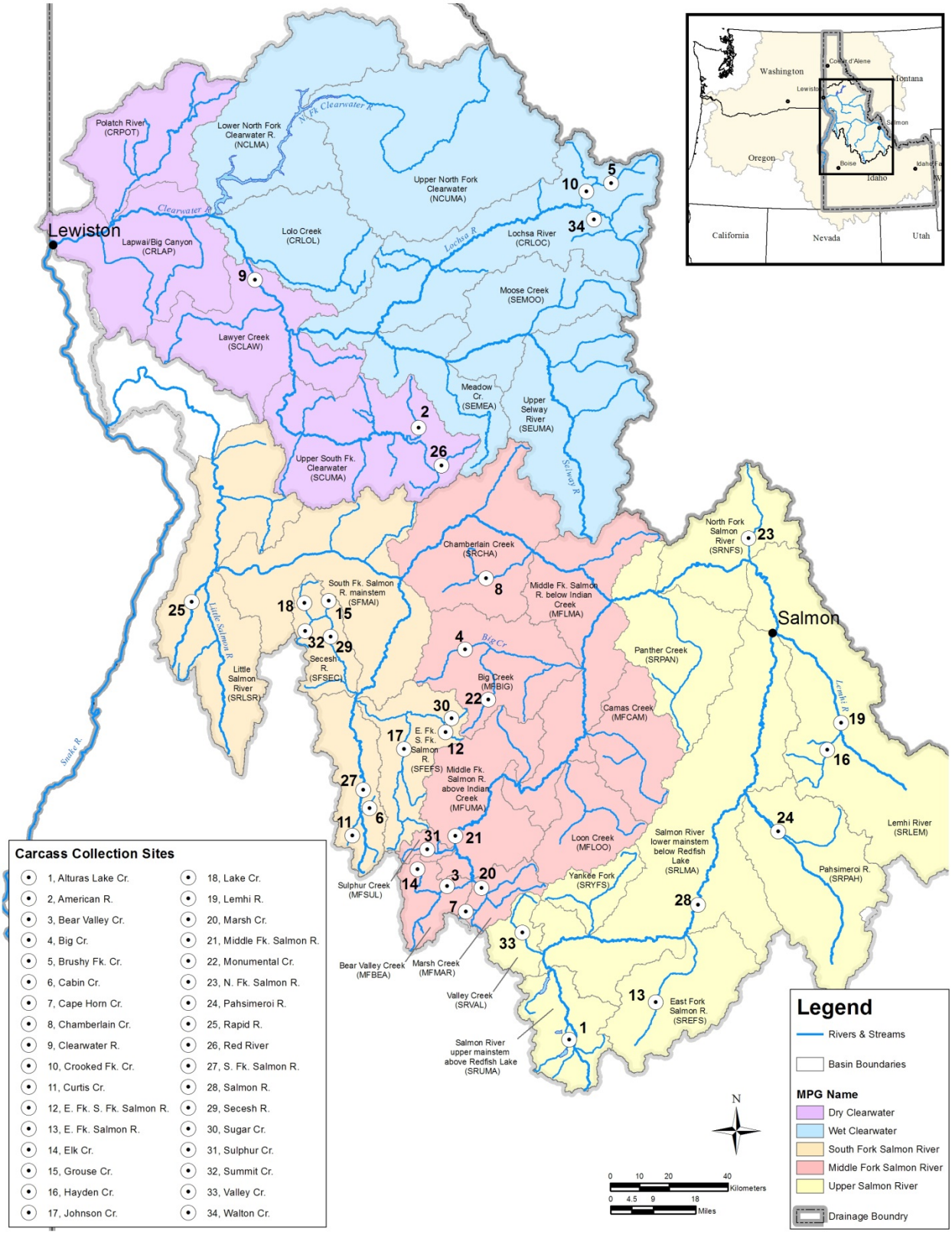

Figure 3. Spawning ground survey locations where wild Snake River spring-summer Chinook salmon carcasses were collected in 2012.

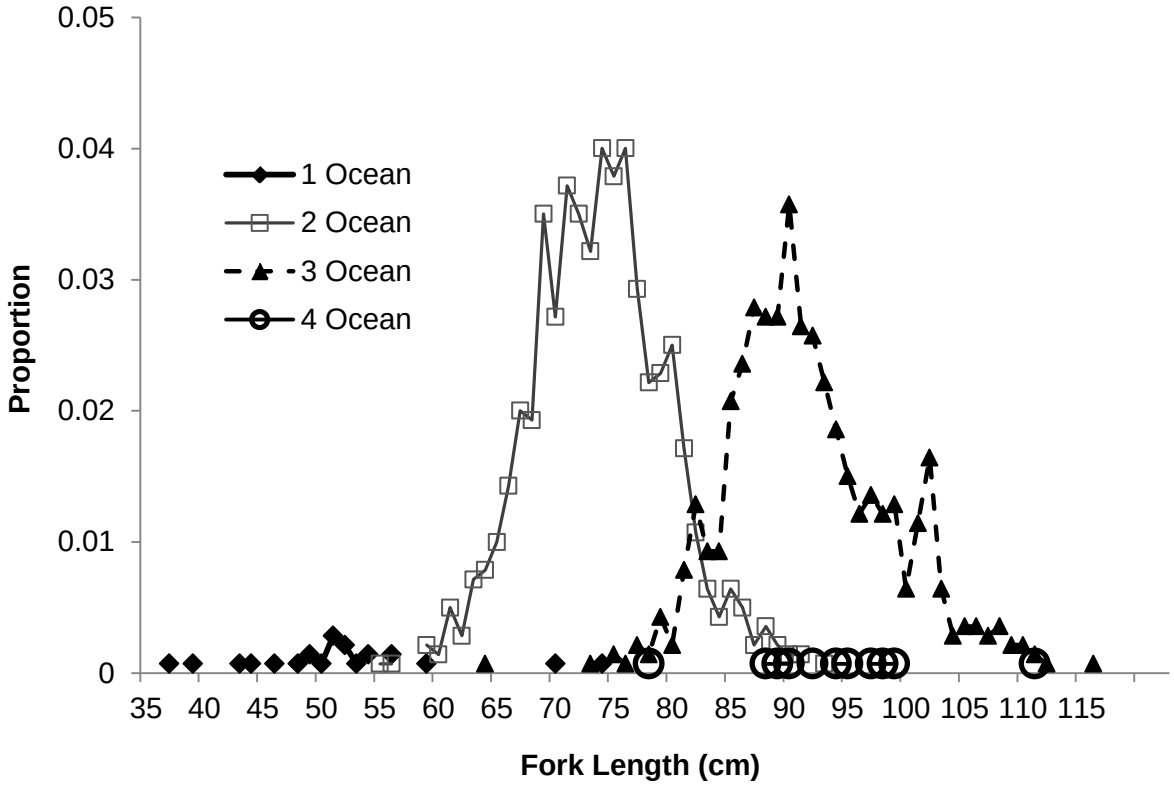

Figure 4. Length distribution by ocean-age of wild Snake River spring-summer Chinook salmon carcasses collected on the spawning grounds in 2012. Ages were determined from fin ray analysis (*n* = 1,399).

Table 4. Mean length (cm) for wild Chinook salmon by ocean-age, major population group, and spawn year. Confidence intervals (alpha = 0.95) are given in parentheses.

Major Population Group	Spawn Year	Sample Size	Mean Lengths (cm) Ocean-Age 1	2	3	4
South Fork Salmon	2009	360	56 (54-57)	79 (78-79)	93 (91-94)	92[a] (84-99)
	2010	591	54 (50-59)	78 (77-78)	92 (89-95)	97[b] --
	2011	337	56 (54-58)	76 (75-77)	91 (90-92)	93[a] (90-96)
	2012	383	51 (49-53)	74 (73-75)	89 (88-90)	94[b] --
Middle Fork Salmon	2009	166	52 (49-55)	77 (76-78)	92 (89-94)	[c] --
	2010	238	50[a] (42-57)	77 (76-77)	94 (92-96)	89[b] --
	2011	329	53 (51-55)	74 (73-75)	92 (91-93)	92[a] (88-96)
	2012	383	51[a] (43-59)	73 (72-74)	91 (90-92)	98[a] (86-111)
Upper Salmon	2009	419	54 (52-56)	79 (78-79)	92 (91-93)	102[b] --
	2010	370	51 (48-54)	76 (75-77)	91 (90-93)	95[b] --
	2011	494	54 (52-55)	74 (74-75)	93 (92-94)	91[a] (84-97)
	2012	526	50[a] (48-52)	74 (73-74)	93 (92-94)	91[a] (86-97)
Dry Clearwater	2009	39	61[a] (51-71)	74 (72-77)	90 (86-93)	85[b] --
	2010	25	45[b] --	73 (71-75)	85[b] --	[c] --
	2011	54	51[a] (35-67)	74 (71-76)	86 (84-89)	[c] --
	2012	91	59[b] --	71 (70-72)	86 (83-90)	[c] --
Wet Clearwater	2009	13	53[b] --	77[a] (71-83)	89[a] (84-94)	85[b] --
	2010	7	[c] --	73[a] (69-77)	[c] --	[c] --
	2011	23	[c] --	73 (71-76)	91[a] (87-96)	[c] --
	2012	16	[c] --	69 (66-72)	82 (76-87)	[c] --
Idaho Aggregate	2009	1,009	55 (54-56)	78 (78-79)	92 (91-93)	93[a] (84-101)
	2010	1,364	52 (50-55)	77 (77-77)	92 (91-93)	93[a] (90-96)
	2011	1,238	54 (53-55)	75 (74-75)	92 (91-92)	91 (89-94)
	2012	1,399	51 (48-55)	73 (73-74)	91 (91-92)	93 (88-98)

[a] Fewer than ten samples in the estimate.
[b] Fewer than three samples in the estimate. Not enough to estimate confidence intervals.
[c] No samples available to estimate an average.

PART 3— MONITORING AGE COMPOSTION OF WILD ADULT SPRING-SUMMER CHINOOK SALMON IN THE SNAKE RIVER BASIN TO ESTIMATE SMOLT-TO-ADULT RETURN RATES

ABSTRACT

Accurate determination of adult age composition is necessary for estimating smolt-to-adult return rates for wild Snake River spring-summer Chinook salmon *Oncorhynchus tshawytscha* over a long-term data series. For the 2012 adult return to Lower Granite Dam, total wild escapement was multiplied by scale-derived ocean age proportions to estimate escapement by age class. These data were combined with previously collected data to complete the cohorts and estimate smolt-to-adult return rates. All adults have returned from the ocean for smolt migration years 1996-2008; returns for smolt migration years 2009-2012 are still incomplete. The smolt-to-adult return rate to Lower Granite Dam for smolt migration year 2008 was 4.21%—the highest recorded in this time series. Total ages were assigned to 2,010 scale samples collected from adult wild Chinook salmon at Lower Granite Dam in 2012.

Author:

Patrick Kennedy
Senior Fishery Research Biologist

INTRODUCTION

Age information is an important tool for fisheries management and monitoring the recovery of Snake River spring-summer Chinook salmon *Oncorhynchus tshawytscha*, hereafter Chinook salmon. Accurate age data are essential to assign returning Chinook salmon to a specific brood year for cohort and productivity analyses. Escapement estimates by cohort are used to forecast run sizes and are the basis for fisheries management plans in the Columbia River basin. Accurate age data, at least for the saltwater phase, are also essential to estimate survival such as smolt-to-adult return rate (SAR; Copeland et al. 2007a).

In this section of the report, I consolidate and verify the wild Chinook salmon age composition time series dating back to adult return year 1998. See Appendix A for a one-time reporting of the data used to calculate the aggregate age composition for the years 1996-2004. I added the most recent age composition estimates from Lower Granite Dam (LGR) to update calculated SAR rates.

METHODS

To estimate the aggregate SAR for wild Chinook salmon, I combined the age composition of adults at LGR with estimates of emigrating wild Chinook salmon smolts at LGR. Prior to 2005, fin ray data obtained from the spawning grounds were combined with fish lengths obtained at LGR to build age-length keys, which were applied to the aggregate run of wild Chinook salmon at LGR to estimate age composition. Since 2005, National Oceanic and Atmospheric Administration Fisheries (NOAAF) personnel have systematically sampled scales from adults at LGR such that age composition can be derived directly. Methods for adult Chinook salmon sampling at LGR, for scale processing in the lab, and for estimating adult abundance and composition are detailed in the annual LGR wild adult reports (Schrader et al. 2011, 2012) or, in the case of return years 2011 and 2012, preliminary IDFG internal reports.

Smolt production in 2012 was estimated by dividing the daily count of wild smolts by the estimated collection efficiency for that day. The daily counts of wild Chinook salmon smolts at LGR were obtained from the Fish Passage Center website (www.fpc.org; accessed February 2013). Estimated daily smolt collection efficiencies were obtained from the Northwest Fisheries Science Center (NWFSC; Steve Smith, personal communication). Efficiencies were estimated by NWFSC personnel using procedures detailed in Sandford and Smith (2002). Daily abundance estimates were summed for the year to get total smolt production.

To calculate a SAR rate for a particular smolt year (SY), I used the sum of ocean returns from that cohort as the numerator and the estimate of wild smolts arriving at LGR as the denominator:

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

where SAR_k is the smolt-to-adult return rate of smolt year k; r_{k+l} is the return from that cohort in year $k+l$; l is ocean 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 ocean age observed for Chinook salmon at LGR (Copeland et al. 2004). I used formulas from Fleiss (1981) to estimate the 95% confidence limits on SAR values. The lower limit is given by

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

and the upper limit by

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

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

RESULTS

Total ages were assigned to 2,010 wild adult Chinook salmon scales sampled at LGR during 2012 (Table 5). Preliminary estimated total wild escapement to LGR during 2012 is 21,746 fish. Preliminary escapements by ocean age are 44 zero-saltwater fish (mini-jacks >30 cm, FL); 1,180 one-saltwater fish; 14,182 two-saltwater fish; 6,286 three-saltwater fish; and 54 four-saltwater fish (Table 6).

Final SAR rates were calculated for cohorts from smolt migration years 1996-2006, and preliminary SAR rates were calculated for the 2007 and 2008 cohorts (Table 6). Returns for the 2009-2012 cohorts are still incomplete. The preliminary SAR rate for the 2008 cohort, the last year for which all adults had returned in 2012, is 4.21% (95% CI 4.17%-4.26%).

DISCUSSION

During the past contract year, all data and methods involved with this extensive SAR time series (*n* = 17 yr.; Table 5) have undergone checks for quality control. Some errors were corrected, and some improved methods were applied. See Appendix A for a one-time reporting of the data used to calculate the aggregate age composition for the years 1996-2004. These changes have resulted in current SAR estimates that differ slightly from past reports. Previously, age-length keys using fin rays were used from 1998-2007 to estimate the age composition of returning adults, whereas scales collected at LGR were used to directly estimate age composition from 2008-2011 (e.g., Kennedy et al. 2012). However, scales have been systematically sampled from wild Chinook salmon at LGR since 2005 in cooperation with NOAAF personnel (Harmon 2009; Copeland et al. 2007a, 2007b, 2009; Kennedy et al. 2011, 2012; Schrader et al. 2011, 2012). Because scales from LGR are highly accurate and more direct, less biased, and very comparable to fin ray ages (Copeland et al. 2007b, 2008), we switched to them for the overlapping years 2005-2007. Scales are not resorbed by the time Chinook salmon are sampled at LGR.

Past estimates of wild escapement at LGR were drawn from multiple sources over this time series, and were updated by the Technical Advisory Committee after annual analyses were completed. In some years, the updated wild escapement estimates were not incorporated into the reported analysis. To ensure consistent estimates were used between projects and within

this time series, new estimates of wild escapement derived by IDFG have been applied to these SAR calculations (Table 5). Quality control within the BioSamples database, raw data, and past smolt estimates has resulted in several updates as well. Smolt estimates were updated for migration years 2009-2012.

The changes to the SAR time series vary in magnitude by year. There was an average of a 6.7 (range 0.8-17.1) change in years where the adult returns and associated SAR estimates were previously complete (smolt migration years 1996-2007). These efforts have resulted in our increased confidence in these survival estimates and this time series will be less vulnerable to changes or updates in the future.

The Chinook salmon 4.21% SAR for smolt migration year 2008 is the highest in the 17 yr. time series (Table 6). The increasing survival trend from smolt migration years 2005-2008 has peaked and it appears the final SAR for 2009 will be lower, though that cohort's returns are incomplete. For smolt migration year 2009, preliminary results suggest adults were returning with slightly diminished success though the final SAR estimate for that cohort is likely to remain above 2.0%, which is the minimum for adult replacement. A number of factors influence cohort returns, including ocean productivity, weather patterns, high water years, harvest, and hydrosystem management.

ACKNOWLEDGEMENTS

We are grateful to the Bonneville Power Administration and Susan Offerdal, our contracting officer's technical representative, for support and funding of this research. Kristin Wright, Leslie Ferguson, Kala Hernandez, Cliff Hohman, and Tyler Johnson provided the age determination for scale samples collected at LGR. Darren Ogden (NOAAF) provided the supervision for sampling Chinook salmon at the LGR adult trap. The IDFG Bureau of Fisheries provided the updated wild escapement estimates at LGR. June Johnson provided quality control over the historical fin ray data. Paul Bunn provided database management and quality assurance for the BioSamples data. Matthew Corsi and Tyler Gross contributed at the adult trap with sampling Chinook salmon and incorporating adult trap data into the database. Bill Schrader and Lance Hebdon provided oversight and review of this analysis and its reform. Kim Apperson, Jon Flinders, Matt Corsi, and Jordan Messner provided helpful reviews of this section of the report. Cheryl Zink helped format and edit the document.

LITERATURE CITED

Copeland, T., J. Johnson, and P. R. Bunn. 2004. Idaho natural production monitoring and evaluation, 2003 annual report. Idaho Department of Fish and Game Report 04-47. Bonneville Power Administration. Project 1991-073-00. Portland, Oregon.

Copeland, T., M. W. Hyatt, and J. Johnson. 2007a. Comparison of methods used to age spring-summer Chinook salmon in Idaho: validation and simulated effects on estimated age composition. North American Journal of Fisheries Management 27:1393-1401.

Copeland, T., J. Johnson, S. Kraft, and P. R. Bunn. 2007b. Idaho natural production monitoring and evaluation, 2006 annual report. Idaho Department of Fish and Game Report 07-31. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and S. Putnam. 2008. Idaho natural production monitoring and evaluation, 2007 annual report. Idaho Department of Fish and Game Report 08-08. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, K. A. Apperson, J. M. Flinders, and R. Hand. 2009. Idaho natural production monitoring and evaluation project. Idaho Department of Fish and Game Report 09-06. 2008 annual report to the U.S. Department of Energy, Bonneville Power Administration. Contract 36423, Project 199107300. Idaho Department of Fish and Game, Boise.

Fleiss, J. L. 1981. Statistical methods for rates and proportions. 2nd edition. John Wiley and Sons, New York.

Harmon, J. 2009. Operation of the Lower Granite Dam adult trap, 2008. Bonneville Power Administration. Project 2005-002-00. Portland, Oregon.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, and R. Hand. 2011. Idaho Natural Production Monitoring and Evaluation, 2009-2010 annual progress report. Idaho Department of Fish and Game Report 11-23. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand, and M. Corsi. 2012. Idaho Natural Production Monitoring and Evaluation, 2011 annual progress report. Idaho Department of Fish and Game Report 12-18. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Sandford, B. P., and S. G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River basin anadromous salmonids, 1990-1997. Journal of Agricultural, Biological and Environmental Statistics 7:243-263.

Schrader, W. C., T. Copeland, M. W. Ackerman, K. Ellsworth, and M. R. Campbell. 2011. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, spawn year 2009. Idaho Department of Fish and Game Report 11-24. Annual report 2009, BPA Projects 1990-055-00, 1991-073-00, 2010-026-00.

Schrader, W. C., T. Copeland, P. Kennedy, M. W. Ackerman, K. K. Wright, and M. R. Campbell. 2012. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, spawn year 2010. Idaho Department of Fish and Game Report 12-16. Annual report 2010, BPA Projects 1990-055-00, 1991-073-00, 2010-026-00.

Table 5. Escapement, aging method used, and ocean age proportion of wild Chinook salmon at Lower Granite Dam by adult return year 1998-2012.

Adult Return Year	Wild Escapement	Aging Method	Sample Size	Ocean Age 0[a]	1	2	3	4	Total
1998	5,500	Fin rays	173	n/a	0.0222	0.1142	0.8303	0.0333	1.0000
1999	2,931	Fin rays	267	n/a	0.0805	0.7376	0.1539	0.0280	1.0000
2000	8,847	Fin rays	311	n/a	0.1695	0.7843	0.0462	0.0000	1.0000
2001	38,684	Fin rays	930	n/a	0.0419	0.9302	0.0273	0.0006	1.0000
2002	28,083	Fin rays	719	n/a	0.0121	0.5344	0.4435	0.0100	1.0000
2003	31,619	Fin rays	688	n/a	0.0743	0.1918	0.7187	0.0152	1.0000
2004	17,790	Fin rays	578	n/a	0.0552	0.8413	0.1011	0.0024	1.0000
2005	9,077	Scales	517	0.0039	0.0387	0.6499	0.3017	0.0058	1.0000
2006	9,067	Scales	745	0.0013	0.0309	0.7570	0.2081	0.0027	1.0000
2007	8,808	Scales	862	0.0012	0.1253	0.4292	0.4432	0.0012	1.0000
2008	16,379	Scales	618	0.0016	0.1408	0.6909	0.1650	0.0016	1.0000
2009	16,479	Scales	808	0.0000	0.2116	0.6077	0.1795	0.0012	1.0000
2010	27,664	Scales	1,151	0.0009	0.0495	0.9001	0.0495	0.0000	1.0000
2011[b]	26,673	Scales	2,004	0.0070	0.1522	0.5554	0.2854	0.0000	1.0000
2012[c]	21,746	Scales	2,010	0.0020	0.0542	0.6522	0.2891	0.0025	1.0000

[a] Mini-jack (ocean age-0) samples were not sampled on the spawning grounds, thus mini-jack fin rays are not available for smolt migration years 1996-2004; only mini-jacks >30 cm, FL, were sampled for scales at Lower Granite Dam for smolt migration years 2005-2012.

[b] Preliminary until the spawn year 2011 Lower Granite Dam report is complete (Schrader et al., in preparation).

[c] Preliminary until the spawn year 2012 Lower Granite Dam report is complete (Schrader et al., in preparation).

Table 6. Estimated number of wild Chinook salmon smolts at Lower Granite Dam, number of adults at Lower Granite Dam by ocean-age, and percent smolt-to-adult return rate (SAR). 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 2005-2012 (below the dashed line). SAR confidence intervals are at 95% and are given in parentheses.

Smolt Migration Year	Smolts	Ocean Age 0[a]	1	2	3	4	%SAR (95% CI)
1996	419,826	n/a	n/a[b]	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	20	0.39 (0.38-0.40)
2006	1,227,474	12	1,104	11,316	2,957	0	1.25 (1.23-1.27)
2007	787,150	10	2,306	10,014	1,370	0[c]	1.74 (1.71-1.77)[c]
2008	856,556	27	3,488	24,900	7,613[c]	54[d]	4.21 (4.17-4.26)[d]
2009	894,629	0	1,370	14,814[c]	6,286[d]		2.51 (2.48-2.54)
2010	1,275,339	24	4,059[c]	14,182[d]			1.43 (1.41-1.45)
2011	1,200,055	187[c]	1,180[d]				0.11 (0.11-0.12)
2012	1,719,047	44[d]					

[a] Mini-jack (ocean age-0) samples were not sampled on the spawning grounds, thus mini-jack fin rays are not available for smolt migration years 1996-2004; only mini-jacks >30 cm, FL, were sampled for scales at Lower Granite Dam for smolt migration years 2005-2012.

[b] Jack (ocean age-1) samples were not collected for migration year 1996.

[c] Preliminary until the spawn year 2011 Lower Granite Dam report is complete (Schrader et al., in preparation).

[d] Preliminary until the spawn year 2012 Lower Granite Dam report is complete (Schrader et al., in preparation).

PART 4—THE STOCK-RECRUITMENT RELATIONSHIP FOR WILD/NATURAL SPRING-SUMMER CHINOOK SALMON IN THE SNAKE RIVER BASIN

ABSTRACT

Stock-recruitment relationships are important for understanding how density-dependent factors affect abundance. I updated the Beverton-Holt stock-recruit model for Snake River spring-summer Chinook salmon with data from the 2010 brood year. The model uses data from 1990 through 2010. The number of females available for natural reproduction in 2010 was 36,348 fish. I estimated that 1,750,864 naturally produced smolts from the 2010 brood year passed Lower Granite Dam. Based on data from the 1990-2010 brood years, I computed intrinsic productivity to be 389 smolts per female and asymptotic production to be 1.64 million smolts estimated by nonlinear fit ($r^2 = 0.943$, $n = 21$). I further estimated the number of females naturally reproducing was 30,755 fish in 2011 and 22,783 fish in 2012. Based on the updated Beverton-Holt curve, I predict that 1.44 million naturally produced smolts should pass Lower Granite Dam in 2011 and 1.38 million smolts in 2012.

Author:

Patrick Kennedy
Senior Fishery Research Biologist

INTRODUCTION

The relationship between parental abundance and subsequent recruitment of progeny is the focus of a significant portion of fisheries research and management efforts. A stock-recruitment analysis describes the intrinsic productivity of a population, or the demographic ability of a population to sustain itself, assuming all influential factors remain constant. This analysis is typically an empirical process simplifying the many intervening stages by aggregating life history stages (Hilborn and Walters 1992). The goal is to produce a predictive model, which is a description of the observed pattern, i.e. the regularities of the system under consideration (Rigler 1982). A mathematical model is chosen and fitted to the data, but such stock-recruit relationships often have poor explanatory power (Hall 1988).

Sources of variation in survival of Pacific salmon *Oncorhynchus sp.* can be split between freshwater and saltwater phases in approximately equal magnitudes (Bradford 1995). For threatened Snake River spring-summer Chinook salmon, hereafter Chinook salmon, variance in survival during both freshwater and saltwater life stages must be understood for decision makers to effectively select measures to promote recovery. Stock-recruit data are useful for evaluating and understanding the effectiveness of management efforts in the freshwater phase (Bradford et al. 2005).

Stock-recruitment relationships for Columbia River basin Chinook salmon have been described using a Beverton-Holt (BH) function (NPPC 1986) or a Ricker function (Petrosky et al. 2001). In a BH function, the relationship is regulated by density-dependent mortality during the juvenile stage and is asymptotic in shape (Beverton and Holt 1957). In a Ricker function, regulatory mechanisms cause declines in recruitment at higher stock densities (Ricker 1954). I used a BH function because previous work showed that it yielded a better model fit than the Ricker function (Copeland et al. 2004).

The most serious problem in a stock-recruitment analysis is error in estimation of adult and recruit abundance (Hilborn and Walters 1992). For Chinook salmon, smolt emigration is a convenient and meaningful stage to assess recruitment (Solomon 1985). The Columbia River hydrosystem presents a unique opportunity to estimate the stock-recruitment relationships (i.e. adult and smolt abundances) using the efficient counting mechanisms that exist at the dams in the Lower Snake River and the Columbia River. Previously, this project has constructed a stock-recruit model of wild smolt production by Chinook salmon spawning naturally upstream of Lower Granite Dam (LGR) (Kiefer et al. 2004; Copeland et al. 2004, 2005, 2006, 2007, 2008; Kennedy et al. 2011, 2012). The model is used to estimate the intrinsic productivity for the wild Snake River spring-summer Chinook salmon Evolutionary Significant Unit (ESU). Here, I updated the BH stock-recruit model with data from the 2010 brood year. I also estimated the number of females spawning naturally in 2012.

METHODS

Females Available for Natural Reproduction

I estimated intrinsic productivity using a stock-recruit model for the aggregate population of Chinook salmon by relating the abundance of emigrating smolts at LGR to the number of female parents available for natural reproduction. The number of Chinook salmon females available for natural reproduction (FANR) upstream of LGR was estimated using methods consistent with Kennedy et al. (2011). The estimated number of adults per run type (excluding

jacks) passing LGR during 2012 was obtained directly from the Fish Passage Center website (www.fpc.org, accessed February 2013). At Columbia River dams, U.S. Army Corps of Engineers (COE) designates jack Chinook salmon as fish between 30 and 56 cm in length at the counting window. Adult Chinook salmon that pass LGR between March 3 and June 17 are defined as "spring run," and those passing LGR between June 18 and August 17 are defined as "summer run." The total number of adult Chinook salmon (excluding jacks) captured at hatchery traps and the number of females taken into hatcheries was obtained from the Pacific States Marine Fish Commission hatchery database and the Oregon Department of Fish & Wildlife (ODFW; Joseph Feldhaus, personal communication). McCall and Pahsimeroi hatchery fish were considered summer run and all other hatchery stocks were considered spring run. The percentage of females, by run type, was estimated for all adult Chinook salmon identified to sex at hatchery weirs. The estimated percentage of females was applied to the aggregate LGR counts for each run type to estimate the total number of female Chinook salmon passing LGR. The total harvest estimates upstream of LGR were obtained from the Idaho Department of Fish and Game (IDFG) (Alan Byrne, personal communication), Nez Perce Tribe (Joe Oatman, personal communication), Shoshone-Bannock Tribes (Kurt Tardy, personal communication), and ODFW (Joseph Feldhaus, personal communication). Female harvest was estimated by multiplying run-specific total harvest by the respective sex ratio. To estimate the FANR, the adjusted hatchery female number and the adjusted number of females harvested upstream of LGR were subtracted from the estimated number of females passing LGR. Spring and summer FANR estimates were combined to estimate total FANR.

Stock-Recruit Model

Smolt production was estimated using daily counts of wild smolts at LGR and estimated daily collection efficiencies from March 26 to July 15, 2012. The total daily wild Chinook salmon smolt migration number was estimated by dividing the daily count of wild smolts by the estimated collection efficiency for that day. The daily counts of wild Chinook salmon smolts at LGR were obtained from the Fish Passage Center website (www.fpc.org, accessed February 2013) and estimated daily smolt collection efficiencies were obtained from the Northwest Fisheries Science Center (NWFSC; Steve Smith, personal communication). Efficiencies were estimated by NWFSC personnel using procedures detailed in Sandford and Smith (2002). Daily abundance estimates were summed for the year.

A Beverton-Holt function was used for this analysis. Kennedy et al. (2012) estimated the FANR for brood years (BYs) 1990-2010 and the number of smolts produced by BY 1990-2010. The smolt estimate from the 2012 migration (BY 2010) was added to the data. The stock-recruit model was refit using the Beverton-Holt formula (Ricker 1975).

$$R = \frac{1}{\alpha + \beta/P},$$

where P = parent year spawning escapement (i.e. FANR), R = recruits (smolts) produced by parent year spawning escapement (P), and α and β are fitted parameters representing the slope at the origin and the asymptote. In this formulation, α is the inverse of asymptotic production and β is the inverse of slope at the origin (Quinn and Deriso 1999). Model parameters were estimated using iterative nonlinear regression (Gauss-Newton algorithm; SYSTAT® 13).

RESULTS

Females Available for Natural Reproduction

We estimated 22,783 female Chinook salmon were available for natural reproduction in 2012 (Table 7). From the estimated number of hatchery and wild adult Chinook salmon crossing LGR during 2012 (79,529), which excludes jacks by length, there were 40,250 females comprising 50.6% of the adult run. Estimated removals above LGR totaled 17,468 females. Hatchery take accounted for 6,804 and angler harvest, including estimated incidental mortality, accounted for 10,664 females.

Stock-Recruit Model

The Beverton-Holt stock-recruit model fit the data very well ($r^2 = 0.943$, $n = 21$; Figure 5) and there was no obvious pattern in the model residuals when compared to predicted values (data not shown). The variance may be constrained at low abundances, but there was no indication of accelerating variances with increasing abundance. For BYs 1990-2010, estimated maximum intrinsic productivity (β) was 389 smolts per female and asymptotic production (α) was 1.64 million natural smolts from the Snake River ESU. The estimated number of smolts emigrating from the Snake River ESU past LGR during smolt year 2012 was 1,719,047 Chinook salmon (Table 8). The BH model predicts that smolt production for BY 2011 should exceed 1.4 million smolts and BY 2012 should exceed 1.3 million smolts. This completes the data set for BYs 1990-2010.

DISCUSSION

The stock-recruit curve now describes intrinsic productivity for Chinook salmon for over a 20 year time series (Figure 5; $r^2 = 0.943$, $n = 21$). As escapement decreases, I observe that the predicted smolt abundances follow. Asymptotic production appears to be slightly over 1.6 million wild Chinook salmon smolts under current conditions. There are a number of candidate hypotheses for this observed asymptote in wild Chinook salmon productivity (Table 9). This is the first time the asymptotic production has increased to over 1.6 million natural smolts for over five years. High escapements beginning with BY 2010 resulted in better freshwater productivity.

Historical data that was used to estimate hatchery take may be a substantial source of uncertainty in the FANR time series. A hatchery database for all hatcheries in Idaho is approaching maturation which will result in improved hatchery return estimates. Past estimates of hatchery take and sex ratios should be reviewed for additional quality control when the data are finalized in the database.

The productivity of Idaho's aggregate spring-summer Chinook salmon population has varied widely over the time series as measured by the number of smolts-per-female (Table 8). Over the 21-year time series, there was an average of 155 smolts-per-female. Adult productivity varies with spawner abundance and typically decreases after years with high escapement. This stock-recruit curve describes productivity differently than the status assessments for the Endangered Species Act (ESA), so understanding how current productivity compares between methods is difficult.

ACKNOWLEDGEMENTS

We are grateful to the Bonneville Power Administration and Susan Offerdal, our contracting officer's technical representative, for support and funding of this research. Bill Schrader, Lance Hebdon, Kim Apperson, Jon Flinders, Matt Corsi, and Jordan Messner provided helpful reviews of this section of the report. Cheryl Zink helped format and edit the document.

LITERATURE CITED

Adkison, M. D. 1995. Population differentiation in Pacific salmon: local adaptation, genetic drift, or the environment? Canadian Journal of Fisheries and Aquatic Sciences 52:2762-2777.

Arthaud, D., K. Kratz, J. Morrow, C Vandemoer, and M. Grady. In preparation. Streamflow and salmon production in the interior Columbia basin. National Marine Fisheries Service, Boise, Idaho.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fisheries Investigation Series 2, Vol. 19. U.K. Ministry of Agriculture and Fisheries, London, England. Bradford, M. J. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52:1327-1338.

Bradford, M. J. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52:1327-1338.

Bradford, M. J., J. Korman, and P. S. Higgins. 2005. Using confidence intervals to estimate the response of salmon populations (*Oncorhynchus* sp.) to experimental habitat alterations. Canadian Journal of Fisheries and Aquatic Sciences 62:2716-2726.

Copeland, T., J. Johnson, and P. R. Bunn. 2004. Idaho natural production monitoring and evaluation, 2003 annual progress report. Idaho Department of Fish and Game Report 04-47. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and P. R. Bunn. 2005. Idaho natural production monitoring and evaluation, 2004 annual progress report. Idaho Department of Fish and Game Report 05-38. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and P. R. Bunn. 2006. Idaho natural production monitoring and evaluation, 2005 annual progress report. Idaho Department of Fish and Game Report 06-30. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, S. Kraft, and P. R. Bunn. 2007. Idaho natural production monitoring and evaluation, 2006 annual progress report. Idaho Department of Fish and Game Report 07-31. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and S. Putnam. 2008. Idaho natural production monitoring and evaluation, 2007 annual report. Idaho Department of Fish and Game Report 08-08. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Flebbe, P. A. 1997. Global climate change and fragmentation of native brook trout distribution in the southern Appalachian Mountains. Pages 117-121 in R. E. Gresswell, P. Dwyer, and R. H. Hamre, editors. Wild Trout VI: Putting the native back in wild trout, proceedings of the 6th Wild Trout Conference. Bozeman, Montana.

Fleming, I. A., and M. R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecological Applications 3:230-245.

Hall, C. A. S. 1988. Assessment of several of the historically most influential theoretical models used in ecology and of the data provided in their support. Ecological Modeling 43:5-31.

Hamann, E. J. and B. P. Kennedy. 2012. Juvenile dispersal affects straying behaviors of adults in a migratory population. Ecology 93(4): 733-740.

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment: choices, dynamics, and uncertainty. Kluwer Academic Publishers, Boston.

Isaak, D. J., and R. F. Thurow. 2006. Network-scale and temporal variation in Chinook salmon redd distributions: patterns inferred from spatially continuous replicate surveys. Canadian Journal of Fisheries and Aquatic Sciences 63:285-296.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, and R. Hand. 2011. Idaho Natural Production Monitoring and Evaluation, 2009-2010 annual progress report. Idaho Department of Fish and Game Report 11-23. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand, and M. Corsi. 2012. Idaho Natural Production Monitoring and Evaluation, 2011 annual progress report. Idaho Department of Fish and Game Report 12-18. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kiefer, R. B., J. Johnson, P. R. Bunn, and A. Bolton. 2004. Natural production monitoring and evaluation. Annual report 2003. Idaho Department of Fish and Game Report 03-30. Prepared for U. S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Levin, P. S., S. Achord, B. E. Feist, and R. W. Zabel. 2002. Non-indigenous brook trout and the demise of Pacific salmon: a forgotten threat? Proceedings of the Royal Society of London B 269:1663-1670.

Lichatowich, J. A., and L. E. Mobrand. 1995. Analysis of Chinook salmon in the Columbia River from an ecosystem perspective. Prepared for U. S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 92-18. Portland, Oregon.

Naiman, R. J., R. E. Bilby, D. E. Schindler, and J. M. Helfield. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems 5:230-245.

NPPC (Northwest Power Planning Council). 1986. Columbia River basin fishery planning model. Technical discussion paper. Northwest Power Planning Council. Portland, Oregon.

Petrosky, C. E., H. A. Schaller, and P. Budy. 2001. Productivity and survival rate trends in the freshwater spawning and rearing stage of Snake River Chinook salmon *Oncorhynchus tshawytscha*. Canadian Journal of Fisheries and Aquatic Sciences 58:1196-1207.

Pollock, M. M., G. R. Pess, T. J. Beechie, and D. R. Montgomery. 2004. The importance of beaver ponds to coho salmon production in the Stillaguamish River basin, Washington, USA. North American Journal of Fisheries Management 24:749-760.

Quinn, T. J., and R. B. Deriso. 1999. Quantitative fish dynamics. Oxford University Press, New York.

Ricker, W. E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada 11:559-623.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada Number 191. 382 pp.

Rigler, F. H. 1982. Recognition of the possible: an advantage of empiricism in ecology. Canadian Journal of Fisheries and Aquatic Sciences 39:1323-1331.

Sandford, B. P., and S. G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River basin anadromous salmonids, 1990-1997. Journal of Agricultural, Biological and Environmental Statistics 7:243-263.

Schoennagel, T., T. T. Veblen, W. H. Romme, J. S. Sibold, and E. R. Cook. 2005. ENSO and PDO variability affect drought-induced fire occurrence in Rocky Mountain subalpine forests. Ecological Applications 15:2000-2014.

Solomon, D. J. 1985. Salmon stock and recruitment, and stock enhancement. Journal of Fish Biology 27(Supplement A):45-57.

Thurow, R. F. 2000. Dynamics of chinook salmon populations within Idaho's Frank Church wilderness: implications for persistence. Pages 143-151 In: McCool, S. F.; Cole, D. N.; Borrie, W. T.; O'Loughlin, J. Wilderness science in a time of change conference-Volume 3: Wilderness as a place for scientific inquiry, May 23-27, 1999, Missoula, MT. U.S. Forest Service, Proceedings, RMRS-P-15-VOL-3.

Weber, E. D., and K. D. Fausch. 2003. Interactions between hatchery and wild salmonids in streams: differences in biology and evidence for competition. Canadian Journal of Fisheries and Aquatic Sciences 60:1018-1036.

Table 7. Estimated adult Chinook salmon females available for natural reproduction (FANR) for 2012, estimated from percentage of females based on hatchery sex ratios applied to the total run at Lower Granite Dam, and accounting for adult females removed by harvest and at hatchery weirs. Harvest was increased by 10% to account for incidental hooking mortality.

	Run Type		
Estimate	**Spring**	**Summer**	**Total**
Dam count	66,366	13,163	79,529
Percent females	49.6%	55.7%	50.6%
Total females	32,918	7,332	40,250
Removals			
Hatchery	5,218	1,586	6,804
Harvest	9,416	1,248	10,664
FANR	18,284	4,498	22,783

Table 8. Abundance of Snake River spring-summer Chinook salmon females available for natural reproduction (FANR), and the number of wild smolts estimated at Lower Granite Dam by brood year and smolt year used to construct the Beverton-Holt stock-recruit model. The result of the model estimated the number of smolts-per-female over the 21 year time series.

Brood Year	Smolt Year	FANR	Smolts	Smolts/Female
1990	1992	4,976	527,000	105.9
1991	1993	2,916	627,037	215.0
1992	1994	6,826	627,942	91.9
1993	1995	8,514	1,558,786	183.1
1994	1996	1,043	419,826	402.5
1995	1997	497	161,157	324.3
1996	1998	1,556	599,159	385.1
1997	1999	11,885	1,560,298	131.3
1998	2000	3,726	1,344,382	360.8
1999	2001	1,630	490,534	300.9
2000	2002	8,733	1,128,582	129.2
2001	2003	51,902	1,455,786	28.1
2002	2004	31,415	1,517,951	48.3
2003	2005	26,126	1,734,464	66.4
2004	2006	28,374	1,227,474	43.3
2005	2007	10,899	787,150	72.2
2006	2008	9,253	856,556	92.6
2007	2009	8,562	894,629	104.5
2008	2010	22,942	1,275,339	55.6
2009	2011	17,314	1,200,055	69.3
2010	2012	36,348	1,719,047	47.3
2011	2013	30,755	1,445,683[a]	47.0
2012	2014	22,783	1,387,050[a]	60.9

[a] Predicted values based on the Beverton-Holt model.

Table 9. Candidate hypotheses explaining density dependence observed in smolt production of Snake River spring-summer Chinook salmon populations during 1990-2012.

Hypothesis	Explanation
Marine-derived nutrients	Lack of adult carcasses reduces carrying capacity of infertile spawning streams (Naiman et al. 2002).
Retreat to core areas	Current spawners home to relatively small patches of habitat (Thurow 2000; Isaak and Thurow 2006, Hamann and Kennedy 2012).
Invasion of predators and competitors	Introduced species and hatchery-produced fish compete with and prey on young salmon (Levin et al. 2002; Weber and Fausch 2003).
Hatchery strays and supplementation fish	Hatchery fish do not spawn as effectively as natural fish, and strays or supplementation fish may increase localized density dependence. (Fleming and Gross 1993).
Habitat loss	Reduction of off-channel habitat in spawning and rearing areas (Pollock et al. 2004).
Temperature stress	Global warming and loss of tree cover via forest fires and grazing raise water temperatures at critical times (Flebbe 1997; Schoennagel et al. 2005).
Drought/low flows	High escapements are coincident with drought. Stream flow is critical to juvenile survival in the interior Columbia basin (Arthaud et al. 2004).
Life history diversity	Loss of local adaptations and temporal variations in movement lead to a reduction in occupied habitat and regional productivity (Adkison 1995; Lichatowich and Mobrand 1995).

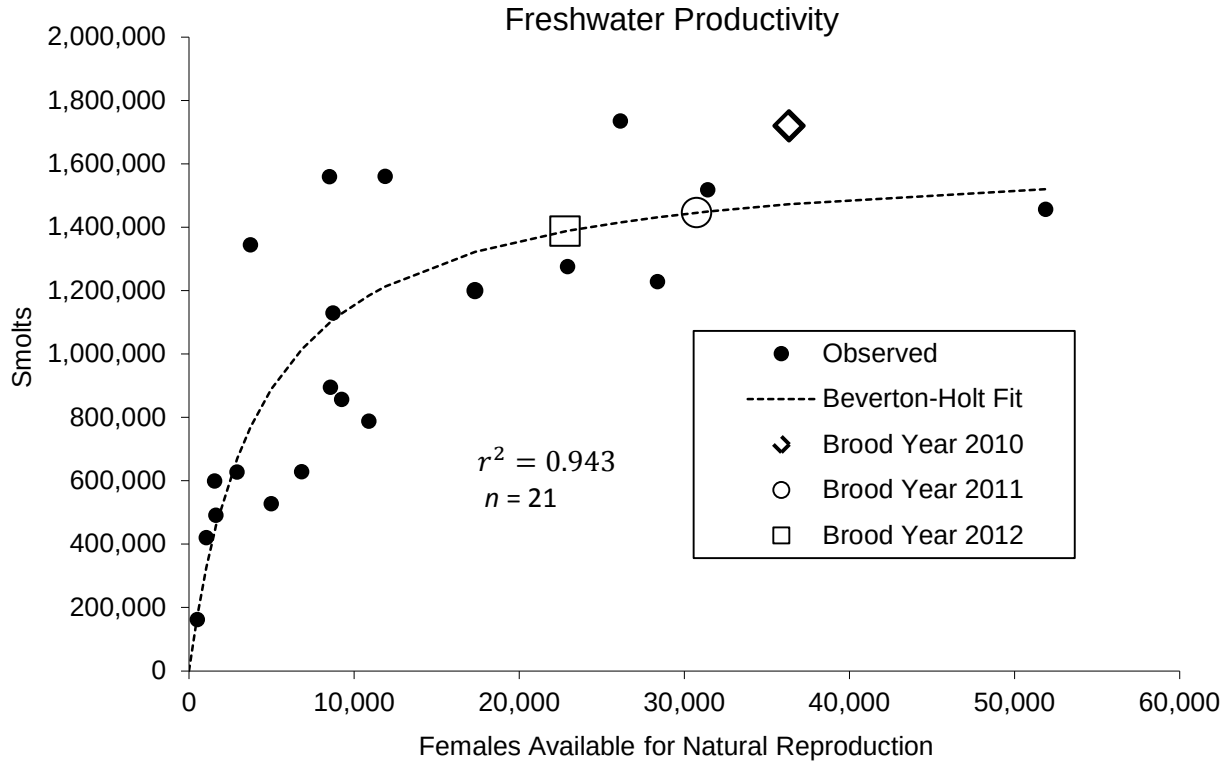

Figure 5. Comparison of observed smolt abundance at Lower Granite Dam and females available for natural reproduction for brood years 1990-2010, to model predictions in 2011 and 2012 from the Snake River spring-summer Chinook salmon Beverton-Holt stock-recruit model.

PART 5— WILD CHINOOK SALMON AND STEELHEAD JUVENILE DENSITY AND SPATIAL STRUCTURE

ABSTRACT

Snorkel surveys are widely used for monitoring fish populations because they are a versatile, cost-effective technique. Idaho Natural Production Monitoring and Evaluation Project crews surveyed transects to describe Chinook salmon and steelhead juvenile density, productivity, and spatial structure. Extensive panel surveys were conducted to assess salmonid distribution at the landscape scale. Extensive surveys document occupancy rates for steelhead in the Potlatch River drainage (55%), South Fork Clearwater drainage (58%), Camas Creek drainage (74%), Rapid River drainage (65%), and the Middle Fork Salmon River drainage (53%). Annual intensive survey panels were completed in Crooked Fork Creek, Fish Creek, Crooked River, and Marsh Creek. These data will be used to calibrate screw trap production estimates to snorkel survey data in a future analysis. We conducted mark-resight studies at 29 locations to assess detection probability for steelhead parr. Transect detection probabilities ranged from 12.5% to 100% with a mean of 45.8%.

Authors:

Jordan Messner
Regional Fisheries Biologist

Patrick Kennedy
Senior Fishery Research Biologist

Kimberly A. Apperson
Regional Fisheries Biologist

Jon Flinders
Regional Fisheries Biologist

Robert Hand
Regional Fisheries Biologist

INTRODUCTION

The purpose of the snorkel surveys is to provide information for monitoring the status of Idaho's wild Chinook salmon and steelhead populations with respect to the viable salmonid population (VSP) criteria (McElhany et al. 2000) and how abundance and spatial structure are trending over time (Schill et al. 2004; Copeland and Meyer 2011). In the 1950s, the Idaho Department of Fish and Game (IDFG) developed a program to index annual spawning escapement by enumerating Chinook salmon redds in selected areas. The number of redds counted in these areas provide an index of the annual wild adult Chinook salmon spawner abundance at the independent population scale (Figure 1; see ICBTRT 2005 for population delineations). In Idaho, steelhead redds are not as useful in describing abundance and spatial distribution because turbid, high water associated with snowmelt coincides with steelhead spawning. Therefore, snorkel survey data describing juvenile abundance and distribution are particularly important for steelhead.

Snorkel surveys are widely used for monitoring fish populations because they are a versatile, cost-effective technique. Snorkel surveys are feasible where environmental conditions limit the effectiveness of other techniques, such as electrofishing (Schill and Griffith 1984). Gear and personnel requirements are comparatively modest, allowing more remote locations to become feasible to sample (Hankin and Reeves 1988; Thurow 1994). Because snorkel surveys are non-lethal and less intrusive than other field methods, they are an appropriate means to monitor fishes listed under the Endangered Species Act (e.g., Chinook salmon, steelhead trout, and bull trout *Salvelinus confluentus*).

Snorkel surveys are one of the main techniques used by the IDFG to monitor juvenile salmonid populations. Methods for conducting fish abundance surveys by snorkeling have been developed and refined by IDFG for decades (e.g., Corley 1972, Lindland 1974, Reingold 1981). Current methods for snorkel surveys for monitoring the parr of Chinook salmon and steelhead trout were originally developed by Petrosky and Holubetz (1986) to assess effects of habitat improvement projects. This effort developed into the General Parr Monitoring program (GPM; Scully et al. 1990). Since then, IDFG snorkel survey methods evolved and were especially influenced by Thurow's (1994) review. More recently, O'Neal (2007) summarized current standards for conducting snorkel surveys for salmonids.

Snorkel survey results from 2012 estimate the distribution and abundance of wild Chinook salmon and steelhead parr in tributaries of the Salmon River and Clearwater River subbasins in coordination with the Idaho Steelhead Monitoring and Evaluation Studies (ISMES; Bonneville Power Administration project #1990-055-00).

METHODS

Field surveys were performed during summer base-flow conditions. The percentage of each habitat type (pool, pocket water, riffle, or run) within each transect was recorded. One to five snorkelers counted fish in each transect while moving upstream. The number of snorkelers depended on the stream width and visibility. All salmonids were identified to species, counted, and their size estimated to the nearest 25 mm length group. Chinook salmon parr were assigned an age based on length. Trout less than 50 mm cannot be distinguished between steelhead and westslope cutthroat trout *Oncorhynchus clarkii lewisi* with underwater observation and were designated as "trout fry." Non-salmonids and amphibians were noted if present. After the crew snorkeled each transect, they measured the total linear length and one to ten widths to

calculate the surface area. We used a rotating panel design (Larsen et al. 2001) to select from previously established snorkeling transects focusing on three objectives: 1) to conduct surveys at core and non-core trend transects for maintaining the long-term juvenile-to-juvenile productivity data series for steelhead; 2) to conduct extensive surveys to assess parr distribution and abundance at the population scale; and 3) to conduct intensive surveys to calibrate parr densities with production of juvenile emigrants estimated from screw traps in target drainages.

For the first objective, transects were selected from previously established trend transects on a two-year rotating panel (Table 10). For the intensive and extensive panels, transect selection was based on a generalized random-tessellation stratification design (Stevens and Olsen 2004) to be a spatially-balanced, probabilistic selection from all potential transects. A list of all potential transects in the Clearwater and Salmon river subbasins were obtained from the U.S. Environmental Protection Agency (EPA) office in Corvallis, Oregon using their Environmental Monitoring and Assessment Program (EMAP). These transects were plotted on a 1:100,000 stream layer and their order randomized by EPA. We used the anadromous stream data layer from StreamNet (www.streamnet.org) to determine which transects in each drainage were within the anadromous production zone. Transects that fell within a 100 m buffer of an anadromous stream were retained. An ordered list of approximately twice the desired number of transects was drawn for the study drainages. Each potential transect was assigned a unique code for data entry forms and the IDFG Standard Stream Survey database. Transect priority started with the lowest number (high priority) and proceeded to the highest number (low priority). High priority transects were included or rejected before lower priority transects could be considered in survey plans. Criteria for rejection were: 1) the transect could not be safely surveyed or boundaries adjusted to make it safe; 2) the location was above a barrier that would block spring movement of adult steelhead; 3) there was no water in the transect at the time of survey; 4) the private property owner denied access to the transect; or 5) the transect was too wide or complex to be surveyed efficiently by the full crew (six surveyors).

Forty transects were assigned to each large extensive drainage (e.g., Potlatch River, Camas Creek). Sample sizes were based upon previous power analysis (Copeland et al. 2008) and logistics. The intensive drainages and smaller extensive drainages were assigned desired sample sizes of 25 (140 total). The desired transect length was 100 m, but transect length and location was adjusted by the crew leader based on stream conditions with transect bounds adjusted to fit within hydraulic controls. A transect was relocated upstream or downstream for up to 500 m from the designated point if necessary.

We estimated summaries of salmonid densities (standardized to abundance per 100 m^2) and occupancy rates observed by drainage. The probabilistic selection of transects was considered a representative sample for the drainage; thus, the proportion of transects where a species is present in a drainage equals the occupancy rate. Occupancy rates were only estimated for extensive and intensive panels. The total number of fish per species within each transect divided by the transect area equaled the density. Density was estimated by species for all transects surveyed annually.

Core and Non-core Trend Surveys

Core trend transects were defined as locations where at least one survey had been conducted within each 5-year period during 1984-2011, including other transects deemed important (e.g., main-stem Middle Fork Salmon River and Selway River transects). There were 218 core trend transects identified. Survey plans were made to do as many core transects as logistically feasible on a 2-year rotating panel (Table 10) during the months of July and August.

Extensive Panel Surveys

Extensive panel surveys were conducted to assess salmonid distribution at the landscape scale. Extensive panel drainages were chosen based on the data needs for steelhead spawning aggregates as defined by the Interior Columbia Technical Recovery Team. For the extensive panel, we chose the Potlatch River drainage, South Fork Clearwater drainage, Camas Creek drainage, Rapid River drainage (Little Salmon River steelhead population), and the Upper Middle Fork Salmon River drainage (Middle Fork Salmon River upper main-stem steelhead population; including Marble Creek, Sulphur Creek, Indian Creek, Dagger Creek, and Bear Valley Creek). All areas were surveyed between May 25 and August 20, 2012.

Intensive Panel Surveys

Intensive surveys were used to calibrate the densities observed during snorkel surveys. Snorkel survey data will be calibrated against screw trap estimated juvenile abundance in selected drainages. Therefore, intensive panel drainages were chosen based upon the location of associated screw traps. The calibration analysis will occur when intensive surveys are completed in all drainages with a screw trap. This knowledge can be applied to the extensive surveys to better understand the production of smolts out of those drainages. For the intensive panel in 2012, we chose Crooked Fork Creek (Lochsa River steelhead population), Fish Creek and the Crooked River (South Fork Clearwater River steelhead population), and Marsh Creek (Middle Fork Salmon River upper main-stem steelhead population).

Detection Probability

We evaluated the efficiency of snorkeling for juvenile steelhead at a subset of transects. A protocol modified from Thurow et al. (2006) was designed to allow us to estimate detection probability through observation of marked individuals. Juvenile steelhead were collected in the transect via angling, measured, marked (upper caudal notch), and released as close to the location of capture as possible. The next day, snorkeling began approximately 50 m downstream of the transect (lower half of oversample transect) and the number of marked fish was recorded. Then, the main 100 m transect (target transect) was snorkeled and all salmonids were counted and recorded by length group. Finally, a section approximately 50 m in length upstream of the main transect (upper half of oversample transect) was snorkeled and the number of marked fish was recorded. Boundaries of target and oversample transects were adjusted to begin and end at hydraulic controls. Habitat variables described by Thurow et al. (2006) were measured in the target transect. A target for the number of resight surveys conducted each year was for at least 10% of the total transects surveyed. We present a summary of data collected at each transect. The probability of detection was computed as the number of marked fish seen in the target and oversample reaches divided by number marked. We assumed fish would not move farther than 50 m between marking and the subsequent snorkel survey.

RESULTS

During 2012, 465 snorkel surveys were completed. Four GPM trend sites were also used as EMAP intensive panel survey transects. Two of those transects were in the Crooked River drainage (West Fork Crooked River – trend site WF2 – EMAP site 256578, and Crooked River – trend site Control1 – EMAP site 50754) and two were in the Crooked Fork Creek

drainage (Crooked Fork Creek – trend site 2 – EMAP site 64321, and Crooked Fork Creek – trend site 1B – EMAP site 94017).

Core and Non-core Trend Surveys

A total of 67 core and 27 non-core trend transects were surveyed in the Salmon River subbasin (Tables 11 and 12). Six salmonid species were identified, and trout fry and hybrid fish were also observed. Steelhead were observed at 78 transects, Chinook salmon were observed at 74 transects, westslope cutthroat trout were observed at 58 transects, bull trout were detected at 26 transects, brook trout *Salvelinus fontinalis* were observed at 25 transects, mountain whitefish *Prosopium williamsoni* were observed at 64 transects, and cutthroat trout X *O. mykiss* hybrids were observed at one transect. Chinook salmon were highly abundant in some transects and exceeded 30 fish/100 m^2 in Bear Valley Creek transect 3A, and 40 fish/100 m^2 in in the Pahsimeroi River transect at Dowton Lane.

In the Middle Fork Salmon River drainage, 31 main-stem trend transects (25 core and 6 non-core) and 24 tributary trend transects (13 core and 9 non-core) were surveyed. In the core main-stem transects (Table 11), five salmonid taxa were identified: juvenile steelhead, Chinook salmon parr, cutthroat trout, bull trout, and mountain whitefish. Mean density was highest for Chinook salmon at 2.23 fish/100 m^2, with the highest observed for this species at the Boundary transect at 23.48 fish/100 m^2. No brook trout, hybrid fish, or trout fry were observed in the main-stem of the Middle Fork Salmon River. The same five salmonid taxa were identified in the MFSR core tributary transects, and brook trout and trout fry were also observed. In the core tributary transects, mean density was highest for Chinook salmon parr (6.49 fish/100 m^2), followed by mountain whitefish (3.11 fish/100 m^2) and steelhead parr (3.04 fish/100 m^2).

Nine trend transects were surveyed in the Little Salmon River drainage in 2012 (three core and six non-core). Six salmonid taxa were identified: juvenile steelhead, Chinook salmon, cutthroat trout, bull trout, brook trout, and mountain whitefish. Unidentified trout fry were also observed. Mean density was highest for steelhead parr at 5.53 fish/100 m^2, with the highest density observed for this species at Boulder Creek transect 5 (16.46 fish/100 m^2).

Fifteen trend transects were surveyed in the South Fork Salmon River drainage in 2012, all of which were core trend transects. Six salmonid taxa were identified: juvenile steelhead, Chinook salmon, cutthroat trout, brook trout, bull trout, and mountain whitefish. Unidentified trout fry and cutthroat trout X *O. mykiss* hybrids were also observed. Mean density was highest for brook trout in the South Fork Salmon River drainage in 2012, at 6.20 fish/100 m^2, with the highest density observed at the Rock Creek transect M1 (80.40 fish/100 m^2). Mean steelhead and Chinook salmon densities at trend transects in the South Fork Salmon River drainage were 3.47 fish/100 m^2 and 1.98 fish/100 m^2, respectively. Cutthroat trout X *O. mykiss* hybrids were observed at one site (EF Salmon River transect 7), with a mean density of 0.21 fish/100 m^2.

In the upper main-stem Salmon River drainage, 15 trend transects were surveyed in 2012 (11 core and 4 non-core). Six species of salmonids were identified (juvenile steelhead, Chinook salmon, cutthroat trout, brook trout, bull trout, and mountain whitefish) along with unidentified trout fry. Chinook salmon parr were the highest observed species on average, at a mean density of 9.30 fish/100 m^2, and juvenile steelhead were the second highest observed at a mean density of 5.82 fish/100 m^2.

A total of 68 trend transects (54 core and 14 non-core) were surveyed in the Clearwater River subbasin in 2012 (Tables 13 and 14). Six salmonid taxa were identified in total (juvenile

steelhead, Chinook salmon, cutthroat trout, brook trout, bull trout, and mountain whitefish), and unidentified trout fry were also observed. Juvenile steelhead were observed at 54 transects, Chinook salmon parr were observed at 41 transects, cutthroat trout were observed at 63 transects, bull trout were observed at 19 transects, brook trout were observed at 16 transects, and mountain whitefish were observed at 45 transects. Chinook salmon parr and juvenile steelhead were the two most abundant salmonids in the Clearwater River subbasin with mean densities of 2.40 fish/100 m^2 and 1.88 fish/100 m^2, respectively. Chinook salmon density was highest in the Red River transect TREAT 2, in stratum 4, at 38.47 fish/100 m^2, and juvenile steelhead were most abundant in the Big Canyon Creek transect 1, with 41.08 fish/100 m^2.

Extensive Panel Surveys

A total of 71 extensive panel survey transects were completed in the Potlatch River drainage in 2012 (Table 15). Three salmonid taxa were identified: juvenile steelhead, brook trout, and mountain whitefish. Unidentified trout fry were also observed. Juvenile steelhead were observed at 39 transects, with a mean density of 1.83 fish/100 m^2. Brook trout were observed at 14 transects with a mean density of 0.31 fish/100 m^2. Mountain whitefish were observed at one transect (Potlatch River EMAP site 482), where density was 0.05 fish/100 m^2. The occupancy rate for steelhead within the drainage was 55%.

In the South Fork Clearwater drainage, 48 extensive panel survey transects were snorkeled in 2012 (Table 16). Six salmonid taxa were identified (juvenile steelhead, Chinook salmon parr, cutthroat trout, brook trout, bull trout, and mountain whitefish), and unidentified trout fry were observed. Chinook salmon parr were the most abundant species observed in the South Fork Clearwater drainage, with a mean density of 6.27 fish/100 m^2. Chinook salmon parr were highly abundant in select transects in the South Fork Clearwater drainage, with densities above 20 fish/100 m^2 at five transects, and above 40 fish/100 m^2 at two sites. Chinook salmon densities were highest at the American River transect 76354 and the Newsome Creek transect 47266, with mean densities of 47.57 fish/100 m^2 and 41.01 fish/100 m^2, respectively. Cutthroat trout were the second most abundant species in the South Fork Clearwater drainage, with a mean density of 1.48 fish/100 m^2. Steelhead had a mean density of 0.63 fish/100 m^2 and an occupancy rate of 58%.

In the Camas Creek drainage, 27 extensive panel survey transects were sampled in 2012 (Table 17). Six species of salmonids were identified (juvenile steelhead, Chinook salmon, cutthroat trout, brook trout, bull trout, and mountain whitefish), and unidentified trout fry were observed. Juvenile steelhead were the most abundant species observed in the drainage, with a mean density of 5.60 fish/100 m^2, and an occupancy rate of 74%. The highest observed density of juvenile steelhead was in Castle Creek (EMAP transect 100255) with 20.18 fish/100 m^2. Bull trout were the second most abundant salmonid in the Camas Creek drainage, with a mean density of 1.27 fish/100 m^2. Bull trout were observed in 19 of the 27 (70%) transects surveyed. Mean densities of cutthroat trout and mountain whitefish were 0.36 fish/100 m^2 and 0.41 fish/100 m^2, respectively. Chinook salmon parr were only observed at two transects, with an overall mean density of 0.01 fish/100 m^2 in the Camas Creek drainage.

Twenty extensive panel survey transects were sampled in the Rapid River drainage in 2012 (Table 18). Four species of salmonids were identified: juvenile steelhead, Chinook salmon, cutthroat trout, and bull trout. Unidentified trout fry were also observed in Rapid River. Juvenile steelhead were the most abundant salmonid observed in 2012, with a mean density of 2.27 fish/100 m^2, and an occupancy rate of 65%. Bull trout were also observed at a high proportion of the transects surveyed, with an occupancy rate of 85% and a mean density of 1.48 fish/100 m^2.

Chinook salmon parr were identified at five of the 20 transects surveyed (20%). Where hatchery origin fish could be distinguished from natural origin fish based on the presence/ absence of an adipose fin, hatchery origin Chinook salmon parr were found at 2 of 20 snorkel transects, but not found at the same transects as natural Chinook salmon parr. Transects were surveyed upstream and downstream of a hatchery weir. Chinook salmon parr were most abundant at Rapid River transect 215954, where only natural origin Chinook salmon were identified, and mean density was 3.02 fish/100 m^2.

There were 51 extensive panel survey transects snorkeled in the upper Middle Fork Salmon River drainage in 2012 (Table 19). Six salmonid taxa were identified (juvenile steelhead, Chinook salmon, cutthroat trout, brook trout, bull trout, and mountain whitefish) and unidentified trout fry were also observed. Juvenile steelhead were identified at 27 transects, Chinook salmon parr were identified at 19 transects, cutthroat trout were identified at 10 transects, bull trout were identified at 12 transects, brook trout were identified at 25 transects, and mountain whitefish were identified at 10 transects. Observed mean density was highest for Chinook salmon parr in the upper Middle Fork Salmon River in 2012, with the highest observed densities at Sack Creek transect 31831 (41.12 fish/100 m^2) and Pole Creek transect 14935 (27.05 fish/100 m^2). Brook trout and juvenile steelhead were the second and third most abundant species observed, with mean densities of 2.05 fish/100 m^2 and 1.88 fish/100 m^2, respectively. The occupancy rate for steelhead was 53%.

Intensive Panel Surveys

In the Crooked Fork drainage, 24 intensive panel transects were surveyed in 2012 (Table 20). Five salmonid taxa were identified: juvenile steelhead, Chinook salmon parr, cutthroat trout, bull trout, and mountain whitefish. Unidentified trout fry were also observed. Cutthroat trout were the most abundant salmonid observed in the Crooked Fork drainage in 2012, with an overall mean density of 1.86 fish/100 m^2 and an occupancy rate of 100%. Cutthroat were most abundant in the main-stem Crooked Fork at transect 80705, with a density of 12.89 fish/100 m^2. Chinook salmon and juvenile steelhead were the second and third most abundant taxa observed in the Crooked Fork drainage, with mean densities of 0.85 fish/100 m^2 and 0.76 fish/100 m^2, respectively, and occupancy rates of 38% and 96%, respectively. Bull trout were present at three transects and mountain whitefish were present at nine transects within the drainage. Both bull trout and mountain whitefish were present in low abundance (mean densities 0.02 fish/100 m^2 and 0.11 fish/100 m^2, respectively).

In the Crooked River drainage, 23 transects were surveyed (Table 21). Six taxa were identified: juvenile steelhead, Chinook salmon, cutthroat trout, bull trout, brook trout, and mountain whitefish. Unidentified trout fry and brook trout X bull trout hybrids were also observed. Occupancy rate and mean density was highest in the drainage for cutthroat trout (100% and 2.98 fish/100 m^2, respectively). The highest density of cutthroat trout in the Crooked River drainage was observed in the East Fork Crooked River transect 247362, with 10.81 fish/100 m^2. Chinook salmon were the second most abundant salmonid identified, with mean density 0.19 fish/100 m^2, although they were only observed at three transects, all in the main-stem Crooked River. Juvenile steelhead were observed in nine of 23 transects (39%), and had an overall mean density of 0.16 fish/100 m^2 in the drainage. Brook trout X bull trout hybrids were identified at one transect (EF Crooked River EMAP transect 219714) at a density of 0.14 fish/100 m^2.

Twenty-one intensive panel survey transects were snorkeled in the Fish Creek drainage in 2012 (Table 22). Five salmonid species were identified (juvenile steelhead, Chinook salmon,

cutthroat trout, bull trout, and mountain whitefish) and unidentified trout fry were observed. Steelhead and cutthroat trout were the most abundant taxa observed in the drainage in 2012, with mean densities of 5.72 fish/100 m^2 and 3.73 fish/100 m^2, respectively, and occupancy rates of 86% and 100%, respectively. Chinook salmon and mountain whitefish were observed in one of 21 transects, and bull trout were observed in two transects.

In the Marsh Creek drainage, 22 intensive panel survey transects were sampled (Table 23). Six salmonid taxa were identified: juvenile steelhead, Chinook salmon parr, cutthroat trout, bull trout, brook trout, and mountain whitefish. Unidentified trout fry were also observed. Mean density was highest for Chinook salmon parr at 12.26 fish/100 m^2 with the highest observed abundance in Marsh Creek (EMAP transect 56663) at 68.27 fish/100 m^2. Chinook salmon densities exceeded 40 fish/100 m^2 in five of the 22 transects. Westslope cutthroat trout were observed in low abundances within the drainage and were only present at two transects. Brook trout and steelhead were the second and third most abundant taxa in the Marsh Creek drainage, which were observed at overall mean densities of 1.71 fish/100 m^2 and 1.63 fish/100 m^2, respectively. Occupancy rates were 77% for steelhead and 55% for Chinook salmon in the drainage.

Detection Probability

We conducted mark-resight studies at 29 locations to assess detection probability for steelhead parr in 2012 (Table 24). Selected habitat variables were measured at these locations (data not shown). Crews marked 580 fish (including several cutthroat trout) and detected 283 of them. Twenty-three were observed outside of the main survey unit, sixteen of which were downstream. Transect detection probabilities ranged from 12.5% to 100% with a mean of 45.8%.

DISCUSSION

In 2012, Chinook salmon densities increased in comparison to the 2011 GPM trend transect surveys in the Salmon River drainage (9.16 fish/100 m^2 vs. 8.18 fish/100 m^2). Densities of steelhead parr increased in the Salmon River drainage as well (Kennedy et al. 2012; 5.31 fish/100 m^2 vs. 4.75 fish/100 m^2). Densities of steelhead parr in the Clearwater subbasin GPM sites were higher than those observed in 2011 (Kennedy et al. 2012; 5.98 fish/100 m^2 vs. 1.10 fish/100 m^2), however, densities of Chinook salmon parr were slightly lower than in 2011 (Kennedy et al. 2012; 3.38 fish/100 m^2 vs. 6.07 fish/100 m^2).

Extensive panel surveys continue to provide the best description of steelhead spatial structure and juvenile abundance. The utility of these surveys will be enhanced when calibrated with the intensive panel surveys to better describe juvenile productivity.

The intensive panel surveys are nearing completion which will facilitate the calibration of snorkel surveys with screw trap estimates. Several more drainages where screw traps are present need to be surveyed before this analysis will be completed.

Detection probability was computed as the number of marked fish seen in the target and oversample reaches divided by number marked. We included all marked fish observed in the oversample reaches because movement of marked fish from the target reach biased the estimate downwards. Keeping marked fish from the overreaches in the calculation increases precision because each marked fish is treated as an independent trial: seen or not seen. Habitat

variables were not measured outside of the target transect in the oversample reaches, nor are fishes other than marked steelhead parr enumerated.

The general parr monitoring (GPM) program has monitored the abundance and distribution of anadromous salmonids since 1985. A large proportion of Idaho's Chinook salmon and steelhead habitat is located within congressionally-designated wilderness areas and the GPM dataset, which includes the core trend transects, is the best description of juvenile salmonid abundance and occurrence (Copeland and Meyer 2011). Spring snowmelt runoff in Idaho precludes the use of redd surveys for steelhead in Idaho. As a result, GPM data are particularly important for monitoring the spatial structure and estimating the juvenile-to-juvenile productivity of these populations.

RECOMMENDATIONS

1. Maintain GPM trend series by surveying core trend transects on a two-year rotating panel.

2. Update the GPM trend analysis using recent data in the time series. Maintain analytical consistency with methods from the 2006 NPM report (Copeland et al. 2007).

3. Calibrate parr densities with production of juvenile emigrants estimated from screw traps in target drainages using intensive survey results.

ACKNOWLEDGEMENTS

We are grateful to the Bonneville Power Administration and Susan Offerdal, our contracting officer's technical representative, for support and funding of this research. Ron Roberts and the ISMES snorkel crew provided data for the general parr monitoring and snorkel surveys. We thank Tim Copeland for reviewing and providing comments to earlier drafts of this section of this report. This section benefited from reviews by Bill Schrader and Lance Hebdon. Cheryl Zink helped format and edit the document.

LITERATURE CITED

Copeland, T., J. Johnson, S. A. Kraft, and P. R. Bunn. 2007. Idaho natural production monitoring and evaluation, 2006 annual progress report. Idaho Department of Fish and Game Report 07-31. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, S. Kraft, and P. R. Bunn. 2008. Idaho natural production monitoring and evaluation, 2007 annual progress report. Idaho Department of Fish and Game Report 08-08. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland T., and K. A. Meyer. 2011. Interspecies synchrony in salmonid densities associated with large-scale bioclimatic conditions in Central Idaho. Transactions of the American Fisheries Society 140:4. pp 928-942.

Corley, D. R. 1972. Snorkel trend counts of fish in the Middle Fork – 1971. Idaho Department of Fish and Game, Boise.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and habitat area in small streams based on visual estimation techniques. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

ICBTRT (Interior Columbia Basin Technical Recovery Team). 2005. Updated population delineation in the interior Columbia basin. Memo to NMFS Northwest Regional Office May 11, 2005.

Kennedy P, T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand, and M. Corsi. 2012. Idaho Natural Production Monitoring and Evaluation, 2011 annual progress report. Idaho Department of Fish and Game Report 12-18. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Larsen, D. P., T. M. Kincaid, S. E. Jacobs, and N. S. Urquhart. 2001. Designs for evaluating local and regional scale trends. BioScience 51:1069-1078.

Lindland, R. L. 1974. Distribution and abundance of cutthroat trout in the Selway River. Evaluation of survival of angling regulations in management of cutthroat trout, job performance report. Project F-49-R-12. Idaho Department of Fish and Game, Boise.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonids populations and the recovery of evolutionarily significant units. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-42.

O'Neal, J. S. 2007. Snorkel surveys. Pages 325-340 in D.H. Johnson, B.M. Shrier, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Petrosky, C. E., and T. B. Holubetz. 1986. Idaho habitat evaluation for off-site mitigation record, annual report 1985. Project 83-7, contract DE-AI79-84BP13381. Bonneville Power Administration, Portland, Oregon.

Reingold, M. 1981. Middle Fork Salmon River fisheries investigations. Job performance report. Project F-73-R-3. Idaho Department of Fish and Game, Boise.

Schill, D. J., and J. S. Griffith. 1984. Use of underwater observations to estimate cutthroat trout abundance in the Yellowstone River. North American Journal of Fisheries Management 4:479-487.

Schill, D. J., E. R. J. M. Mamer, and T. C. Bjornn. 2004. Population trends and an assessment of extinction risk for westslope cutthroat trout in select Idaho waters. pp. 302-318 *in* Moore, S. E.; Carline, R. F.; Dillon, J., eds. 2004. Working together to ensure the future of wild trout; proceedings of Wild Trout VIII symposium—30th anniversary; 2004 September 20-22; Yellowstone National Park, Wyoming. 398 pages.

Scully, R. J., E. J. Leitzinger, and C. E. Petrosky. 1990. Idaho habitat evaluation for off-site mitigation record, annual report 1988. Project 83-7, contract DE-AI79-84BP13381. Bonneville Power Administration, Portland, Oregon.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Thurow, R. F. 1994. Underwater methods for study of salmonids in the intermountain west. General Technical Report INT-GTR-307, Intermountain Research Station, USDA Forest Service, Boise, Idaho.

Thurow, R. F., J. T. Peterson, and John W. Guzevich. 2006. Utility and validation of day and night snorkel counts for estimating bull trout abundance in first- to third-order streams. North American Journal of Fisheries Management 26:217-232.

Table 10. IDFG core trend snorkel survey transects ($n = 218$) by Snake River steelhead major and independent population.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name
Hells Canyon Tributaries			
Hells Canyon (SNHCT-s)	Granite Creek	---	1
	Granite Creek	---	3
	Sheep Creek	---	1
	Sheep Creek	---	2
Independent Population Total:			4
MPG Total:			4
Clearwater River			
Lower Main-stem (CRLMA-s)	Big Canyon Creek	---	1
Independent Population Total:			1
Lolo Creek (CRLOL-s)	---	N/A	N/A
Independent Population Total:			0
South Fork Clearwater (CRSFC-s)	American River	2	1
	American River	3	2
	Crooked River	1	BOULDER-A
	Crooked River	1	BOULDER-B
	Crooked River	1	SILL-LOG-B
	Crooked River	2	CONTROL1
	Crooked River	2	CONTROL2
	Crooked River	2	TREAT2
	Crooked River	3	NATURAL1
	Crooked River	4	MEANDER1
	Crooked River	C	CAN2
	Crooked River	C	CAN3
	East Fork Crooked River	H	EF1
	East Fork Crooked River	H	EF2
	Johns Creek	1	1
	Johns Creek	1	2
	Johns Creek	2	3
	Red River	1	CNTL 1
	Red River	1	CNTL 2
	Red River	2	CNTL 2
	Red River	2	TREAT 2
	Red River	4	CNTL 2
	Red River	4	TREAT 2
	Red River	5	CNTL 2
	Red River	5	TREAT 2
	Relief Creek	1	1A
	Relief Creek	1	1B
	Tenmile Creek	---	1
	West Fork Crooked River	H	WF1
	West Fork Crooked River	H	WF2
Independent Population Total:			30
Lochsa River (CRLOC-s)	Brushy Fork	3	1
	Brushy Fork	3	2
	Colt Creek		BRIDGE
	Crooked Fork Creek	1	2A
	Crooked Fork Creek	2	3A
	Crooked Fork Creek	2	4A
	Crooked Fork Creek	3	1
	Crooked Fork Creek	3	2
	Crooked Fork Creek	3	2B
	Crooked Fork Creek	4	1B
	Fish Creek	---	1
	Fish Creek	---	2
	Lochsa River	---	L1
	Lochsa River	---	L2
	Lochsa River	---	L3
	Lochsa River	---	L4
	Old Man Creek	---	1

Table 10. Continued.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name
	Postoffice Creek	---	1
	Postoffice Creek	---	2
	Warm Springs Creek	---	1
	White Sands Creek	---	LWRMONITOR
Independent Population Total:			21
Selway River (CRSEL-s)	Bear Creek	---	1
	Bear Creek	---	2
	Deep Creek	---	CACTUS
	Deep Creek	---	SCIMITAR
	East Fork Moose Creek	---	3
	Meadow Creek	---	1
	Moose Creek	---	1
	Moose Creek	---	2
	Running Creek	---	1
	Running Creek	---	2
	Selway River	---	HELLSHALF
	Selway River	---	LITTLE-CW
	Selway River	---	MAG-XING
	Selway River	---	RUNNING CR
	Three Links Creek	---	1
	White Cap Creek	3	1
	White Cap Creek	4	2
	White Cap Creek	5	3
Independent Population Total:			18
MPG Total:			70
Salmon River			
Little Salmon River (SRLSR-s)	Boulder Creek	ABOVE	1
	Boulder Creek	ABOVE	2
	Boulder Creek	BELOW	3
	Boulder Creek	BELOW	5
	Hazard Creek	---	HAZ1
	Little Salmon River	---	1
	Little Salmon River	---	2
	Rapid River	BLW W FK	RAP2
	Slate Creek	---	1
	Slate Creek	---	2
	Slate Creek	---	3
	Slate Creek	---	4
	Slate Creek	---	6
	South Fork White Bird Creek	---	SF-#2
	South Fork White Bird Creek	---	SF-#3
	West Fork Rapid River	BLW FALLS	RAP1
	White Bird Creek	---	1
Independent Population Total:			17
South Fork Salmon (SFMAI-s)	East Fork South Fork Salmon	ABV JHNSN	3
	East Fork South Fork Salmon	BLW JHNSN	6
	East Fork South Fork Salmon	BLW JHNSN	7
	Johnson Creek	LOWER IV	L2
	Johnson Creek	LOWER IV	L3
	Johnson Creek	MID LOWIII	PW3B
	Johnson Creek	MID UPR II	PW3A
	Johnson Creek	UPPER I	M1
	Johnson Creek	UPPER I	M2
	Johnson Creek	UPPER I	M3
	Johnson Creek	UPPER I	PW1A
	Rock Creek	UPPER I	M1
	Sand Creek	UPPER I	M2
	South Fork Salmon River	---	11
	South Fork Salmon River	---	14
	South Fork Salmon River	---	16
	South Fork Salmon River	---	5
	South Fork Salmon River	---	7
	South Fork Salmon River	---	POVERTY
	South Fork Salmon River	---	STOLLE1

Table 10. Continued.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name
	South Fork Salmon River	---	STOLLE2
Independent Population Total:			21
Secesh River (SFSEC-s)	Lake Creek	---	BURGDORF
	Lake Creek	---	WILLOW CR
	Lick Creek	---	L3
	Secesh River	---	GROUSE
	Secesh River	---	LONG-GULCH
Independent Population Total:			5
Chamberlain Creek (SRCHA-s)	Bargamin Creek	---	1
	Bargamin Creek	---	2
	Chamberlain Creek	---	CHA1
	Chamberlain Creek	---	CHA4
	Sheep Creek	---	L1
	Sheep Creek	---	L2
	West Fork Chamberlain Cr.	---	CHA2
	West Fork Chamberlain Cr.	---	CHA3
Independent Population Total:			8
Lower Middle Fork (Loon Creek and below; MFBIG-s)	Big Creek	LOWER	L1
	Big Creek	MIDDLE	Cabin Cr
	Big Creek	MIDDLE	TAYLOR 1
	Big Creek	UPPER	LOGAN CR
	Camas Creek	---	2
	Camas Creek	---	CAM1
	Loon Creek	C CHANNEL	2
	Loon Creek	LNM1	3
	Loon Creek	PACK BR	1
	Middle Fork Salmon River	2	HOSPPL
	Middle Fork Salmon River	2	HOSPRUN
	Middle Fork Salmon River	2	TAPPANPOOL
	Middle Fork Salmon River	2	TAPPANRUN
	Middle Fork Salmon River	3	AIRSTRIP
	Middle Fork Salmon River	3	FLYING-B
	Middle Fork Salmon River	3	SURVEY
	Middle Fork Salmon River	4	BIG-CR-BR
	Middle Fork Salmon River	4	GOATPOOL
	Middle Fork Salmon River	4	GOATRUN
	Middle Fork Salmon River	4	LITOUZEL
	Middle Fork Salmon River	4	LOVEBAR
	Middle Fork Salmon River	4	OTTERBAR
	Middle Fork Salmon River	4	SHIPISLAND
	Monumental Creek	---	MON1
	Monumental Creek	---	MON2
	Monumental Creek	---	MON3
	Monumental Creek	---	MON5
	West Fork Monumental Creek	---	MON4
Independent Population Total:			28
Upper Middle Fork (above Loon Creek; MFUMA-s)	Beaver Creek	---	A
	Beaver Creek	---	B
	Cape Horn Creek	1	A
	Cape Horn Creek	2	B
	Elk Creek	---	1A
	Elk Creek	---	1B
	Elk Creek	---	2A
	Elk Creek	---	2B
	Knapp Creek	1	A
	Knapp Creek	1	B
	Knapp Creek	1	LCKD FENCE
	Marble Creek	UPPER	MAR1
	Marble Creek	UPPER	MAR1B
	Marble Creek	UPPER	MAR2
	Marsh Creek	1	A
	Marsh Creek	1	B
	Marsh Creek	3	A
	Marsh Creek	4	B

Table 10. Continued.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name
	Marsh Creek	5	A
	Middle Fork Salmon River	1	BOUNDARY
	Middle Fork Salmon River	1	ELKHORN
	Middle Fork Salmon River	1	GRDLHOLE
	Middle Fork Salmon River	1	GREYHOUND
	Middle Fork Salmon River	1	INDIAN
	Middle Fork Salmon River	1	RAPID-R
	Middle Fork Salmon River	1	SHEEPEATER
	Middle Fork Salmon River	1	VELVET
	Middle Fork Salmon River	2	COUGAR
	Middle Fork Salmon River	2	LJACKASS
	Middle Fork Salmon River	2	MARBLPL
	Middle Fork Salmon River	2	PUNGO
	Middle Fork Salmon River	2	ROCK IS
	Middle Fork Salmon River	2	SKIJUMP
	Middle Fork Salmon River	2	WHITEYCX
Independent Population Total:			34
Panther Creek (SRPAN-s)	Horse Creek	---	L1
	Horse Creek	---	L2
	Panther Creek	ABOVE	PC9
	Panther Creek	DS-BIGD	PC4
	Panther Creek	DS-BLACKB	PC6
	Panther Creek	DS-CLEAR	PC1
Independent Population Total:			6
North Fork Salmon (SRNFS-s)	North Fork Salmon River	2	DAHLONEGA
	Pine Creek	---	BRIDGE
	Pine Creek	---	SAWMILL CR
	North Fork Salmon River	2	HUGHES
Independent Population Total:			4
Lemhi River (SRLEM-s)	Big Springs Creek	LEM1	A
	Hayden Creek	HC2	B
	Hayden Creek	HC3	B
	Lemhi	1	LEM3A
Independent Population Total:			4
Pahsimeroi River (SRPAH-s)	Pahsimeroi River	LOWER	DWTNLANE
Independent Population Total:			1
East Fork Salmon River (SREFS-s)	East Fork Salmon River	ABOVE-WEIR	2
	East Fork Salmon River	ABOVE-WEIR	3
	Morgan Creek	UPPER	BLM CAMP
Independent Population Total:			3
Upper Salmon River Main-stem (SRUMA-s)	Alturas Lake Creek	2	2B
	Redfish Lake Creek	---	LOWER
	Redfish Lake Creek	---	WEIR DS
	Salmon River	1	RBNSN-BAR
	Salmon River	2	2B
	Salmon River	3	3B
	Salmon River	3	3BRA
	Salmon River	4	4B
	Salmon River	7	7A
	Valley Creek	1	B
	Valley Creek	3	A
	Valley Creek	3	B
	Valley Creek	6	B
Independent Population Total:			13
MPG Total:			144
Snake River DPS Total:			218

Table 11. Densities (fish/100 m^2) of salmonids observed at core trend transects snorkeled in the Salmon River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout.

		Density (fish/100 m^2)									
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Cutt/ Steel Hybrid**	**Visibility (m)**	**Temp (C)**
Big Springs Creek	LEM-1/A	0	2.37	2.37	0	0	7.20	0	0	1.4	17
Boulder Creek	5	2.23	16.46	2.23	0.17	0.17	0	0	0	2	14
EF Salmon River	Above-Weir/3	2.85	1.12	2.05	0	0.06	0	0.62	0	3.5	11
EF Salmon River	Above-Weir/2	0	3.02	2.68	0.06	0	0	1.88	0	3.5	9
EF SF Salmon River	6	0.75	0.6	5.45	0.21	0.06	0	1.7	0	3.7	18
EF SF Salmon River	7	0	11.29	5.95	1.03	0	0	1.23	0.21	3.7	16
Elk Creek	1A	0	0	4.67	0	0	1.2	5.95	0	3.2	14
Elk Creek	1B	0	0	3.98	0	0	0.79	11.86	0	3.5	14
Elk Creek	2A	0.3	0.17	6.52	0	0	6.6	4.3	0	4.5	14
Elk Creek	2B	0.04	0	7.06	0	0	1.18	8.01	0	3.3	17
Hayden Creek	HC2/B	0.45	2.26	0	0.23	3.16	0	0	0	3.1	13
Hayden Creek	HC3/B	15.28	5.75	22.29	0	0.52	0	1.15	0	3.2	13
Johnson Cr.	PW3B	1.21	6.51	0.04	0.27	0.04	0	0.31	0	3.3	14
Johnson Cr.	PW3A	0	9.18	0	0.2	0	0	0	0	4	13
Johnson Cr.	M3	0.31	0.39	0	0	0	8.05	0	0	3	18
Knapp Creek	1/B	0.17	0.87	0	0	0	1.56	0	0	2.5	15
Knapp Creek	1/A	0.57	2.09	27.13	0	0	3.98	0	0	2.3	14
Lick Creek	L3	2.61	9.6	0	0.09	0	3.82	0.19	0	10	12
Little Salmon River	2	0.08	9.78	8.2	0	0.08	0.08	0.38	0	2	19
Marble Creek	MAR1	0.24	2.66	0	1.45	0.48	0	0	0	3	10
Marble Creek	MAR1B	0.8	22.68	0	0	0	0	0	0	>3	13
Marble Creek	MAR2	0	1.96	0	0.15	0	0	0	0	3.9	15
Marsh Creek	3A	0.34	1.6	22.09	0	0	8.81	0.11	0	1.8	12
Marsh Creek	1/B	0.07	2.93	12.51	0.53	0.07	0.02	2.89	0	3.2	12
MF Salmon River	BOUNDARY	0	1.98	23.48	0.58	0	0	2.67	0	3	12
MF Salmon River	GRDLHOLE	0	0.07	2.72	0.15	0	0	0.29	0	2.7	14
MF Salmon River	VELVET	0	1.5	1.13	1.5	0	0	0	0	1.8	11
MF Salmon River	SHEEPEATER	0	0.53	0.85	0.11	0.11	0	0.53	0	2.3	15
MF Salmon River	ELKHORN	0	0.64	3.2	0.48	0	0	0.32	0	2.3	13
MF Salmon River	INDIAN	0	0.08	0	0.83	0	0.08	0.25	0	2.2	16
MF Salmon River	PUNGO	0	0.14	0.14	2.4	0	0	0.14	0	2.3	15
MF Salmon River	RAPID-R	0	2.15	0.46	1.84	0	0	2.76	0	2.2	14
MF Salmon River	HOSPPL	0	0.12	2.66	0.58	0	0	0.23	0	2.7	18
MF Salmon River	COUGAR	0	0.43	0.43	0.87	0	0	1.74	0	2.3	18
MF Salmon River	LJACKASS	0	0	0	1.37	0	0	0.29	0	2.3	17
MF Salmon River	MARBLPL	0	0.15	5.82	3.29	0	0	1	0	2.3	15
MF Salmon River	HOSPRUN	0	0.28	4.35	0.14	0.14	0	0.42	0	2.7	18
MF Salmon River	WHITEYCX	0	0	0	0.91	0	0	0	0	2.7	18
MF Salmon River	ROCK IS	0	0.23	2.66	0.23	0	0	0.23	0	2.7	18
MF Salmon River	TAPPANPOOL	0	0.07	0	0.74	0	0	0	0	2.7	18
MF Salmon River	SURVEY	0	0	0	0.16	0	0	0	0	2.1	20

Table 11. Continued.

		Density (fish/100 m^2)									
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Cutt/ Steel Hybrid**	**Visibility (m)**	**Temp (C)**
MF Salmon River	FLYING-B	0	0	0	1.11	0	0	0.32	0	2.1	18
MF Salmon River	AIRSTRIP	0	0.43	2.16	1.19	0	0	0.11	0	2.1	18
MF Salmon River	SHIPISLAND	0	0	2.93	1.13	0.09	0	0.28	0	2.1	19
MF Salmon River	BIG-CR-BR	0	0.26	0	0.39	0.06	0	0	0	2.1	18
MF Salmon River	LOVEBAR	0	0.6	0	0.36	0	0	0.48	0	2.1	18
MF Salmon River	GOATRUN	0	0.09	2.14	0.28	0	0	0.19	0	2.2	19
MF Salmon River	GOATPOOL	0	0.17	0.34	0.17	0	0	0.17	0	2.2	19
MF Salmon River	OTTERBAR	0	0.24	0.16	0.4	0	0	0	0	2.2	19
Morgan Creek	Upper/BLM Camp	0	10.68	0	0	0	0	0.31	0	1.7	11
NF Salmon River	2/Hughes	0.34	1.69	2.84	0.14	0.07	0.07	0.88	0	3.1	10
Pahsimeroi River	Lower/DWT-Lane	0	15.57	46.01	0	0	1.48	16.58	0	1.8	14
Panther Creek	DS-BIGD/PC-4	0.76	4.21	13.86	0	0	0	4.11	0	1.4	18
Pine Creek	Bridge	0	11.71	0	0.73	0	0	0	0	1.7	11
Pine Creek	Sawmill creek	0.45	1.36	0	1.36	0	0	0	0	1.3	9
Rapid River	RAP2	7.95	6.76	0.72	0	0	0	0	0	2.2	13
Rock Creek	M1	12.18	0	0	0	0	80.4	0	0	4.4	19
Salmon River	7A	0	0	0	0	0	0	7.21	0	2.9	11
SF Salmon River	11	0.29	4.27	3.07	0.05	0	0.14	1.68	0	2.8	18
SF Salmon River	14	0.37	0.62	6.74	0.03	0.03	0.34	2.55	0	4.4	20
SF Salmon River	16	0.06	2.11	1.47	0.03	0.03	0.12	1.79	0	2.9	18
SF Salmon River	5	0	0	0.71	0	0	0	0.97	0	2.3	12
SF Salmon River	7	0	3.43	1.29	0	0	0	3.34	0	2.3	14
SF Salmon River	STOLLE1	0	0	3.99	0	0	0.09	3.99	0	3.8	10
SF Salmon River	STOLLE2	0	0	1.05	0	0	0	0.08	0	3.8	11
SF Salmon River	RAP1	0.27	4	0	0	0.27	0	0	0	1.5	12
Valley Creek	6B	0.73	4.55	0.44	0	0	4.25	0.15	0	2.5	15
Mean		0.77	2.90	4.08	0.42	0.08	1.94	1.44	0.00		
SD		2.55	4.59	7.88	0.64	0.39	9.93	2.87	0.03		

Table 12. Densities (fish/100 m^2) of salmonids observed at non-core trend transects snorkeled in the Salmon River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout.

		Density (fish/100 m^2)									
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Cutt/ Steel Hybrid**	**Visibility (m)**	**Temp (C)**
Bear Valley Creek	2B	0.41	0.61	4.07	0	0	2.47	1.8	0	2.8	17
Bear Valley Creek	3A	0.46	1.37	35.47	0	0	2.41	7.76	0	2.6	19
Big Springs creek	1/BSC Bridge	0	7.05	0.81	0	0	1.21	0	0	1.4	22
Camas Creek	Upper	0	2.65	1.41	2.82	0.18	0	4.23	0	2	17
Camas Creek	L1-Mouth	0	0.8	2.69	1.96	0.22	0	4.8	0	2	17
Indian Creek	Lower	0	1.2	0.3	0	0.15	0	0.15	0	2.2	17
Indian creek	Upper	0	4.32	22.5	0.45	0.23	0	0.23	0	2.2	17
Loon Creek	L2-Run	0	0.4	0.79	0	0	0	0.79	0	1.5	18
Loon Creek	L1-Bridge	0	2.24	7.05	2.24	0	0	1.28	0	1.5	16
Marble Creek	L1	0	0.34	0.45	0.11	0	0	0.11	0	2.3	16
MF Salmon River	LICRGS	0	1.53	0.64	0.38	0	0	2.05	0	2.3	15
MF Salmon River	MAHONEY CMP	0	0	7	2	0	0	0.8	0	2.5	17
MF Salmon River	WCPB	0	0.03	1.05	0.46	0	0	0.19	0	2.7	18
MF Salmon River	AIRSTP	0	0	0	0.83	0	0	0.12	0	2.1	18
MF Salmon River	HANPOL	0	0.09	0	0.95	0	0	0	0	2.2	19
MF Salmon River	CLIFPL	0	0.12	0.16	0.2	0	0	0.04	0	2.1	20
Pahsimeroi River	1/Ponds	1.72	14.06	22.8	0.31	0	1.25	28.11	0	2	10
Pahsimeroi River	Weir	3.29	2.5	21.96	0	0	0	5.92	0	1.4	11
Panther Creek	DS-Clear/PC-2	0	3.94	1.77	0.07	0	0	3.19	0	1.4	19
Pistol Creek	L1/LOWER	0	3.09	5.88	1.86	0	0	0.93	0	2.2	15
Pistol Creek	L2/UPPER	0	1.85	0.31	0.46	0	0	0	0	2.2	15
Rapid River	CASTLE CR	0	4.94	0	0	0.22	0	0	0	2.1	12
Rapid River	CLIFF HANG	0.22	3.09	0	0	0.22	0	0	0	2.1	12
Rapid River	COPPER CR	0.12	2.12	0	0.12	0.12	0	0	0	1.8	11
Rapid River	CORA CLIFF	0.19	5.3	0	0	0.28	0	0	0	2.5	13
Rapid River	PARADISE	0	0.4	0	0	0.3	0	0	0	2.2	13
Rapid River	4	0.2	0.94	0	0	0	0	0	0	2.1	13
Mean		0.24	2.41	5.08	0.56	0.07	0.27	2.31	0.00		
SD		0.70	2.98	9.27	0.84	0.11	0.71	5.56	0.00		

Table 13. Densities (fish/100 m^2) of salmonids observed at core trend transects snorkeled in the Clearwater River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout.

		Density (fish/100 m^2)								
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
American River	1	0.45	0.67	10.94	2.01	0	0.89	2.57	3.1	15
American River	2	0	0.09	19.31	0	0	0.09	0.52	1.7	13
Bear Creek	1	0	5.37	0.07	0.96	0	0	1.93	--	20
Bear Creek	2	0	0.21	0.21	0.21	0	0	0.07	--	--
Brushy Fork	1	0.09	0.45	0.09	1.81	0.18	0	0.27	2.8	11
Brushy Fork	2	1.16	2.61	2.99	1.16	0.1	0	0.1	4	14
Crooked Fork	2	0	0.4	3.6	2.4	0	0	0.8	4.4	16
Crooked Fork	1	0.6	0	2	1.4	0	0	0.5	5.5	16
Crooked Fork	3A	0	0	0	1.82	0.2	0	0	3.6	13
Crooked Fork	2A	0	0	0	4.82	0	0	0	4.6	8
Crooked Fork	1B	0.43	1.91	0.31	0.49	0	0	0.19	5.2	15
Crooked Fork	2B	0.65	1.16	0.23	0.65	0.05	0	0.74	4.8	11
Crooked Fork	4A	0	0	0	3.55	0	0	0	4.6	13
Crooked River	SILL-LOG-B	0	0	0	3.28	0.21	0	0	2	13
Crooked River	BOULDER-A	0	0.22	0	3.74	0	0	0.44	2.1	12
Crooked River	BOULDER-B	0	0	0	1.26	0	0	0.23	2.1	13
Crooked River	NATURAL1	0.15	0.08	0.92	0.77	0.08	0.46	0.23	2.4	12
Crooked River	MEANDER1	0	0	0.97	0.22	0	0.54	0.76	2.2	17
Crooked River	TREAT 2	0	0.11	2.19	0.88	0	0.11	0.44	2.2	12
Crooked River	CONTROL1	0	0.24	0	2.12	0	0	0	1.5	11
Crooked River	CONTROL2	0	2.23	5.57	2.43	0	0	0.81	2.2	14
Crooked River	CAN3	0	0.33	2.21	1.43	0	0.44	0.88	1.6	15
Crooked River	CAN2	0	0.56	4.38	1.8	0.11	0.11	0.67	2.1	16.5
Deep Creek	CACTUS	2.9	0.97	1.45	5.32	0.24	0	0	3.1	14
Deep Creek	SCIMITAR	1.24	5.21	0.74	1.49	0.25	0	0	5.9	14
EF Crooked River	EF1	0	0.37	0	2.23	0	0	0	2	8
EF Crooked River	EF2	0	0	0	2.15	0	0	0	1.8	8
Fish Creek	1	3.02	5.14	0.08	6.95	0	0	0	2.4	21
Fish Creek	2	2.45	5.18	0	0.58	0	0	0	3.1	13
Johns Creek	2	0	2.52	0	0.08	0	0	0.08	3	15
Lochsa River	L3	0	0.06	0	0.47	0	0	0.51	4.8	16
Lochsa River	L4	0	0.21	0.4	0.42	0	0	0.08	5.9	14.5
Moose Creek	1	0	5.83	0.57	0.75	0	0	1.84	--	22
Postoffice Creek	1	2.32	2.32	0	0.29	0	0	0	4.1	12
Red River	2_TREAT 2	0	0	1.12	1.55	0	0.7	0.42	2.7	14
Red River	4_TREAT 2	0	0.41	38.47	0.22	0	0.81	0.26	2.1	12
Red River	5_TREAT 2	0	0.17	11.25	0.78	0	0.11	0.78	2	18
Red River	5_CNTL 2	0	0	8.1	0	0	0.08	0.87	1.7	19
Red River	4_CNTL 2	0	0.2	18.03	0.08	0	0.64	0.4	3	14
Red River	2_CNTL 2	0	0	1.13	0.91	0.23	0.23	0.45	2.2	18
Red River	1_CNTL 2	0	0	0	0	0	0.96	0	1.7	8.5
Red River	CNTL 1	0	0	0	0	0	0.79	0	2.8	12

Table 13. Continued.

Stream	Transect	Density (fish/100 m^2) Trout Fry	Steelhead	Chinook salmon	Cutthroat Trout	Bull Trout	Brook Trout	Whitefish	Visibility (m)	Temp (C)
Relief Creek	1A	0	2.53	0	7.22	0	0	0	2.6	14
Relief Creek	1B	0	0	0	7.15	0	0	0	2.8	14
Running Creek	1	0	2.79	0	0.93	0	0	0.93	--	20
Running Creek	2	0	1.51	0.43	0.65	0	0	0	4.2	--
Selway River	MAG-XING	0	0.18	1.55	0.11	0.07	0	0.27	4	16
Selway River	HELLSHALF	0.32	1.61	7.81	0.89	0.24	0	0.64	3.9	16
Selway River	LITTLE-CW	0	0.74	8.3	0.56	0.12	0	2.29	6.1	12
Warmsprings Cr.	1	0.92	1.1	0.37	1.1	0.46	0	0	4.5	14
WF Crooked River	WF2	0	0.2	0	3.22	0.40	0	0.2	2	11
White Cap Creek	1	0	2.3	0.22	0.79	0	0	0.29	4.6	18
White Cap Creek	2	0	0.41	0.07	0.21	0	0	0.07	5.4	18
White Cap Creek	3	0	0.86	0	0.92	0	0	0	5.4	18
Mean		0.31	1.10	2.89	1.62	0.05	0.13	0.42		
SD		0.74	1.60	6.54	1.80	0.11	0.27	0.58		

Table 14. Densities (fish/100 m^2) of salmonids observed at non-core trend transects snorkeled in the Clearwater River subbasin during 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout.

		Density (fish/100 m^2)								
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Big Canyon Creek	1	0.78	41.08	0	0	0	0	0	1.9	19
Colt Killed Creek	LWRMONITOR	0	0.79	0	0.15	0	0	0	3.7	14
Crooked River	NATURAL3	0	0.53	0.13	1.46	0.13	0.13	1.99	3	13
Little Clearwater	1	0	1.22	0	0.49	0	0	0	0	0
Little Clearwater	2	0	0.96	0.14	0.41	0	0	0.14	4.9	13
Marten Creek	1	0	10.53	0	1.5	0	0	0	--	11.5
NF Moose Creek	4	0	4.74	1.09	3.86	0	0	2.19	--	16
Old Man Creek	1	3.94	7.55	0.03	3.34	0.07	0	1.49	2.6	16.5
Selway River	BEAVERPT	0	0.08	5.31	0.04	0.12	0	0.56	4.80	18
Selway River	BELOW TANGO	0	0.1	0.08	0.54	0	0	0.48	--	16
Selway River	OSPREY ISLAND	0	0.4	0	0.5	0.02	0	1.02	--	16
Selway River	BAD LUCK CREEK	0	0.18	0	0.57	0	0	0.64	--	15
Selway River	NORTH STAR	0	0.11	0.03	1.13	0	0	1.9	--	--
Selway River	BIG BEND	0	0.11	0	0.5	0	0	1.32	--	16
Mean		0.34	4.88	0.49	1.04	0.02	0.01	0.84		
SD		1.06	10.91	1.42	1.19	0.05	0.03	0.81		

Table 15. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Potlatch River drainage in the Clearwater lower main-stem steelhead population, from May 25 to July 11, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)					
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Big Bear Creek	30690	0	0	0	0	1	20
Big Bear Creek	79842	0	0.33	0	0	1	22
Big Bear Creek	91154	0	17.66	0	0	1.7	17
Big Bear Creek	106514	0	0	0	0	0.5	25
Big Bear Creek	373778	0	10.25	0	0	1.3	21
Big Bear Creek	417506	8.42	3.09	0	0	2.1	20
Big Meadow Creek	12818	0	0	0	0	1.4	10.2
Big Meadow Creek	166418	0	0	0	0	1	16
Big Meadow Creek	176658	0	0	0	0	1.1	12
Big Meadow Creek	369170	0	1.34	0	0	2.1	9
Big Meadow Creek	483858	0	2.19	0	0	2.1	8.5
Bob's Creek	37745	0	0	1.66	0	2.5	9
Bob's Creek	54129	0	2.28	3.04	0	1.9	8.5
Bob's Creek	86897	0	0.59	4.15	0	1.25	10
Bob's Creek	103281	0	0.27	0	0	1.9	11
Cedar Creek	16866	7.38	0	0.67	0	0.8	15
Cedar Creek	59106	0	0	0	0	0.8	13
Cedar Creek	141026	0	1.11	0	0	1	19
Cedar Creek	147938	0	2.63	0	0	0.9	18
Cougar Creek	18	0	0	0.76	0	1.7	13.5
E. F. Big Bear	36882	0	1.97	0	0	0.8	10
EF Potlatch River	13169	0	0	0	0	1.2	9
EF Potlatch River	34786	0	0	0	0	3	10
EF Potlatch River	95089	0	0	1.06	0	2	8.5
EF Potlatch River	130018	0.3	0.1	0	0	1.8	11.5
EF Potlatch River	134001	0.9	0.22	0.9	0	1.4	7.5
EF Potlatch River	136049	0	0	0	0	2	11
EF Potlatch River	144241	0	0	0	0	1.25	9.5
EF Potlatch River	168817	0	0.52	0	0	1.1	11
EF Potlatch River	182242	0	0	0	0	1.6	10
EF Potlatch River	2929	0	0.22	0	0	2	8
EF Potlatch River	359394	0	0.09	0.28	0	1.7	11
EF Potlatch River	457698	0	0	0	0	1.8	10.5
Feather Creek	122850	0.43	0.43	1.72	0	2	13
Leopold Creek	3810	0	3.41	0	0	2	11
Leopold Creek	38626	0	0	0.31	0	2	11
Little Bear Creek	13330	32.37	10.9	0	0	1.7	21
Little Bear Creek	158226	30.16	0.28	0	0	1.3	16
Little Bear Creek	173074	124.76	1.86	0	0	1.9	18
Little Bear Creek	177170	15.48	11.47	0	0	1.8	20
Little Potlatch	19986	0	0	0	0	1	23
Little Potlatch	32274	0	0	0	0	--[a]	--[a]
MF Big Bear Creek	4114	0	0	0	0	0.6	20
Middle Potlatch	14354	0	0	0	0	--	22
Middle Potlatch	30738	0	0	0	0	--[a]	--[a]

Table 15. Continued.

Stream	Transect	Density (fish/100 m^2) Trout Fry	Steelhead	Brook Trout	Whitefish	Visibility (m)	Temp (C)
Pine Creek	181266	0	7.71	0	0	0.75	16
Potlatch River	482	0.05	2.72	0	0.05	1.5	16
Potlatch River	3042	0	3.86	0	0	2	25
Potlatch River	8210	0	0	0	0	2.05	13
Potlatch River	18402	0	0.13	0	0	1.5	14
Potlatch River	48866	0	1.59	0	0	1.2	20
Potlatch River	49170	0	0	0	0	1.2	13.2
Potlatch River	117730	0	0.07	0	0	2.35	21
Potlatch River	127970	0	0.48	0	0	1.7	22
Potlatch River	144354	0	1.45	0	0	1.7	22.5
Potlatch River	193506	0	4.57	0	0	2.8	25
Ruby Creek	2018	0	0	0	0	1.5	11
Ruby Creek	31714	0	1.02	4.57	0	1.4	10
Ruby Creek	67554	0	0	0.42	0	1.5	11.5
Schwartz Creek	24594	0	5.67	0	0	1.2	8
WF Big Bear Creek	73746	0	0	0	0	1.1	15
WF Little Bear	60434	17.52	6.35	0.22	0	1.1	12
WF Little Bear	78354	0	0	0	0	1.3	12
WF Little Bear	136210	23.89	9.56	0	0	1.1	21
WF Little Bear	150034	10.6	4.77	0	0	1.4	17
WF Little Bear	340498	0	0	0	0	0.8	11.5
WF Little Bear	471570	0	0	0	0	1.2	14
WF Little Bear	297490	1.46	3.22	0	0	1	13
WF Little Bear	363026	2.67	3.33	0	0	1.1	18
WF Potlatch River	16354	0	0	1.96	0	1.6	13.5
WF Potlatch River	89221	0	0	0	0	2.4	14
Mean		3.89	1.83	0.31	0.00		
SD		15.95	3.37	0.88	0.01		

[a] Stream channel was dry at time of survey.

Table 16. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the South Fork Clearwater River drainage in the Clearwater River steelhead population, June 24-26 and July 6-10, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)								
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook**	**Cutthroat**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
American River	35618	0	0	0.98	6.11	0.73	3.91	0.49	2.8	12
American River	37666	0	0	0	5.33	0	0.76	0	2.2	10
American River	39714	0.15	0	23.6	0.73	0	0.29	0.29	1.8	14
American River	43586	1.29	0.13	4.51	0.26	0.26	0	0.39	1.6	14
American River	59970	0.84	0	12.65	0.84	0	0.32	1.48	2.2	16
American River	68386	0	2.31	27.34	0.71	0	0.18	0.71	2.5	15
American River	76354	0	0	47.57	0.48	0	0.24	0.16	1.2	16.5
American River	92738	0.5	1.21	17.55	1.21	0	0	0.71	2.5	10
Big Elk Creek	51778	1.75	0.44	8.97	0	0	5.47	6.13	2.3	21
Buffalo Gulch	20034	0	0	0	11.81	0	0	0	2	12
Kirks Fork	45122	0	0	0	7.38	0	0	0	1.8	11
Lick Creek	92962	0	0	0	1.16	0	3.47	0	3	15
Moose Butte Cr	16706	0	0	0	4.05	0	0.27	0	1.8	12.5
Moose Butte Cr	82242	0	0	0	0.52	0	0	0	1.8	11
Newsome Cr	14498	0	2.58	7.4	3.79	0	0	0.77	2.6	14
Newsome Cr	47266	0	0.91	41.01	0.84	0.21	0	0.42	3	15
Newsome Cr	80034	0.07	2.48	10.14	2.26	0	0.07	0.51	2.3	14
Newsome Cr	96418	0.18	0.92	9.62	1.48	0	0	0.83	2.3	15
Red Horse Cr	29250	0	0.16	0	0	0	6.36	0	2.9	12
Red Horse Cr	35394	0	0.8	0	0.54	0	1.61	0	2.3	11.5
Red River	13634	0	0	0	0	0	3.64	0	2.1	12
Red River	19010	0.23	0	12.59	0.31	0	0.08	0.15	2.2	17
Red River	42562	0.33	0	2.84	0.44	0	0	0.33	1.6	14
Red River	46402	0	0	0	0	0	0.53	0	1.8	12
Red River	51522	0	0	22.36	0.26	0.09	0.26	0.17	1.2	17
Red River	54594	0.76	0.09	0	0	0	0.38	0.09	1.7	11
Red River	84290	0	0.46	16.75	0	0	0.26	0.52	2	11
MF Red River	65858	0	0	0	3.46	0	0	0	3.5	8
SF Red River	13122	0	1.02	0	0.13	0	0.13	0.13	1.3	11
SF Red River	18754	0	1.38	0	0	0	0.31	0	1.2	12.5
SF Red River	33090	0	1.21	0	0	0	0.4	0	1.9	8
SF Red River	69954	0	0.29	0	0	0	0	0	1.6	8.5
Siegel Creek	85058	0	0	0	0.42	0	4.24	0	2.2	13
Siegel Creek	94530	0	0	0	1.88	0	2.41	0	2.4	14
Soda Creek	87362	0	0	0	2.68	0	0.54	0	2	11
SF Clearwater	2338	0.66	4.13	0.24	0.06	0	0	1.26	1.9	19
SF Clearwater	3650	0	0.63	5.51	1.03	0.4	0	0.69	1.8	17
SF Clearwater	48930	3.29	3.61	1.48	0.52	0.06	0.06	0.84	1.7	19
SF Clearwater	52018	0.32	1.98	0.45	0.06	0	0	1.41	2	17
SF Clearwater	63042	0	0.6	3	0.9	0.18	0	1.08	2.3	17.5
SF Clearwater	67874	0.43	0.7	2.34	0	0	0	1.1	1.9	19
SF Clearwater	69186	0	0.27	5.16	0.44	0	0	1.43	2.1	16.5
SF Clearwater	79426	0	0.24	13.56	0.32	0	0	0.57	2.2	19
SF Clearwater	95810	0.05	0.32	2.71	0.27	0	0	0.54	2.7	19
SF Clearwater	97858	0.03	1.2	0.41	0.1	0	0	0.65	2.1	15.5
Trapper Creek	24510	0	0	0	1.55	0	0.89	0	2.3	11
Trapper Creek	41794	0	0	0	3.08	0	0	0	2	10
Trapper Creek	45890	0	0	0	3.58	0	0	0	1.7	9
Mean		0.23	0.63	6.27	1.48	0.04	0.77	0.50		
SD		0.58	0.98	10.72	2.30	0.13	1.54	0.94		

Table 17. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Camas Creek Drainage in the Middle Fork Salmon River steelhead population, July 6 to August 7, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)								
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Camas Creek	66287	0	1.68	0	0.5	0.04	0	0	1.7	13
Camas Creek	54175	0.13	4.83	0	0.73	0.07	0.07	0.4	1.3	10
Camas Creek	751	0	4.51	0.06	0.93	0	0	0.29	1.7	13
Camas Creek	101279	0	4.91	0.11	0.5	0.06	0	0.34	1.9	13
Camas Creek	44143	0	0	0	0.19	0.56	0	0	1.3	10.5
Camas Creek	92271	0	0.24	0	0.08	0	0	0	1.9	10
Camas Creek	18543	0	2.33	0	0.39	0	0	0	1.6	14
Camas Creek	64415	0	1.91	0	0.99	0	0	0	1.6	15
Castle Creek	79535	0	0.7	0	0	4.92	0	0	2.5	9
Castle Creek	13999	0	0	0	0	5.39	0	0	2.5	8
Castle Creek	100255	0.19	20.18	0	0.19	0.38	0	0	2.4	16
Hoodoo Creek	88991	0	0	0	0	3.34	0	0	2.9	8.5
SF Camas Cr.	78959	0	0	0	1.83	2.56	0	0	2	9
SF Camas Cr.	60527	0	0.46	0	0	0.46	0	0	1.7	9
SF Camas Cr.	46191	0	0	0	1.81	9.48	0	0	3.2	8
Silver Creek	42911	0.43	3.04	0	0.22	0	0	2.6	1.1	18
Silver Creek	10143	0.17	1.87	0	0.17	0	0.17	1.87	1.1	15
Silver Creek	83871	0	16.49	0	0.26	0	1.03	5.67	2.1	18
Trail Creek	52127	0	0	0	0	2.62	0	0	3.8	12
Yellowjacket Cr	66463	0.27	17.27	0	0.27	0	0	0	3.4	15
Yellowjacket Cr	28063	0	2.87	0	0	1.72	0	0	2.9	10
Yellowjacket Cr	7071	0.32	19.6	0	0	0.11	0	0	3	12
Yellowjacket Cr	15775	0.22	20.61	0	0.56	0.34	0	0	3.3	10.5
Yellowjacket Cr	29599	0.17	12.96	0	0	0.25	0	0	3.3	9
Yellowjacket Cr	93087	1.76	9.06	0	0	0.63	0	0	3	15
Yellowjacket Cr	93599	0	5.72	0	0	0.57	0	0	4.6	13
Yellowjacket Cr	9887	0	0	0	0	0.78	0	0	2.8	6
Mean		0.14	5.6	0.01	0.36	1.27	0.05	0.41		
SD		0.35	7.13	0.02	0.51	2.23	0.20	1.21		

Table 18. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Rapid River drainage in the lower main-stem Salmon River steelhead population, August 1 to August 8, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)							
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Hatchery Chinook**	**Cutthroat Trout**	**Bull Trout**	**Visibility (m)**	**Temp (C)**
Rapid River	135250	0	0	0	0	0	6.63	2.3	9.5
Rapid River	24658	0	0	0	0	0	2.35	2.7	6
Rapid River	200786	0	0	0	0	0	3.31	2.5	8
Rapid River	237650	0	0	0	0	0	1.92	2.5	9
Rapid River	90194	0	0	0	0	0	4.27	2.6	11
Rapid River	155730	0	0	0	0	0	4.21	2.4	11.5
Rapid River	196690	0	0	0	0	0	1.47	2.7	8
Rapid River	323474	0	0.82	0	0	0	1.55	2.5	10
Rapid River	192402	0	0.57	0	0	0	1.38	2.8	12.5
Rapid River	126866	0	0.77	0	0	0	0.51	2.3	12.5
Rapid River	17298	0.39	3.26	0	0	0	0.89	1.6	11
Rapid River	15762	0.22	5.43	0	0	0	0	2.2	8.5
Rapid River	294290	0	5.56	0	0	0.21	0.1	2.7	10
Rapid River	324498	0.58	3.67	0	0.08	0	0.08	3	10
Rapid River	193426	0.22	2.74	0	0.29	0	0.14	2.9	10
Rapid River	390034	1.1	5.71	0	0.3	0.2	0.4	1.8	12.5
Rapid River	62354	4.16	3.9	0	0	0	0.08	3	12
Rapid River	19346	7.95	6.76	0.72	0	0	0	2.2	13
Rapid River	215954	6.24	2.25	3.02	0	0	0.39	2.2	13
WF Rapid River	163218	0	3.9	0	0	0	0	2.3	12.5
Mean		1.04	2.27	0.19	0.03	0.02	1.48		
SD		2.23	2.29	0.67	0.09	0.06	1.79		

Table 19. Densities (fish/100 m^2) of salmonids observed at extensive panel transects snorkeled in the Upper Middle Fork Salmon River Drainage in the Middle Fork Salmon River steelhead population, July 10 to August 20, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)								
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Ayers	13303	0	0	0	0	0	0	0	--[a]	--[a]
Bear Valley Cr	3063	0.11	0.06	4.41	0	0	1.03	2.21	2.5	13
Bear Valley Cr	35831	0	0	0.5	0	0	0.85	1.1	2.8	17
Bear Valley Cr	52215	0.14	0.02	5.05	0	0	0.29	1.14	3	11
Bear Valley Cr	70231	0	0	0	0	0	0	0	--[a]	--[a]
Bearskin Cr	15447	0	0	0	0	0	5.2	0	3.1	14
Bearskin Cr	29271	0	0.41	0	0	1.22	0	0	3.3	9
Bearskin trib	23639	0	0	20.83	0	0	5.79	0	1.8	11
Big Chief Cr	40991	0	0	0	3.97	1.49	0	0	2.8	14
Big Chief Cr	4127	0	0	0	5.12	0.21	0	0	2.4	14
Blue Moon Cr	64503	0	0	0	0	0	0	0	--[a]	--[a]
Boundary Cr	42999	0.2	8.05	0	0	0.6	0	0	3	14
Cache Creek	13399	0.2	1.97	0	0	0	0	0	2.5	13
Cache Creek	21591	0	0	0	0	0	0.49	0	3.3	11.5
Cache Creek	54359	0	0	0	0	0	3.03	0	2.9	14
Cold Creek	34391	0	0	0	0	0.83	0	0	>3	11
Cook Creek	27735	0	0	0	0	0	1.05	0	2.4	10
Dynamite Cr	18159	0.22	3.03	0	0.43	0.22	0	0	>3	14
EF Elk Creek	53239	0	0.2	0	0	0	2.01	0	2.4	10
EF Elk Creek	55287	0	1.72	26.87	0	0	1.5	0	3.6	16
Elk Creek	22519	0.8	0	17.6	0	0	3.73	0.44	3.5	16
Elk Creek	29687	0.81	0.88	18.09	0	0	7.51	8.07	3	16
Elk Creek	37879	0.16	0	1.26	0	0	0.86	26.64	4.6	12
Elk Creek	38903	0	0	5.52	0	0	3.5	8.94	2.7	12
Elk Creek	62455	0	1.2	25.26	0	0	5.43	15.24	3	16
Elk Creek	70647	0	0.4	8.95	0	0	1.58	22.17	3.4	16
Full Moon Cr	45047	0.56	4.79	0	0	1.41	0	0	>3	12
Indian Creek	25071	0	1.07	0	0.54	0	0	0	3.1	12
Little Beaver Cr	4087	0	0	0	0	0	4.27	0	--	10
Little Indian Cr	4591	0	0.48	0	0	0	0	0	3.8	--
Little Indian Cr	495	0	0	0	1.56	1.95	0	0	>3	--
Mace Creek	37975	0	0	0	0	0	0	0	>3	9
Mace Creek	56407	0	0	0	0	0	3.88	0	>3	14
Mace Creek	70743	0	0	0	0	0	15.1	0	2	14
Marble Creek	13039	0.52	0.81	0.89	0	0	0	0	2.1	19
Marble Creek	1775	0.66	0.95	3.52	0	0.07	0	0	2.4	18
Marble Creek	20207	0	2.96	0	0.99	0	0	0	>3	11
Marble Creek	27375	0	6.18	0	0	0.26	0	0	2.7	12
Marble Creek	37615	0	0	0.06	0.12	0	0	0	2.1	12
Marble Creek	5871	0.79	1.11	0.48	0.08	0	0	0	2.6	15
NF Elk Creek	14327	0	0.56	0	0	0	9.44	0	2.5	15
NF Elk Creek	40951	0	10.36	0	0	0	11.3	0	2.2	14
Pole Creek	14935	0	8.73	27.05	0	0	3.49	0	>3	10
Pole Creek	55895	0	0	0	0	0	0	0	>3	9
Sack Creek	25687	0	0	0	0	0	0	0	3.5	9
Sack Creek	31831	0.22	6	41.12	0	1.11	11.34	0.22	2.5	16
Sulphur Creek	24567	0	13.32	2.41	0	0.28	0	0	4	16
Sulphur Creek	4111	4.04	7.23	0	1.28	0	0	0	4	14
Trail Creek	23279	8.29	11.61	0	7.3	0	0	0	3.4	15
WF Elk Creek	47095	0	0	0.43	0	0	1.28	0	1.9	15
Wyoming Cr	19447	0	1.73	0	0	0	0.35	0	3.8	14
Mean		0.41	1.88	4.12	0.42	0.19	2.05	1.69		
SD		1.32	3.36	9.12	1.36	0.45	3.47	5.37		

[a] Snorkeling the transect was not feasible due to environmental conditions.

Table 20. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Crooked Fork Creek drainage, in the Lochsa River steelhead population, July 19-25, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)							
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Boulder Creek	34625	0	0.81	0	2.84	0.27	0	0	4.2
Brushy Fork	101185	0.46	0.33	0	0.59	0	0	0	3.5
Brushy Fork	103233	0.31	0.12	0	0.06	0	0.06	0.06	4.7
Brushy Fork	117569	0	1.16	0	0.94	0	0.07	0.07	4.7
Brushy Fork	136001	0.99	0.2	0	0.33	0	0	0	3
Brushy Fork	150337	0.52	2.09	0	1.96	0	0	0	4.3
Brushy Fork	21313	0.08	2.27	0	0.31	0	0	0	3.4
Crooked Fork Cr	10049	0	0.89	0	3.66	0	0	0	7.8
Crooked Fork Cr	12097	0	0.46	4.71	0.63	0	0.55	0.55	5
Crooked Fork Cr	122689	0	0.21	0	4.25	0	0	0	4.4
Crooked Fork Cr	132929	0.19	0.25	0.68	2.22	0	0.06	0.06	5
Crooked Fork Cr	64321	0	0.4	3.6	2.4	0	0.8	4.4	16
Crooked Fork Cr	94017	0.43	1.91	0.31	0.49	0	0.19	5.2	15
Crooked Fork Cr	151361	2.48	1.43	6.32	0.54	0	0	0	4.1
Crooked Fork Cr	159553	0.97	0.38	1.55	0.38	0	0.46	0.46	3.7
Crooked Fork Cr	165697	0.09	0.74	0.19	0.74	0	0	0	4.5
Crooked Fork Cr	28481	0	1.76	0	0.95	0	0.48	0.48	4
Crooked Fork Cr	48961	0	1.21	0	1.59	0.09	0	0	7
Crooked Fork Cr	97089	0.82	0.22	2.73	1.42	0	0.05	0.05	4.5
Crooked Fork Cr	67393	0.93	0.07	0.4	1.8	0.07	0	0	5.2
Crooked Fork Cr	80705	0.29	0.29	0	12.89	0	0	0	3.8
Hopeful Creek	105281	0	0	0	1.47	0	0	0	3.8
Spruce Creek	111425	0	0.85	0	1.91	0	0	0	2.2
Spruce Creek	123969	0	0.08	0	0.17	0	0	0	2.3
Mean		0.36	0.76	0.85	1.86	0.02	0.11		
SD		0.57	0.69	1.72	2.60	0.06	0.22		

Table 21. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Crooked River drainage in the South Fork Clearwater steelhead population, July 5-12, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)									
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Brook/ Bull Hybrid**	**Visibility (m)**	**Temp (C)**
Crooked River	161346	0	0.08	0	0.08	0	0	1.36	0	2.9	15
Crooked River	202306	0	0.5	0	1.33	0.17	0	0.33	0	2.1	11.5
Crooked River	214594	0	0	0	2.06	0	0	0.48	0	1.8	14
Crooked River	243266	0	0.06	0.06	0.99	0	0	0.31	0	1.7	15
Crooked River	5698	0	0.84	2.53	1.58	0	0	0.53	0	2.4	16
Crooked River	72258	0.25	0	0	1.51	0	0	0	0	1.8	12
Crooked River	73282	0	0	1.77	0.66	0.11	0	0.89	0	1.8	16.5
Crooked River	50754	0	0.24	0	2.12	0	0	0	0	1.5	11
EF Crooked R	55874	0	0	0	1.13	0	0	0	0	2.5	7
EF Crooked R	219714	0	0	0	0.57	0.14	0	0	0.14	2.6	9
EF Crooked R	157250	1.12	0	0	8.96	0	0	0	0	1.8	11
EF Crooked R	247362	0	1.14	0	10.81	0	0	0	0	1.8	9.5
EF Crooked R	58946	0.4	0	0	6.46	0	0	0	0	1.5	11
Fivemile Creek	14914	1.38	0	0	3.45	0	0	0	0	2.1	10
Fivemile Creek	186946	1.32	0	0	3.96	0	0	0	0	1.7	11.5
Relief Creek	124482	0	0.33	0	6.25	0	0	0	0	1.8	8
Relief Creek	181826	0	0	0	2.18	0	0	0	0	1.5	8.5
Relief Creek	235074	0	0	0	1.6	0	0	0	0	2	7.5
WF Crooked R	170562	0	0	0	1	0	0	0	0	1.4	8
WF Crooked R	178754	0	0.19	0	5.4	0.77	0.39	0	0	1.55	10
WF Crooked R	236098	0	0	0	1.51	1.32	0.19	0	0	2	9.5
WF Crooked R	244290	0	0	0	1.77	1.06	0	0	0	1.8	10
WF Crooked R	256578	0	0.2	0	3.22	0.4	0	0.2	0	2	11
Mean		0.19	0.16	0.19	2.98	0.17	0.03	0.18	0.01		
SD		0.44	0.30	0.63	2.80	0.37	0.09	0.35	0.03		

Table 22. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Fish Creek drainage in the South Fork Clearwater steelhead population from July 18-25, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)							
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Fish Creek	69666	0	0	0	5.05	0	0	1.9	13
Fish Creek	57378	0.79	0	0	8.44	0	0	2.1	13
Fish Creek	194498	2.27	8.62	0	1.21	0	0	2.7	16
Fish Creek	96194	0	11.52	0	2.22	0	0	3.5	10.5
Fish Creek	167874	0	2.48	0	1.73	0	0	3.4	14
Fish Creek	151490	0.12	2.11	0	1.99	0	0	3.3	12
Fish Creek	102338	0	5.66	0	1.5	0	0	2.9	16
Fish Creek	20418	0.1	7	0	4.7	0	0	4	14
Fish Creek	172738	2.95	3.73	0	5	0	0	2.3	18
Fish Creek	74434	4.28	12.06	0	3	0	0	2.5	15
Fish Creek	41666	4.2	10.45	0	1.4	0.06	0	2.9	16
Fish Creek	12994	2.21	3.26	1.99	3.42	0	0.33	2.2	21
Hungery Cr	24610	0.76	4.56	0	2.53	0	0	2	14
Hungery Cr	33698	0	4.07	0	0.9	0	0	4	15.5
Hungery Cr	164770	2.19	0	0	15.03	0	0	2.1	14
Hungery Cr	17314	0	8.09	0	2.98	0	0	2.3	14.5
Hungery Cr	213922	0	7.12	0	3.98	0	0	2.7	17
Hungery Cr	97698	0.72	6.5	0	2.68	0	0	2.8	14.5
Hungery Cr	58050	1.23	14.13	0	2.21	0.12	0	2.3	20
Willow Creek	221890	0	3.39	0	5.64	0	0	2.3	15
Willow Creek	156354	4.4	5.38	0	2.69	0	0	4.4	16.5
Mean		1.25	5.72	0.09	3.73	0.01	0.02		
SD		1.53	3.94	0.42	3.08	0.03	0.07		

Table 23. Densities (fish/100 m^2) of salmonids observed at intensive panel transects snorkeled in the Marsh Creek drainage in the Middle Fork Salmon upper main-stem steelhead population from July 18-24, 2012. Trout fry = all trout <50 mm that could not be distinguished between steelhead and cutthroat trout. Mean and standard deviation are given by species.

		Density (fish/100 m^2)								
Stream	**Transect**	**Trout Fry**	**Steelhead**	**Chinook salmon**	**Cutthroat Trout**	**Bull Trout**	**Brook Trout**	**Whitefish**	**Visibility (m)**	**Temp (C)**
Bear Creek	109911	0	0	0	0	3.88	0	0	2.7	11
Beaver Creek	97111	0	0	0	0	1.73	0.43	0	2	11
Beaver Creek	32111	0	0	0	0	1.93	0	0	2	9
Beaver Creek	11607	0.86	0.36	55.26	0	0	3.3	0.29	3.1	11
Beaver Creek	27991	0	0.17	6.71	0	0	0	0.5	3.1	8
Beaver Creek	15703	0	0.9	0	0	0	0.22	0	2.6	12
Beaver Creek	51031	0	0.87	0	0	1.57	1.4	0	3.5	10.5
Beaver Creek	83799	0	0.48	0	0	0.71	0.95	0	3.6	9
Bench Creek	101719	0	0	0	0	0	0	0	3.3	7
Cape Horn Cr	150871	1.46	2.91	58.3	0	0.12	0.36	0.24	2.3	15
Knapp creek	126295	0	4.07	6.65	0	0	4.07	0	2.3	17
Knapp Creek	60759	0.27	4.77	53.54	0	0	13.9	0.27	2.7	17
Knapp Creek	40279	0	3.96	3.35	0	0	3.65	0	3.8	12
Knapp Creek	164695	0	0.4	0	0	0	0	0	4.9	10
Knapp Creek	73047	0	1.69	0.13	0	0	1.69	0.13	4.9	12
Knapp Creek	130391	0	0	0	0	0	2.13	0	4.9	10
Lola Creek	60274	0	1.68	0	0	0	5.45	0	2.3	11
Marsh creek	56663	0	0.7	68.27	0	0	3.02	0.81	1.7	17
Marsh creek	89431	0	3.14	42.85	0.12	0	0.81	0	2.4	14
Marsh creek	105815	0.87	10.82	17.48	0	0.11	0.98	0.98	2.8	14
Marsh Creek	125783	0	3.99	5.92	0.28	0	0	1.03	3.7	12
Swamp Creek	120151	0	0	0.36	0	0.36	0.72	0	3.6	12
Mean		0.13	1.63	12.26	0.02	0.40	1.71	0.16		
SD		0.36	2.43	22.22	0.06	0.91	2.90	0.31		

Table 24. Steelhead trout detection probabilities from mark-resight studies in 2012. Fish were marked with an upper caudal clip in the main transect and resighted during a subsequent snorkel survey. Asterisks indicate that juvenile cutthroat trout were included in the number marked.

Stream	Transect	Number Marked	Number Resighted	Efficiency (%)	Visibility (m)	Temp (C)
American River	68386	6*	1	16.7	2.7	17.5
American River	GPM 1:2	7*	3	42.9	3.1	15.0
Boulder Creek	Re-sight 1	25*	6	24.0	2.0	14.0
Buckhorn Creek	Re-sight 1	15	10	66.7	5.8	13.0
Curtis Creek	Re-sight 1	6	1	16.7	3.5	10.0
Fish Creek	FC06 - 41666	44*	10	22.7	2.5	15.0
Fish Creek	GPM 2	33*	6	18.2	3.1	13.0
Fitsum Creek	Re-sight 1	14	7	50.0	2.6	14.0
Fitsum Creek	Re-sight 2	28	25	89.3	2.6	15.0
Hazard Creek	Re-sight 1	44	26	59.1	5.2	14.0
Johnson Creek	Re-sight 1	18	13	72.2	3.2	13.0
Johnson Creek	Re-sight 2	6	6	100.0	4.5	17.0
Johnson Creek	Re-sight 3	31*	30	96.8	3.5	17.0
Johnson Creek	PW3A	31	19	61.3	4.0	13.0
Johnson Creek	Pw3B	22	19	86.4	3.3	14.0
Marsh creek	Resight 2012	19	7	36.8	2.6	12.0
Morgan creek	BLM Camp	35	23	65.7	1.8	12.0
Newsome Creek	80034	37	15	40.5	2.8	15.0
Newsome Creek	96418	13*	6	46.2	3.0	16.0
Newsome Creek	14498	23*	13	56.5	2.1	12.0
Rapid River	RR03 - 19346	14	5	35.7	2.2	13.0
Rapid River	RR05 - 62354	10	3	30.0	3.0	12.0
Red River	42562	9*	2	22.2	1.6	14.0
Selway River	SR_2012_Resight	27	7	25.9	4.2	16.0
Selway River	LITTLE-CW	8	1	12.5	3.9	13.0
SF Clearwater River	79426	6*	2	33.3	2.3	18.0
SF Clearwater River	69188	14*	2	14.3	2.1	16.5
Yellowjacket creek	Lower Camp Resight	18	9	50.0	3.0	9.0
Yellowjacket creek	Upper Camp Resight	17	6	35.3	3.0	7.0

APPENDICES

Appendix A. Data Used to Calculate Wild Adult Snake River Spring-Summer Chinook Salmon Age Proportions at Lower Granite Dam from 1998-2004

In 1998, this project began collecting fin rays from adult Chinook salmon carcasses on the spawning grounds to determine ocean ages. Ocean ages based on fin rays were >94% accurate based on known-age adult Chinook salmon (Kiefer et al. 2001, 2002, 2004; Copeland et al. 2004, 2005, 2006, 2007b, 2008; Kennedy et al. 2011, 2012). Fin ray data allowed accurate reconstruction of the age composition of the returning adults and accurate estimates of smolt-to-adult return (SAR) rates when combined with lengths of adult Chinook salmon obtained at Lower Granite Dam (LGR). Lengths were measured either from video of the window at the fish ladder or from fish measured at the adult trap. The resulting length data was used to construct a length frequency distribution by 5 cm increments:

$$p_i = \frac{f_i}{F},$$

where p_i is the proportion of the run in length category i, f_i is the number of fish in length category i, and F is the number of all fish measured. Similarly, the age distribution of each length group was calculated based on fin ray samples from adult carcasses on the spawning grounds:

$$a_{ij} = \frac{m_{ij}}{M_i},$$

where a_{ij} is the proportion of carcasses of length i at ocean age j, m_{ij} is the number of carcasses of length i at ocean age j, and M_i is the total number of carcasses of length i. The age distribution of the carcass sample was expanded to the entire run by multiplying the matrix of a_{ij} by the vector of p_i which resulted in an age-length key specific to the adult return. These proportions were then summed for each age to estimate annual age composition for the adult return year.

The tables below are a one-time reporting of the data used to estimate the SAR rate for Chinook salmon from 1998-2004. Since 2005, National Oceanic and Atmospheric Administration Fisheries (NOAAF) personnel have been systematically sampling lengths and scales from adult Chinook salmon as they migrate upstream past LGR (Harmon 2009). We have used the scale ages and lengths from LGR (Schrader et al. 2011, 2012) to estimate the annual SAR rates since 2005 (Table 6). We completed an intensive review of the entire SAR time series estimated by this project (Tables 5 and 6). The tables below provide an accurate and transparent detail of the final data used over the time period when fin rays were used to determine ages.

Table A-1. Chinook salmon lengths estimated from video footage of the trap window at Lower Granite Dam in 1998.

Fork Length (cm)	Sample Size	Proportion
<50	2	0.0038
50-54	4	0.0075
55-59	2	0.0038
60-64	4	0.0075
65-69	7	0.0132
70-74	25	0.0470
75-79	27	0.0508
80-84	63	0.1184
85-89	143	0.2687
90-94	135	0.2537
95-99	85	0.1598
100-104	27	0.0508
>104	8	0.0150
Total	532	1.0000

Table A-2. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 1998.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
<50	n/a[a]	1.0000 (0)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	n/a	1.0000 (0)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	n/a	0.9167 (0)	0.0833 (0)	0.0000 (0)	0.0000 (0)	1.0000
60-64	n/a	0.8190 (0)	0.1810 (0)	0.0000 (0)	0.0000 (0)	1.0000
65-69	n/a	0.0975 (0)	0.8935 (0)	0.0090 (0)	0.0000 (0)	1.0000
70-74	1	0.0000 (0)	1.0000 (1)	0.0000 (0)	0.0000 (0)	1.0000
75-79	6	0.0000 (0)	0.8333 (5)	0.1667 (1)	0.0000 (0)	1.0000
80-84	15	0.0000 (0)	0.0000 (0)	0.9333 (14)	0.0667 (1)	1.0000
85-89	40	0.0000 (0)	0.0250 (1)	0.9500 (38)	0.0250 (1)	1.0000
90-94	54	0.0000 (0)	0.0185 (1)	0.9815 (53)	0.0000 (0)	1.0000
95-99	34	0.0000 (0)	0.0000 (0)	0.9706 (33)	0.0294 (1)	1.0000
100-104	14	0.0000 (0)	0.0000 (0)	0.8571 (12)	0.1429 (2)	1.0000
>104	9	0.0000 (0)	0.0000 (0)	0.5556 (5)	0.4444 (4)	1.0000
Total	173					

[a] Carcasses <70 cm (FL) were not targeted; average results from 1999-2001 were used for age proportions (Kiefer et al. 2002).

Table A-3. Age-length key for Chinook salmon in 1998 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0038	0.0000	0.0000	0.0000
50-54	0.0075	0.0000	0.0000	0.0000
55-59	0.0035	0.0003	0.0000	0.0000
60-64	0.0061	0.0014	0.0000	0.0000
65-69	0.0013	0.0118	0.0001	0.0000
70-74	0.0000	0.0470	0.0000	0.0000
75-79	0.0000	0.0423	0.0085	0.0000
80-84	0.0000	0.0000	0.1105	0.0079
85-89	0.0000	0.0067	0.2553	0.0067
90-94	0.0000	0.0047	0.2490	0.0000
95-99	0.0000	0.0000	0.1551	0.0047
100-104	0.0000	0.0000	0.0435	0.0073
>104	0.0000	0.0000	0.0083	0.0067
Total Age Proportions	0.0222	0.1142	0.8303	0.0333

Table A-4. Chinook salmon fork lengths estimated from video footage of the trap window at Lower Granite Dam in 1999.

Fork Length (cm)	Sample Size	Proportion
<50	4	0.0089
50-54	15	0.0336
55-59	13	0.0291
60-64	1	0.0022
65-69	15	0.0336
70-74	54	0.1208
75-79	120	0.2684
80-84	99	0.2215
85-89	56	0.1253
90-94	33	0.0738
95-99	22	0.0492
100-104	8	0.0179
>104	7	0.0157
Total	447	1.0000

Table A-5. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 1999.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
<50	5	1.0000 (5)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	5	1.0000 (5)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	12	1.0000 (12)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
60-64	3	1.0000 (3)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
65-69	5	0.2000 (1)	0.8000 (4)	0.0000 (0)	0.0000 (0)	1.0000
70-74	23	0.0000 (0)	0.9565 (22)	0.0435 (1)	0.0000 (0)	1.0000
75-79	79	0.0000 (0)	0.9747 (77)	0.0253 (2)	0.0000 (0)	1.0000
80-84	69	0.0000 (0)	0.9275 (64)	0.0725 (5)	0.0000 (1)	1.0000
85-89	25	0.0000 (0)	0.8000 (20)	0.2000 (5)	0.0000 (0)	1.0000
90-94	23	0.0000 (0)	0.3043 (7)	0.6087 (14)	0.0870 (2)	1.0000
95-99	9	0.0000 (0)	0.1111 (1)	0.5556 (5)	0.3333 (3)	1.0000
100-104	6	0.0000 (0)	0.0000 (0)	1.0000 (6)	0.0000 (0)	1.0000
>104	3	0.0000 (0)	0.0000 (0)	0.6667 (2)	0.3333 (1)	1.0000
Total	267					

Table A-6. Age-length key for Chinook salmon in 1999 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0089	0.0000	0.0000	0.0000
50-54	0.0336	0.0000	0.0000	0.0000
55-59	0.0291	0.0000	0.0000	0.0000
60-64	0.0022	0.0000	0.0000	0.0000
65-69	0.0067	0.0269	0.0000	0.0000
70-74	0.0000	0.1155	0.0053	0.0000
75-79	0.0000	0.2616	0.0068	0.0000
80-84	0.0000	0.2054	0.0161	0.0000
85-89	0.0000	0.1002	0.0251	0.0000
90-94	0.0000	0.0225	0.0449	0.0064
95-99	0.0000	0.0055	0.0273	0.0164
100-104	0.0000	0.0000	0.0179	0.0000
>104	0.0000	0.0000	0.0105	0.0052
Total Age Proportions	0.0805	0.7376	0.1539	0.0280

Table A-7. Chinook salmon fork lengths estimated from video footage of the trap window at Lower Granite Dam in 2000.

Fork Length (cm)	Sample Size	Proportion
<50	12	0.0316
50-54	21	0.0553
55-59	20	0.0526
60-64	12	0.0316
65-69	29	0.0763
70-74	95	0.2500
75-79	123	0.3238
80-84	39	0.1026
85-89	11	0.0289
90-94	14	0.0368
95-99	3	0.0079
100-104	0	0.0000
>104	1	0.0026
Total	380	1.0000

Table A-8. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 2000.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
<50	5	1.0000 (5)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	10	1.0000 (10)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	10	1.0000 (10)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
60-64	7	0.8571 (6)	0.1429 (1)	0.0000 (0)	0.0000 (0)	1.0000
65-69	26	0.0385 (1)	0.9615 (25)	0.0000 (0)	0.0000 (0)	1.0000
70-74	42	0.0000 (0)	1.0000 (42)	0.0000 (0)	0.0000 (0)	1.0000
75-79	83	0.0000 (0)	1.0000 (83)	0.0000 (0)	0.0000 (0)	1.0000
80-84	45	0.0000 (0)	0.9556 (43)	0.0444 (2)	0.0000 (0)	1.0000
85-89	53	0.0000 (0)	0.9245 (49)	0.0755 (4)	0.0000 (0)	1.0000
90-94	14	0.0000 (0)	0.2143 (3)	0.7857 (11)	0.0000 (0)	1.0000
95-99	9	0.0000 (0)	0.0000 (0)	1.0000 (9)	0.0000 (0)	1.0000
100-104	5	0.0000 (0)	0.0000 (0)	1.0000 (5)	0.0000 (0)	1.0000
>104	2	0.0000 (0)	0.0000 (0)	1.0000 (2)	0.0000 (0)	1.0000
Total	311					

Table A-9. Age-length key for Chinook salmon in 2000 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0316	0.0000	0.0000	0.0000
50-54	0.0553	0.0000	0.0000	0.0000
55-59	0.0526	0.0000	0.0000	0.0000
60-64	0.0271	0.0045	0.0000	0.0000
65-69	0.0029	0.0734	0.0000	0.0000
70-74	0.0000	0.2500	0.0000	0.0000
75-79	0.0000	0.3238	0.0000	0.0000
80-84	0.0000	0.0980	0.0046	0.0000
85-89	0.0000	0.0267	0.0022	0.0000
90-94	0.0000	0.0079	0.0289	0.0000
95-99	0.0000	0.0000	0.0079	0.0000
100-104	0.0000	0.0000	0.0000	0.0000
>104	0.0000	0.0000	0.0026	0.0000
Total Age Proportions	0.1695	0.7843	0.0462	0.0000

Table A-10. Chinook salmon fork lengths estimated from video footage of the trap window at Lower Granite Dam in 2001.

Fork Length (cm)	Sample Size	Proportion
<50	1	0.0014
50-54	10	0.0140
55-59	5	0.0070
60-64	16	0.0224
65-69	86	0.1203
70-74	229	0.3202
75-79	230	0.3216
80-84	97	0.1357
85-89	24	0.0336
90-94	11	0.0154
95-99	4	0.0056
100-104	1	0.0014
>104	1	0.0014
Total	715	1.0000

Table A-11. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 2001.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
< 50	2	1.0000 (2)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	5	1.0000 (5)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	4	0.7500 (3)	0.2500 (1)	0.0000 (0)	0.0000 (0)	1.0000
60-64	5	0.6000 (3)	0.4000 (2)	0.0000 (0)	0.0000 (0)	1.0000
65-69	37	0.0541 (2)	0.9189 (34)	0.0270 (1)	0.0000 (0)	1.0000
70-74	181	0.0000 (0)	0.9945 (180)	0.0055 (1)	0.0000 (0)	1.0000
75-79	259	0.0039 (1)	0.9884 (256)	0.0077 (2)	0.0000 (0)	1.0000
80-84	249	0.0000 (0)	0.9920 (247)	0.0080 (2)	0.0000 (0)	1.0000
85-89	100	0.0000 (0)	0.9000 (90)	0.0900 (9)	0.0100 (1)	1.0000
90-94	48	0.0000 (0)	0.4583 (22)	0.5417 (26)	0.0000 (0)	1.0000
95-99	33	0.0000 (0)	0.1212 (4)	0.8182 (27)	0.0606 (2)	1.0000
100-104	3	0.0000 (0)	0.0000 (0)	1.0000 (3)	0.0000 (0)	1.0000
>104	4	0.0000 (0)	0.0000 (0)	1.0000 (4)	0.0000 (0)	1.0000
Total	930					

Table A-12. Age-length key for Chinook salmon in 2001 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0014	0.0000	0.0000	0.0000
50-54	0.0140	0.0000	0.0000	0.0000
55-59	0.0053	0.0018	0.0000	0.0000
60-64	0.0134	0.0090	0.0000	0.0000
65-69	0.0065	0.1105	0.0032	0.0000
70-74	0.0000	0.3184	0.0018	0.0000
75-79	0.0013	0.3179	0.0025	0.0000
80-84	0.0000	0.1346	0.0011	0.0000
85-89	0.0000	0.0302	0.0030	0.0003
90-94	0.0000	0.0071	0.0083	0.0000
95-99	0.0000	0.0007	0.0046	0.0003
100-104	0.0000	0.0000	0.0014	0.0000
>104	0.0000	0.0000	0.0014	0.0000
Total Age Proportions	0.0419	0.9302	0.0273	0.0006

Table A-13. Chinook salmon fork lengths estimated from video footage of the trap window at Lower Granite Dam in 2002. Lengths were adjusted by +5 cm to reconcile differences between lengths measured on the spawning grounds and lengths measured at Lower Granite Dam.

Fork Length (cm)	Sample Size	Proportion
<50	1	0.0024
50-54	0	0.0000
55-59	2	0.0047
60-64	3	0.0071
65-69	2	0.0047
70-74	30	0.0706
75-79	85	0.2000
80-84	108	0.2541
85-89	65	0.1529
90-94	47	0.1106
95-99	47	0.1106
100-104	21	0.0494
>104	14	0.0329
Total	425	1.0000

Table A-14. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 2002.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
<50	1	1.0000 (1)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	4	1.0000 (4)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	5	1.0000(5)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
60-64	3	0.6667 (2)	0.3333 (1)	0.0000 (0)	0.0000 (0)	1.0000
65-69	29	0.0690 (2)	0.9310 (27)	0.0000 (0)	0.0000 (0)	1.0000
70-74	77	0.0000 (0)	1.0000 (77)	0.0000 (0)	0.0000 (0)	1.0000
75-79	138	0.0000 (0)	0.9783 (135)	0.0217 (3)	0.0000 (0)	1.0000
80-84	133	0.0000 (0)	0.8346 (111)	0.1654 (22)	0.0000 (0)	1.0000
85-89	92	0.0000 (0)	0.2826 (26)	0.6957 (64)	0.0217(2)	1.0000
90-94	113	0.0000 (0)	0.0265 (3)	0.9735 (110)	0.0000 (0)	1.0000
95-99	70	0.0000 (0)	0.0286 (2)	0.9571 (67)	0.0143 (1)	1.0000
100-104	36	0.0000 (0)	0.0000 (0)	0.9722 (35)	0.0278 (1)	1.0000
>104	18	0.0000 (0)	0.0000 (0)	0.8889 (16)	0.1111 (2)	1.0000
Total	719					

Table A-15. Age-length key for Chinook salmon in 2002 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0024	0.0000	0.0000	0.0000
50-54	0.0000	0.0000	0.0000	0.0000
55-59	0.0047	0.0000	0.0000	0.0000
60-64	0.0047	0.0024	0.0000	0.0000
65-69	0.0003	0.0044	0.0000	0.0000
70-74	0.0000	0.0706	0.0000	0.0000
75-79	0.0000	0.1957	0.0043	0.0000
80-84	0.0000	0.2121	0.0420	0.0000
85-89	0.0000	0.0432	0.1064	0.0033
90-94	0.0000	0.0029	0.1077	0.0000
95-99	0.0000	0.0032	0.1059	0.0016
100-104	0.0000	0.0000	0.0480	0.0014
>104	0.0000	0.0000	0.0292	0.0037
Total Age Proportions	0.0121	0.5344	0.4435	0.0100

Table A-16. Chinook salmon fork lengths estimated from video footage of the trap window at Lower Granite Dam in 2003. Lengths were adjusted by +5 cm to reconcile differences between lengths measured on the spawning grounds and lengths measured at Lower Granite Dam.

Fork Length (cm)	Sample Size	Proportion
<50	2	0.0049
50-54	5	0.0122
55-59	13	0.0318
60-64	10	0.0244
65-69	3	0.0073
70-74	11	0.0269
75-79	18	0.0440
80-84	42	0.1027
85-89	49	0.1198
90-94	59	0.1443
95-99	89	0.2177
100-104	63	0.1540
>104	45	0.1100
Total	409	1.0000

Table A-17. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 2003.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
<50	6	1.0000 (6)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	6	1.0000 (6)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	2	1.0000(2)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
60-64	1	1.0000 (1)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
65-69	7	0.1429 (1)	0.8571 (6)	0.0000 (0)	0.0000 (0)	1.0000
70-74	22	0.0000 (0)	0.9091 (20)	0.0909 (2)	0.0000 (0)	1.0000
75-79	62	0.0000 (0)	0.9032 (56)	0.0968 (6)	0.0000 (0)	1.0000
80-84	53	0.0000 (0)	0.8113 (43)	0.1887 (10)	0.0000 (0)	1.0000
85-89	92	0.0000 (0)	0.2391 (22)	0.7609 (70)	0.0000 (0)	1.0000
90-94	138	0.0000 (0)	0.0652 (9)	0.9203 (127)	0.0145 (2)	1.0000
95-99	141	0.0000 (0)	0.0000 (0)	0.9574 (135)	0.0426 (6)	1.0000
100-104	82	0.0000 (0)	0.0000 (0)	0.9756 (80)	0.0244 (2)	1.0000
>104	76	0.0000 (0)	0.0000 (0)	1.0000 (76)	0.0000 (0)	1.0000
Total	688					

Table A-18. Length-age key for Chinook salmon in 2003 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0049	0.0000	0.0000	0.0000
50-54	0.0122	0.0000	0.0000	0.0000
55-59	0.0318	0.0000	0.0000	0.0000
60-64	0.0244	0.0000	0.0000	0.0000
65-69	0.0010	0.0063	0.0000	0.0000
70-74	0.0000	0.0245	0.0024	0.0000
75-79	0.0000	0.0397	0.0043	0.0000
80-84	0.0000	0.0833	0.0194	0.0000
85-89	0.0000	0.0286	0.0912	0.0000
90-94	0.0000	0.0094	0.1328	0.0021
95-99	0.0000	0.0000	0.2084	0.0093
100-104	0.0000	0.0000	0.1502	0.0038
>104	0.0000	0.0000	0.1100	0.0000
Total Age Proportions	0.0743	0.1918	0.7187	0.0152

Table A-19. Chinook salmon fork lengths estimated from video footage of the trap window at Lower Granite Dam in 2004.

Fork Length (cm)	Sample Size	Proportion
<50	4	0.0128
50-54	6	0.0192
55-59	5	0.0160
60-64	15	0.0481
65-69	49	0.1571
70-74	86	0.2757
75-79	83	0.2660
80-84	29	0.0929
85-89	15	0.0481
90-94	13	0.0417
95-99	4	0.0128
100-104	2	0.0064
>104	1	0.0032
Total	312	1.0000

Table A-20. Fin ray age proportions and frequencies (in parentheses) by length group for Chinook salmon collected on the spawning grounds in 2004.

Fork Length (cm)	Sample Size	1 Ocean	2 Ocean	3 Ocean	4 Ocean	Total
<50	2	1.0000 (2)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
50-54	3	1.0000 (3)	0.0000 (0)	0.0000 (0)	0.0000 (0)	1.0000
55-59	5	0.8000 (4)	0.0000 (0)	0.2000 (1)	0.0000 (0)	1.0000
60-64	16	0.0625 (1)	0.9375 (15)	0.0000 (0)	0.0000 (0)	1.0000
65-69	57	0.0351 (2)	0.9649 (55)	0.0000 (0)	0.0000 (0)	1.0000
70-74	146	0.0068 (1)	0.9932 (145)	0.0000 (0)	0.0000 (0)	1.0000
75-79	153	0.0000 (0)	0.9935 (152)	0.0065 (1)	0.0000 (0)	1.0000
80-84	75	0.0000 (0)	0.9333 (70)	0.0667 (5)	0.0000 (0)	1.0000
85-89	38	0.0000 (0)	0.3421 (13)	0.6579 (25)	0.0000 (0)	1.0000
90-94	35	0.0000 (0)	0.0571 (2)	0.9143 (32)	0.0286 (1)	1.0000
95-99	29	0.0000 (0)	0.0690 (2)	0.8620 (25)	0.0690 (2)	1.0000
100-104	7	0.0000 (0)	0.0000 (0)	1.0000 (7)	0.0000 (0)	1.0000
>104	12	0.0000 (0)	0.0000 (0)	0.9167 (11)	0.0833 (1)	1.0000
Total	578					

Table A-21. Age-length key for Chinook salmon in 2004 determined from fin ray analysis multiplied by the length group proportions from Lower Granite Dam video estimates.

Fork Length (cm)	1 Ocean	2 Ocean	3 Ocean	4 Ocean
<50	0.0128	0.0000	0.0000	0.0000
50-54	0.0192	0.0000	0.0000	0.0000
55-59	0.0128	0.0000	0.0032	0.0000
60-64	0.0030	0.0451	0.0000	0.0000
65-69	0.0055	0.1516	0.0000	0.0000
70-74	0.0019	0.2738	0.0000	0.0000
75-79	0.0000	0.2643	0.0017	0.0000
80-84	0.0000	0.0867	0.0062	0.0000
85-89	0.0000	0.0165	0.0316	0.0000
90-94	0.0000	0.0024	0.0381	0.0012
95-99	0.0000	0.0009	0.0110	0.0009
100-104	0.0000	0.0000	0.0064	0.0000
>104	0.0000	0.0000	0.0029	0.0003
Total Age Proportions	0.0552	0.8413	0.1011	0.0024

LITERATURE CITED

Copeland, T., J. Johnson, and P. R. Bunn. 2004. Idaho natural production monitoring and evaluation, 2003 annual report. Idaho Department of Fish and Game Report 04-47. Bonneville Power Administration. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and P. R. Bunn. 2005. Idaho natural production monitoring and evaluation, 2004 annual report. Idaho Department of Fish and Game Report 05-38. Bonneville Power Administration. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and P. R. Bunn. 2006. Idaho natural production monitoring and evaluation, 2005 annual. Idaho Department of Fish and Game Report 06-30. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, S. Kraft, and P. R. Bunn. 2007. Idaho natural production monitoring and evaluation, 2006 annual report. Idaho Department of Fish and Game Report 07-31. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, and S. Putnam. 2008. Idaho natural production monitoring and evaluation, 2007 annual report. Idaho Department of Fish and Game Report 08-08. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Copeland, T., J. Johnson, K. A. Apperson, J. M. Flinders, and R. Hand. 2009. Idaho natural production monitoring and evaluation project. Idaho Department of Fish and Game Report 09-06. 2008 annual report to the U.S. Department of Energy, Bonneville Power Administration. Contract 36423, Project 199107300. Idaho Department of Fish and Game, Boise.

Harmon, J. 2009. Operation of the Lower Granite Dam adult trap, 2008. Bonneville Power Administration. Project 2005-002-00. Portland, Oregon.

Kiefer, R. B., J. Johnson, P. Bunn, and D. Anderson. 2001. Idaho Natural Production Monitoring and Evaluation: annual progress report, July 1, 2000 to June 30, 2001. Idaho Department of Fish and Game Report Number 01-41. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kiefer, R. B, P. R. Bunn, and J. Johnson. 2002. Idaho Natural Production Monitoring and Evaluation: annual progress report, July 1, 2001 to June 30, 2002. Idaho Department of Fish and Game Report Number 02-24. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kiefer, R. B., J. Johnson, P. R. Bunn, and A. Bolton. 2004. Natural production monitoring and evaluation. Annual report 2003. Idaho Department of Fish and Game Report 03-30. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, and R. Hand. 2011. Idaho Natural Production Monitoring and Evaluation, 2009-2010 annual progress report. Idaho Department of Fish and Game Report 11-23. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Kennedy, P., T. Copeland, J. Johnson, K. A. Apperson, J. Flinders, R. Hand, and M. Corsi. 2012. Idaho Natural Production Monitoring and Evaluation, 2011 annual progress report. Idaho Department of Fish and Game Report 12-18. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project 1991-073-00. Portland, Oregon.

Schrader, W. C., T. Copeland, M. W. Ackerman, K. Ellsworth, and M. R. Campbell. 2011. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, spawn year 2009. Idaho Department of Fish and Game Report 11-24. Annual report 2009, BPA Projects 1990-055-00, 1991-073-00, 2010-026-00.

Schrader, W. C., T. Copeland, P. Kennedy, M. W. Ackerman, K. K. Wright, and M. R. Campbell. 2012. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, spawn year 2010. Idaho Department of Fish and Game Report 12-16. Annual report 2010, BPA Projects 1990-055-00, 1991-073-00, 2010-026-00.

Appendix B. Data Collected By INPMEP During 2012 Relevant To VSP Criteria

Table B-1. Data provided by INPMEP during 2012 as applicable to viable salmonid population criteria for wild Chinook salmon populations.

Major population group	Population	Viable salmonid population criterion			
		Abundance	Productivity	Spatial Structure	Diversity
South Fork Salmon River	South Fork Salmon	Redd abundance[t]	Adult ages	Redd distribution[t], Juvenile occurrence[t]	Adult ages
	Secesh River	Redd abundance[t]	Adult ages	Redd distribution[t]	Adult ages
	East Fork South Fork	Parr densities[t]	Adult ages	Juvenile occurrence[t]	Adult ages
	Little Salmon	Parr densities[tg]	--	Juvenile occurrence[tg]	--
Middle Fork Salmon River	Chamberlain Creek	Redd abundance[t]	Adult ages	Redd distribution[t]	Adult ages
	Lower Main Middle Fork	Redd abundance[t], Parr densities[t]	--	Redd distribution[t], Juvenile occurrence[t]	--
	Big Creek	Redd abundance[t]	Adult ages	Redd distribution[tt]	Adult ages
	Camas Creek	Redd abundance[t]. Parr densities[g]	--	Redd distribution[t], Juvenile occurrence[g]	--
	Loon Creek	Redd abundance[t]	--	Redd distribution[t]	--
	Upper Main Middle Fork	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages
	Sulphur Creek	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages
	Bear Valley/Elk Creek	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages
	Marsh Creek	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages
Upper Salmon River	North Fork Salmon	Redd abundance[t]	Adult ages	Redd distribution[t]	Adult ages
	Lemhi River	Redd abundance[t]	Adult ages	Redd distribution[t]	Adult ages
	Pahsimeroi River	Redd abundance[t], Parr densities[t]	--	Redd distribution[t], Juvenile occurrence[t]	--
	Lower Main Salmon	Redd abundance[t]	--	Redd distribution[t]	--
	East Fork Salmon	Redd abundance[t], Parr densities[t]	Adult ages	Redd distribution[t]	Adult ages
	Panther Creek	Redd abundance[t], Parr densities[t]	Adult ages	Juvenile occurrence[t]	--
	Yankee Fork	--	--	--	--
	Valley Creek	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[t]	Adult ages
	Upper Main Salmon	Redd abundance[t]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages
Dry Clearwater	South Fork Clearwater	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages
	Lawyer Creek	--	--	--	--
	Potlatch River	--	--	--	--
	Lapwai/Big Canyon	--	--	--	--
Wet Clearwater	Lolo Creek	--	--	--	--
	Lochsa River	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[gt]	Adult ages
	Meadow Creek	--	--	--	--
	Moose Creek	Parr densities[tg]	--	Juvenile occurrence[tg]	--
	Upper Selway	Redd abundance[t], Parr densities[tg]	Adult ages	Redd distribution[t], Juvenile occurrence[tg]	Adult ages

[a] Based on a generalized random-tessellation stratification design.
[b] Based on non-random trend transects.

Table B-2. Data collected by INPMEP during 2012 as applicable to viable salmonid population criteria for steelhead populations.

Major population group	Population	Viable Salmonid Population Criterion			
		Abundance	Productivity	Spatial structure	Diversity
Clearwater River	Lower Clearwater	Parr density[tg] (Potlatch)	Parr-parr productivity[t]	Juvenile occurrence[tg]	--
	Lolo Creek	--	--	--	--
	Lochsa River	Parr densityt[tg]	Parr-parr productivity[t]	Juvenile occurrence[tg]	--
	Selway River	Parr density[t]	Parr-parr productivity[t]	Juvenile occurrence[t]	--
	South Fork Clearwater	Parr densityt[g]	Parr-parr productivity[t]	Juvenile occurrence[tg]	--
Salmon River	Little Salmon	Parr density[tg]	Parr-parr productivity[t]	Juvenile occurrence[tg]	--
	Secesh River	--	--	--	--
	South Fork Salmon	Parr density[t]	Parr-parr productivity[t]	Juvenile occurrence[t]	--
	Chamberlain Creek	--	--	--	--
	Lower Middle Fork Salmon	Parr density[t]	Parr-parr productivity[t]	Juvenile occurrence[t]	--
	Upper Middle Fork Salmon	Parr density[tg]	Parr-parr productivity[t]	Juvenile occurrence[tg]	--
	Panther Creek	Parr density[t]	Parr-parr productivity[t]	Juvenile occurrence[t]	--
	North Fork Salmon	--	--	--	--
	Lemhi River	--	--	--	--
	Pahsimeroi River	Parr density[t]	Parr-parr productivity[t]	Juvenile occurrence[t]	--
	East Fork Salmon	Parr density[t]	Parr-parr productivity[t]	Juvenile occurrence[t]	--
	Upper Main Salmon	--	--	--	--

[a] Based on a generalized random-tessellation stratification design.
[b] Based on non-random trend transects.

Appendix C. Other Project Accomplishments

Presentations by project personnel

Kennedy, P. 2012. Wild Chinook, the INPMEP, and fisheries management. Presented at the Idaho Department of Fish and Game annual Anadromous Meeting. February 2, 2012. Boise, Idaho.

Kennedy, P. 2012. Monitoring wild Chinook salmon and steelhead in Idaho. Presented to the Boise Valley Trout Unlimited chapter. May 9, 2012. Boise, Idaho.

Kennedy, P., and J. Johnson. 2012. An explanation and demonstration on how to conduct Chinook salmon carcass surveys. Presented at the annual cooperative spawning ground survey training workshop. August 7, 2012. Warm Lake, Idaho.

Publications

Johnson, J., T. Johnson, and T Copeland. 2012. Defining life histories of precocious male parr, minijack, and jack Chinook salmon using scale patterns. Transactions of the American Fisheries Society 141. pp. 1545-1556.

Data Management

Project efforts with data management begin with training personnel prior to data collection. When sampling in the field during data collection we foster a strict regard for quality assurance. All project data are then monitored for quality control before they are incorporated into databases for long-term storage and reliable dissemination. Project data are stored in several databases. The Spawning Ground Survey database stores all of the redd survey and carcass recovery data. The Biological Samples database stores the derived ages from the fin ray samples. The Standard Stream Survey database stores all of the snorkel survey data. All of the observed data are publicly available via the Idaho Fish and Wildlife Information System website (https://fishandgame.idaho.gov/ifwis/portal/).

Prepared by:

Patrick Kennedy
Fishery Research Biologist

Kimberly A. Apperson
Regional Fisheries Biologist

Jon Flinders
Regional Fisheries Biologist

Matthew Corsi
Regional Fisheries Biologist

June Johnson
Senior Fishery Technician

Robert Hand
Regional Fisheries Biologist

Jordan Messner
Regional Fisheries Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

_____
Peter F. Hassemer
Anadromous Fish Manager

_____
Edward B. Schriever, Chief
Bureau of Fisheries