FISHERY RESEARCH

IDAHO ANADROMOUS PARR MONITORING

2020 ANNUAL REPORT

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IDFG Report Number 21-09
March 2021

Idaho Anadromous Parr Monitoring

2020 Annual Report

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IDFG Report Number 21-09
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Suggested citation:

Poole, J.R., B. Barnett, C. McClure, S. Putnam, R.V. Roberts, E.J. Stark. 2021. Idaho anadromous parr monitoring. Annual report 2020. Idaho Department of Fish and Game Report 21-09, Boise.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Page

LIST OF APPENDICES

Page

FOREWORD

This report consists of two chapters. Chapter 1 addresses data collected by snorkel surveys in 2020 to monitor occupancy, density, and spatial structure of anadromous salmonid parr and resident fish. Significantly fewer sites were surveyed in 2020 than were typically surveyed in previous years (less than 5%) due to restrictions associated with the COVID-19 pandemic. The goal of Chapter 1 is to present the results from snorkel surveys performed in 2020 and analyze the densities of fishes observed. Comparison to previous years were not made due to the sparse data collected in 2020. Chapter 2 addresses the relationship between observed fish density from snorkel surveys (parr standing stock) and juvenile steelhead emigrant abundance estimated from rotary screw traps (emigrant production) over several years and locations. The goal of Chapter 2 is to compare how parr standing stocks observed in snorkel surveys compare with emigrant production estimated at rotary screw traps.

CHAPTER 1: ANADROMOUS PARR MONITORING THROUGH SNORKEL SURVEYS

ABSTRACT

Idaho Department of Fish and Game monitors occupancy, density, and spatial structure of anadromous salmonid parr and resident fish with snorkel surveys. In this report, we summarize the snorkel methods and results from 2020 surveys. Only 22 snorkel surveys were completed in 2020—less than 5% compared to previous years—due to restrictions from the COVID-19 pandemic and the resulting decision to not employ snorkel crews. Four core trend transects were completed in Chamberlain Basin and 18 non-core snorkel surveys were completed throughout the Pahsimeroi River Basin to assist with data collection for a separate IDFG anadromous fish screen monitoring program. In the Chamberlain Basin surveys, mean density of Steelhead *Oncorhynchus mykiss* parr was 1.9 fish/100 m^2 (SD = 0.6), and mean density of Chinook Salmon *O. tshawytscha* parr was 0.3 fish/100 m^2 (SD = 0.3). Both adults and age-1 Chinook Salmon were observed in Chamberlain Basin; however, no age-0 parr were observed. This supports our findings from 2019 where no redds were observed in the basin. For the Pahsimeroi River Basin surveys, mean density of Steelhead parr was 0.6 fish/100 m^2 (SD = 0.8), and mean density of Chinook Salmon parr was 0.4 fish/100 m^2 (SD = 0.7). Occupancy and mean densities presented in this report were calculated from a small subset of snorkel surveys that are completed in a typical year. As such, no comparisons were made between 2020 data and previous years' data. We anticipate returning to a near-normal field schedule in 2021.

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INTRODUCTION

Populations of Chinook Salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* in the Snake River Basin declined substantially following the construction of hydroelectric dams in the Snake and Columbia rivers. Snake River Chinook Salmon were listed as threatened in 1992 under the Endangered Species Act (ESA). Within the Snake River Chinook Salmon evolutionarily significant unit (ESU), 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, and the Wet Clearwater. However, the Dry Clearwater and the Wet Clearwater MPGs were re-established with out-of-basin stocks after extirpation and are not listed under the ESA. A total of 28 extant demographically independent populations of Chinook Salmon have been identified. Snake River steelhead were listed as threatened under the ESA in 1997 (Busby et al. 1996). Within the Snake River Basin steelhead distinct population segment (DPS), the Interior Columbia Basin Technical Recovery Team (ICBTRT) delineated six MPGs: Lower Snake River, Grande Ronde River, Imnaha River, Clearwater River, Salmon River, and Hells Canyon Tributaries (ICBTRT 2003, 2005). However, the Hells Canyon MPG is considered to be extirpated (Table 1).

The Idaho Department of Fish and Game (IDFG) anadromous fish program's long-range goal is to rebuild and preserve Idaho's Chinook Salmon and steelhead runs to healthy and harvestable levels to provide benefits for all users. Key objectives to achieve the management goal are: 1) maintain genetic and life history diversity of naturally occurring and hatchery produced fish; 2) rebuild naturally reproducing populations of anadromous fish to utilize existing and potential habitat at an optimal level; 3) improve overall life cycle survival sufficient for delisting and recovery by addressing key limiting factors identified in all "H's" of hydropower: habitat, harvest, and hatchery effects; 4) allow consumptive harvest through sport and treaty fishing; and 5) coordinate Pacific Northwest regional management with Idaho anadromous management to ensure achievement of Idaho management objectives and the long-range program goal (IDFG 2019). Management to achieve these goals requires an understanding of how salmonid populations function as well as periodic status assessments (McElhany et al. 2000). However, specific data on some Snake River steelhead and Chinook Salmon populations are lacking, particularly key parameters such as abundance, age composition, genetic diversity, recruits per spawner, and survival rates (ICBTRT 2003).

Snorkel surveys are widely used for monitoring fish populations because they are a versatile and cost-effective technique. Snorkel surveys are efficient where environmental conditions limit the effectiveness of other techniques, such as electrofishing (Schill and Griffith 1984; Bonneau et al. 1995). Gear and personnel requirements are comparatively modest, so logistical demands are reduced and remote locations become feasible to sample (Hankin and Reeves 1988; Thurow 1994). Counts taken through underwater observations are non-lethal and less intrusive than other field methods, and are an appropriate means to monitor fishes listed under the Endangered Species Act (e.g., Chinook Salmon, steelhead, and Bull Trout *Salvelinus confluentus*). In addition, steelhead spawning cannot be directly assessed in many Idaho streams in an efficient manner because springtime water conditions make it difficult to observe them. Therefore, snorkel survey data describing juvenile densities and distribution are particularly important for steelhead.

Freshwater salmonid production can fluctuate greatly between years. Snorkel surveys provide information related to the density (relative abundance), distribution, and historical trends of Idaho's wild Chinook Salmon and steelhead populations. Spatially-balanced snorkel surveys can also be used to address ESA reporting needs (Poole et al. 2020). Valuable abundance and distribution information on resident salmonids are also collected during our monitoring (Copeland and Meyer 2011); for example, approximately 20 surveys per year are specifically conducted to monitor resident salmonids, with funding from Dingell-Johnson Act and IDFG license funds (Appendix A3).

In 2020, restrictions were placed on field work due to the COVID-19 pandemic. Snorkel field personnel—which generally consists of more than 20 temporary employees—were not hired due to safety concerns. A limited number of snorkel surveys were conducted in 2020 by two crews to address specific questions. The majority of our monitoring sites were not completed in 2020, thus the results presented in this report cannot effectively be compared to other years.

The snorkel program addresses four specific, long-term questions relative to population status and the effectiveness of our monitoring techniques. In 2020, snorkel sites were conducted to address two additional questions (questions 5 and 6):

1. How is abundance of anadromous salmonid parr changing over time?

2. How is steelhead emigrant production related to parr density?

3. What is the distribution and relative abundance of steelhead within the populations identified in the recovery plans?

4. What major and minor spawning habitats do anadromous salmonids occupy?

5. Are age-0 fish rearing in Chamberlain River Basin, given that zero redds were observed in trend spawning ground surveys during 2019?

6. Have fish screens, habitat improvement, and reconnection of habitat in the Pahsimeroi drainage been effective in achieving higher density of Chinook Salmon and steelhead? Snorkeling related to this question was conducted to assist the Idaho Fish Screening Improvement Project (BPA project 1994-115-00).

In this report, we summarize the results of snorkel surveys conducted by IDFG in anadromous waters during 2020.

METHODS

Methods for conducting fish abundance surveys by snorkeling are detailed in Apperson et al. (2015), which include specific protocols used to evaluate anadromous parr density and should be used as the primary methods reference for this report. We describe here the types of transects surveyed by IDFG staff that are used to address the questions presented above. Exceptions or additions to protocols outlined in Apperson et al. (2015) are described. In 2020, few surveys were completed; however, methods are described below for all types of surveys to maintain continuity in reporting.

Unless otherwise noted, six salmonid species were observed within all major basins that include Chinook Salmon, Brook Trout *Salvelinus fontinalis*, Bull Trout, Mountain Whitefish *Prosopium williamsoni,* steelhead, and Westslope Cutthroat Trout *Oncorhynchus clarkii*. Trout fry (*Oncorhynchus spp* less than 75 mm) are not distinguishable to the species level and are recorded separately. Lastly, the presence of all other fishes, amphibians, and freshwater mussels were also recorded.

Three different types of surveys are outlined below: 1) Trend surveys, which consist of core, noncore, and resident transects; 2) probabilistic surveys (GRTS), which consist of intensive and extensive transects; and 3) detection probability surveys, or mark-resights. In 2020, only trend core and non-core surveys were completed.

Trend Surveys

Core

Core transects are subsets of long-established transects that were subjectively selected because they represent suitable Chinook Salmon and steelhead habitat. These transects were originally developed by the General Parr Monitoring (GPM) program, which was a focused effort by IDFG to measure the juvenile response of wild/natural anadromous populations to off-transect mitigation habitat actions and improvements (Rich et al. 1990). Core trend transects were defined as locations where at least one survey had been conducted within each 5-year period during 1984-2011. Core trend transects also included corridor surveys in the Middle Fork Salmon River and the Selway River, which had been completed for many consecutive years, and therefore were deemed important to IDFG management programs. Corridor survey methods are described in greater detail below. Core transect data are used to evaluate how the abundance of anadromous salmonid parr is changing over time. We identified 218 core trend transects (Stiefel et al. 2014). Based on logistical difficulty, core transects are surveyed annually, biennially, or triennially during the months of June, July, and August. Regular monitoring of these transects provides the "core" of Idaho's monitoring of the abundance trend of juvenile anadromous salmonids. In 2020, four core sites were surveyed.

Non-core

Non-core survey panels are performed for other purposes as deemed necessary for IDFG regional fishery management needs. Non-core transects are surveyed opportunistically. They are surveyed as time allows, and are not necessarily surveyed on a consistent basis. As such, they are not relied on to provide statewide status and trend information for Chinook Salmon or steelhead. In 2020, eighteen non-core sites were surveyed. The non-core surveys in 2020 were conducted to assist the Idaho Fish Screening Improvement Project to assess the efficacy of fish screens, habitat improvement, and water reconnection.

Resident

Resident snorkel survey panels are conducted to address monitoring needs for resident salmonids (e.g., Westslope Cutthroat Trout, Bull Trout, and Mountain Whitefish). Resident transects are surveyed opportunistically. They are surveyed as time allows, and are not necessarily surveyed on a consistent basis. As such, they are not relied on to provide statewide status and trend information for Chinook Salmon or steelhead. No resident sites were surveyed in 2020.

Probabilistic Surveys (GRTS)

In 2007, a probabilistic approach was adopted for establishing sites to obtain a spatially-balanced and representative set of sample sites. A generalized random-tessellation stratified

(GRTS) design (Stevens and Olsen 2004) was used to obtain estimates of steelhead parr density at the population scale. The GRTS design randomly selects a suite of sites that are spatially distributed evenly across the available distribution of Chinook Salmon and steelhead parr (Stevens and Olsen 2004). Crews are provided an ordered list of sites "such that each successive site on the list maintains the spatial balance of the full set of sites in the sample" (Stevens and Olsen 2004). The crew then surveys or attempts to survey higher priority transects before lower priority transects are surveyed. Extra sites, up to two times the sample goals, are included on the site list in case some sites cannot be sampled. No probabilistic sites were surveyed in 2020.

Intensive

Panels of intensive transects were developed to evaluate the relationship between fish density from snorkel surveys and juvenile steelhead emigrant abundance derived from rotary screw traps over several years. Intensive panel surveys are generally conducted annually upstream of associated screw traps, and generally consist of at least 20 transects. In a typical year, GRTS Intensive snorkel sites are performed in the Potlatch River (lower Clearwater River steelhead population), Fish Creek (Lochsa River steelhead population), Crooked River (South Fork Clearwater River steelhead population), Marsh Creek (Upper Middle Fork Salmon River steelhead population), North Fork Salmon River (North Fork Salmon River steelhead population), South Fork Salmon River (South Fork Salmon River steelhead population), and Rapid River (Little Salmon River steelhead population).

Extensive

To evaluate the distribution and relative abundance of steelhead and Chinook Salmon within specific populations, extensive panels were established to obtain occupancy and distribution information from key steelhead population and spawning aggregates as defined by the ICBTRT (2003, 2005).

Detection Probability Surveys (Mark-Resight)

To assess observation bias during snorkel surveys, field crews implement a mark-resight methodology to estimate the observation or detection efficiency of steelhead parr and Westslope Cutthroat Trout in a subjectively chosen set of transects each year. A protocol modified from Thurow et al. (2006) was designed to estimate detection probability through observation of individuals marked with a caudal fin clip (Apperson et al. 2015). Since Thurow et al. (2006) found that steelhead and Westslope Cutthroat Trout had the same detection efficiency, we evaluate the observation efficiency of snorkeling for juvenile steelhead and Cutthroat Trout combined at a subset of transects. Mark-resight surveys are selected at the snorkel crew leader's discretion, based on time availability, ability to catch enough fish, and water conditions, but the program goal is to perform them in 10% of transects annually. Mark-resights should aim to mark 30 fish; however, as few as 15 fish can be marked. No more than five sites should be conducted in the same river annually. No mark-resight surveys were completed in 2020.

Detection probability was the number of marked fish observed in the 100 m target transect and oversample reaches (50 m sections on the upstream and downstream side of the target transect) divided by number of fish marked. We assumed limited movement; however, 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 oversample reaches in the calculation increases precision, because each marked fish is treated as an independent trial: seen or not seen.

Analytical Methods

Densities for all species were expressed as number of fish/100m^2 for each transect. In transects for which the entire stream width is surveyed, this is accomplished by calculating the surface area of the transect using wetted widths measured during a basic habitat survey and the total length of the transect (Apperson et al. 2015). In a corridor survey, the transect is surveyed by floating from the upstream boundary to the downstream boundary. The entire stream width may or may not be surveyed. Typically, a corridor along the bank is surveyed using a snorkeler for each bank or a single snorkeler in the thalweg. Transect area for corridor surveys are based on the surface area of the corridor visible to the observer as measured before the survey (Rich et al. 1990). The total area of the transect is then calculated by multiplying the visible corridor by the transect length.

Occupancy of steelhead and Chinook Salmon was calculated for transects based on presence and absence. This metric refers to the proportion of transects in which a specific species was encountered in comparison to the total number of transects surveyed in that basin. Standard deviation is calculated for occupancy by treating occupancy as a binomial random variable and multiplying the probability that a transect is occupied by the probability that it is not and dividing by the sample size. For the purposes of this report, occupancy provides a metric that describes the amount of available habitat occupied by Chinook Salmon and steelhead.

RESULTS

During 2020, a total of 22 snorkel surveys were completed. Data related to the density and abundance of steelhead and Chinook Salmon is summarized below. Detailed results are presented in appendix B.

Chamberlain Basin Snorkel Surveys

A total of 4 core trend sites were surveyed in Chamberlain Basin in 2020. Mean steelhead density was 1.9 fish/100 m^2 (SD = 0.6; Figure 1; Appendix B1) and mean Chinook Salmon density was 0.3 fish/100 m^2 (SD = 0.3; Figure 1; Appendix B1). This density constituted zero age-0, eight age-1, and four adult Chinook Salmon. Steelhead occupancy was 1.0 (SD >0.1) and Chinook Salmon occupancy was 0.8 (SD = 0.2, Figure 2).

Screen Shop Assessment Snorkel Surveys

A total of 18 non-core sites were surveyed in the Pahsimeroi River Basin in 2020. Mean steelhead density was 0.6 fish/100 m^2 (SD = 0.8; Figure 1; Appendix B2) and mean Chinook Salmon density was 0.4 fish/100 m^2 (SD = 0.7; Figure 1; Appendix B2). Steelhead occupancy was 0.6 (SD = 0.1) and Chinook Salmon occupancy was 0.5 (SD = 0.1, Figure 2).

DISCUSSION

Few snorkel sites were surveyed in 2020 due to restrictions on hiring snorkel crews enacted to safely handle the COVID-19 pandemic. Surveys that were completed were intended to address two specific purposes and were completed in a manner designed to reduce risk. Occupancy and mean densities presented in this report were calculated from a small subset of snorkel surveys that are completed in a typical year. As such, no comparisons were made between 2020 data and previous years' data, as has been done in previous reports (see Poole et al. 2020). Data collected in 2020 should not be included when calculating five-year averages or comparing densities in the future, except on a site-to-site basis. We anticipate returning to a near-normal field schedule in 2021.

Screen shop assessment surveys are typically completed by dedicated anadromous fish screen monitoring personnel with the intent to index distribution and density of juvenile salmonids following reach reconnection and habitat restoration. However, reductions of staff in 2020 limited their ability to snorkel transects. Instead wild salmon and steelhead personnel assisted snorkeling 18 sites to help fill that personnel gap. Therefore, data collected during these surveys are included in this report. However, data are analyzed and discussed in a dedicated screen shop assessment report, separately from this document. A screen shop report with data from 2016-2021 is scheduled to be completed in 2021.

Snorkel surveys were of particular interest in Chamberlain Basin since no redds or adult Chinook Salmon were observed in the basin in 2019 (Felts et al. 2020). Snorkel surveys were conducted in Chamberlain Basin in 2020 for two primary reasons: 1) to determine if age-0 Chinook were present despite no adults being observed in 2019, and 2) to determine if adult Chinook Salmon were present in the basin, prior to redd surveys. Adults and age-1 Chinook Salmon were observed; however, no age-0 parr were observed. This supports our findings from 2019 where no redds were observed in the basin, as eggs laid in redds in the fall of 2019 would be observable parr in the summer of 2020. The observation of adults also showed that Chinook were able to reach the basin in 2020 and no blockages were preventing their movement into the basin. Later in the season, 18 redds were observed in the basin during spawning ground surveys (Nau et al. 2021).

Snorkel survey data are used for many purposes, ranging from reporting spatial distribution of salmonids for ESA status reviews (Copeland et al. 2015) to assessing how new roadways or mining activities may affect threatened populations. This dataset is the most spatially and temporally robust information on salmonid distribution and abundance in the state. However, it is important to acknowledge limitations in these data so users can better interpret the results and ultimately use them appropriately. Core snorkel transects address trends in the population; however, where sightability remains unknown, fish densities should be viewed as minimum density within a transect (as opposed to an absolute density). It is appropriate to compare prior years to assess fluctuation over time, or to visualize parr on the landscape, but may not be appropriate to extrapolate fish populations beyond the surveyed sight.

Intensive survey panels were established to determine if a relationship exists between juvenile densities from snorkeling and emigration abundance upstream of rotary screw traps. Intensive panels were first established in 2007 in Marsh Creek, Fish Creek, and Rapid River. Crooked Fork Creek (Lochsa River tributary), Big Bear Creek, and the East Fork Potlatch River were then added in 2008. However, the Crooked Fork Creek trap was pulled and intensive surveys were discontinued in that basin in 2014. Intensive panels have since been established in the South Fork Salmon River upstream from the Krassel Creek PIT tag array and rotary screw trap in 2015, and in the North Fork Salmon River, upstream of the rotary screw trap and PIT tag array in 2016. The relationship between juvenile densities from snorkeling and emigration abundance estimates from screw traps is explored in Chapter 2 of this report.

The error associated with snorkel data can be greatly influenced by site-, year-, and crew-specific factors affecting sightability of fish. Although influences on resight efficiency have not been thoroughly investigated, Roth et al. (2019) recommended that crews conduct mark-resights during a similar time of year at the same locations each year, attempt to conduct a greater number of resights each year, and spread resight surveys throughout the season to account for varying water levels and a crews' experience. Increased focus on mark-resights will be placed on future years and analysis on the factors affecting sightability of fish should continue.

RECOMMENDATIONS

1. Maintain long-term time series of both core and intensive GRTS surveys, including trends from the first to most recent surveys.

2. Determine relationship between production of juvenile emigrants estimated from screw traps to parr densities from GRTS intensive snorkel surveys for each of the eight target basins (Chapter 2). Expand on this to understand how snorkel surveys could be used outside of the eight intensive drainages to predict juvenile emigrant production.

3. To provide information for ESA status reviews and help visualize fish on the landscape, create distribution maps based on extensive panels completed in previous years to describe the spatial structure of steelhead, Chinook Salmon, and other salmonids in Idaho; and specifically for steelhead, analyze and report distribution and density of parr by major and minor spawning aggregations (MSAs).

4. Continue to conduct mark-resight surveys in addition to standard snorkel surveys. Conduct mark-resights only when a minimum of 15 fish can be marked.

5. Conduct no more than five mark-resight surveys in a single stream or river.

6. Continue assessing the factors that influence sightability and incorporate results into mark-resight design.

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TABLES

Table 1. Major population groups and independent populations within the Snake River steelhead distinct population segment (DPS) (ESU; ICBTRT 2003, 2005; Ford et al. 2010; NMFS 2011).

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

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

Table 2. Major population groups and independent populations within the Snake River spring-summer Chinook Salmon evolutionary significant unit (ESU; ICBTRT 2003, 2005; Ford et al. 2010; NMFS 2011).

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

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

FIGURES

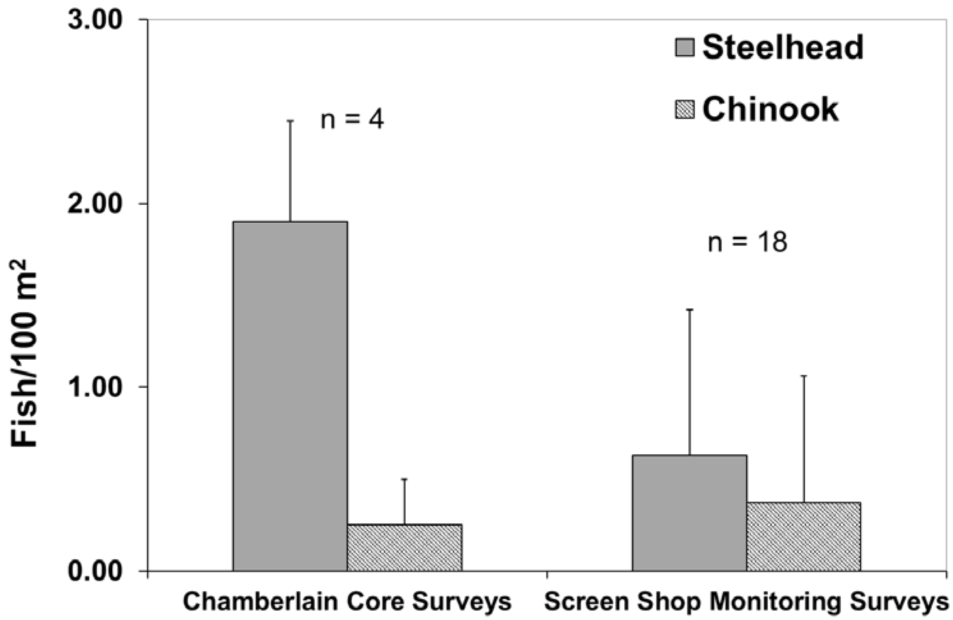

Figure 1. Mean densities of steelhead and Chinook Salmon per 100 m^2 observed during 2020 snorkel surveys. Error bars represent standard deviation.

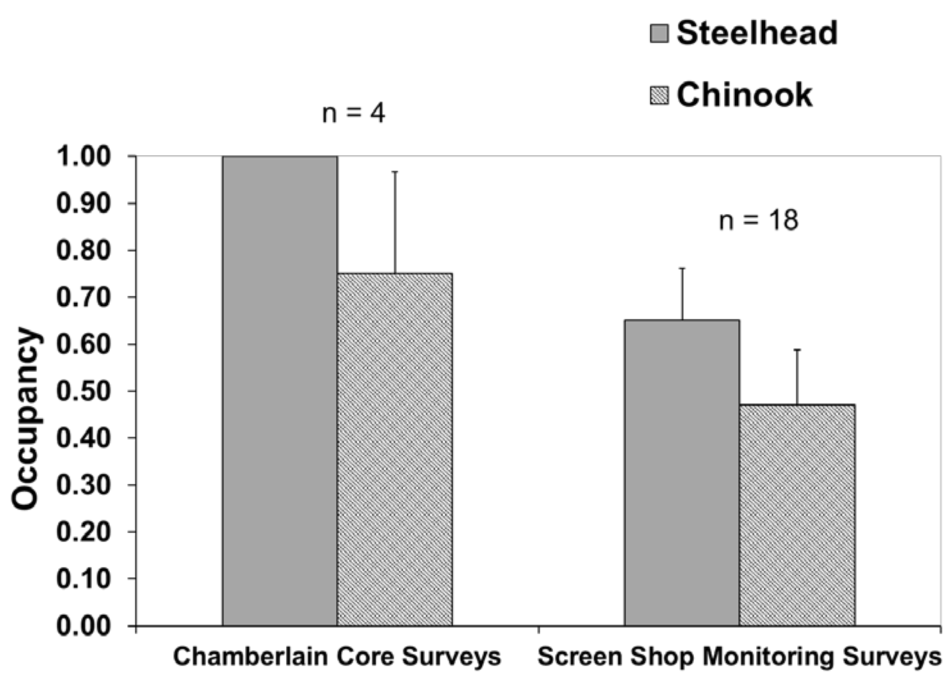

Figure 2. Occupancy rates of steelhead and Chinook Salmon observed during 2020 snorkel surveys. Error bars represent standard deviation.

CHAPTER 2: ANALYSIS OF THE RELATIONSHIP BETWEEN OBSERVED STEELHEAD DENSITIES DURING SNORKEL SURVEYS AND EMIGRATION ESTIMATES FROM ROTARY SCREW TRAPS

ABSTRACT

The goal of Idaho Salmon and Steelhead Monitoring and Evaluation Studies is to collect data and provide information to assess the status of wild steelhead and Chinook Salmon populations in Idaho. Juvenile data are collected in selected tributaries of the Clearwater River and Salmon River basins through a variety of methods including standard snorkel surveys and rotary screw traps (RSTs). Often these two methods occur in the same drainage, but how observations from each method compare to each other is not well understood. Over 1,000 snorkel surveys and 62 year-site combinations of RST steelhead emigrant estimates were combined and analyzed using linear regression with the RST emigrant estimate as the dependent variable and the mean snorkel survey steelhead density by trap location as the independent variables. The linear model indicated that the parr density observed in our snorkel surveys, along with trap site, explained 76.4% of the variation observed in steelhead emigrant abundance estimated from RSTs. My modeling demonstrates that observed density of steelhead from snorkel surveys is highly predictive of steelhead emigrant abundance at the associated RST during the following migration period. The analysis presented here should be improved by testing alterative modeling structures and applying correction factors to snorkel and RST data to fill data gaps and increase sample size. In the future, the model should be expanded outside of the current range, such that snorkel densities from a basin could be used to predict emigrant outmigration, without the need for a RST in the basin.

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INTRODUCTION

Populations of steelhead trout *Oncorhynchus 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 *O. tshawytscha* 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 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 steelhead remain critically low, especially for stocks with later run timing (B-run populations; Busby et al. 1996). As a result, Snake River steelhead trout (hereafter steelhead) were classified as threatened under the Endangered Species Act (ESA) in 1997. Within the Snake River Steelhead Evolutionarily Significant Unit, there are six major population groups, of which three are located in Idaho (Clearwater River, Salmon River, and Hells Canyon tributaries; ICBTRT 2003; 2005). A total of 17 demographically independent populations have been identified within Idaho (ICBTRT 2003; 2005).

The goal of Idaho Salmon and Steelhead Monitoring and Evaluation Studies (ISSMES) is to collect data and provide information to assess the status of wild steelhead and salmon populations in Idaho. Data are collected on selected tributaries in the Clearwater River and Salmon River basins through a variety of methods including operating rotary screw traps (RSTs) to estimate juvenile out-migration (McClure et al. 2020) and conducting snorkel surveys to assess occupancy, density, and spatial structure of anadromous salmonids (Poole et al. 2020). Often, these two methods occur in the same basins; however, how observations from each method compare to one another is not well understood.

Panels of intensive transects were developed to evaluate the relationship between steelhead density observed during snorkel surveys and juvenile steelhead emigrant abundance derived from RSTs in 2007. Intensive panel surveys are conducted annually upstream of associated RSTs, and generally consist of at least 20 transects. Intensive panels were first established in 2007 in Marsh Creek, Fish Creek, and Rapid River. Crooked Fork Creek (Lochsa River tributary), Big Bear Creek, and the East Fork Potlatch River were then added in 2008. However, the Crooked Fork Creek trap was pulled and intensive surveys were discontinued in that basin in 2014. Intensive panels have since been established in the South Fork Salmon River upstream from the Krassel Creek PIT tag array and rotary screw trap in 2015, and in the North Fork Salmon River, upstream of the rotary screw trap and PIT-tag array in 2016. To date, over 1,000 intensive snorkel surveys have been conducted and rotary screw traps have produced emigrant estimates for 62 year-site combinations, ranging from four years of emigrant estimates on the South Fork Salmon River rotary screw trap (RST) to 13 years at the Fish Creek RST.

Our objective in this chapter was to determine the relationship between production of juvenile emigrants estimated from screw traps to parr densities from GRTS intensive snorkel surveys for each of the eight target basins. A linear model was developed to assess the relationship between steelhead observed through intensive snorkel sites and steelhead emigrants estimates at the associated RSTs. This analysis is a first step toward understanding how snorkel surveys could be used to predict juvenile emigrant production in drainages without RSTs.

METHODS

Data from intensive snorkel surveys were obtained from each of the eight drainages between 2007 and 2019 by querying the Idaho Fish and Wildlife Information System's Lakes and Streams database (LSdB). Surveys were excluded if no area was recorded or if the same site was not surveyed during each year included in the analysis (n = 61). Sites that were not sampled consistently each year were also excluded from the analysis (n = 45 sites). A total of 1,162 snorkel surveys fit these criteria and were included in the analysis. Steelhead density was calculated in fish/100m^2 for each of the sites by dividing the number of steelhead observed by the measured area of the drainage and multiplying by 100. The mean of steelhead density was then calculated for each drainage, such that each unique year in which intensive snorkel surveys occurred was paired with a mean steelhead density. Methods used for intensive snorkel surveys are specified in Chapter 1 of this report and outlined in detail in Apperson et al. 2015.

Emigrant abundance estimates were obtained from RSTs in each of the seven target drainages from 2007 to 2020 from an online juvenile data spreadsheet located on the Wild Salmon and Steelhead Collaboration Site. Abundance estimates are calculated for steelhead at each RST using a stratified Lincoln-Peterson estimator with Bailey's modification (McClure et al. 2020). Estimates for steelhead abundance are separated into a spring season (from the date the RST is deployed to May 31) and a summer/fall season (from June 1 to the date the RST is removed prior to onset of winter conditions). Since spring coincides with the highest proportion of older juvenile steelhead compared to summer or fall (Dobos et al. 2020), the cohort of steelhead migrating in the spring have a more similar brood year composition to the fish that migrated the previous fall compared to fish that migrated in spring or summer of the same calendar year. Thus, cohorts of steelhead were created by combining the summer/fall estimate of the previous year with the spring estimate of the next year to create a migratory cohort. For example, the 2019 migratory cohort consists of the summer/fall 2019 emigrant estimate combined with the 2020 spring emigrant estimate. This grouping is also logical given the timing of our snorkel surveys, which are completed in mid-summer. Thus, the first opportunity of observed steelhead to move past an operational RST is the same summer and fall or the following spring. Emigrant estimates are generally calculated for a particular RST only when a minimum of seven fish are recaptured in a given spring or summer/fall season. Years where estimates could not be made for either the spring or summer/fall were excluded from this analysis (n = 4); however, if an estimate was made for one of the seasons, it was included (n = 8 spring only; n = 13 summer/fall only).

The mean observed steelhead density from snorkeling was paired with the emigrant abundance estimate from the corresponding RST for each year. In total, there were 62 unique year-location pairings of snorkel density and emigrant abundance ranging from as few as four to as many as 13 in a single target drainage (Appendix C1). Observations for both mean steelhead density and RST estimates were log-transformed to achieve a normal distribution and fulfill the assumptions of a linear model. The relationship between RST steelhead estimates and mean snorkel survey density was analyzed using the lm function in R statistical software. The model was arranged such that the RST emigrant estimate was the dependent variable with predictors being the mean steelhead snorkel density and the trap site. The model was specified:

log(RST steelhead estimate) = log(mean steelhead observed density) + trap site + year

Model assumptions were tested by plotting residuals using the plot function in R statistical software, and were deemed acceptable in the final model. The linear model was tested using the caret package in R (Kuhn 2008) by sub-setting 80% of the data into a training set and 20% into a test set. The training set was then used to create a model with the same parameters described above and the test set was used to assess the model. The process was done iteratively, 5,000 times. Error was evaluated by comparing values in the test data set to values predicted by the training data set and expressed as relative mean squared error (RMSE).

RESULTS

From 2007 to 2020, 62 year-location combinations of emigrant abundance estimates and snorkel survey mean observed parr densities were paired for this analysis (Figure 1). Estimates of steelhead emigrant abundance varied widely, from 238 to 75,043, while observed mean parr densities from snorkel surveys ranged from 0.06 to 8.84 fish/100m^2. The number of paired observations ranged from four years of data for the South Fork Salmon River to 13 years of data for Fish Creek.

The linear model indicated that the parr density observed in our snorkel surveys, along with trap site, explained 76.4% of the variation observed in steelhead emigrant abundance estimated from RSTs (Figure 2; Table 1). The model showed that seven traps had a positive slope and one trap (Rapid River) had a negative slope, indicating that at most traps, as increased steelhead were observed during snorkel surveys, emigrant estimates of steelhead at RSTs also increased. The iterative model testing process showed that the linear model built was able to predict logged RST emigrant abundance by trap with relatively low error (mean RMSE = 0.47, 5.3% of the independent variable's mean; Figure 3).

DISCUSSION

This modeling exercise demonstrates that observed density of steelhead from snorkel surveys is highly and positively correlated with steelhead emigrant abundance at the associated RST during the following migration period. This accomplishes the first portion of recommendation two outlined in Chapter 1 of this report. It also corroborates that snorkeling and RSTs are collecting meaningful, biologically relevant data that can be supported by using alternate methods.

Using logged values for our observed snorkel densities and our RST emigrant abundance values led to relatively low error in the model, but less biological relevance. For example, if the values are unlogged during the model testing process, we see a shift from relative mean squared error being approximately 5% of the independent variables mean to around 40% of the mean. This means that we can produce relatively precise logged estimates of emigrant abundance; however, when we convert back to a biologically relevant number, the predicted emigrant abundance has large error bounds.

Sample sizes on a trap by trap basis varied greatly in this exercise (Figure 1). Fish Creek, which had the greatest number of years included, showed the strongest relationship and lowest error (slope = 6680; standard error = 0.35), while drainages with low sample sizes showed weaker relationships and larger error. For example, when an additional year of data was added to the South Fork Salmon River trap, it changed the slope from negative to positive. Narrow ranges in observed snorkel densities and emigrant estimates could also limit the ability to extrapolate results. For example, Rapid River had narrow ranges in observed snorkel densities and emigrant estimates, and was the only trap to have a negative slope in the model. This shows the need for a large time series and a range of data before relationships can be meaningfully observed, and cautions against interpretation of this model for traps with low sample size or a narrow range. Continuing to build on this dataset through intensive snorkel surveys in these basins, especially in watersheds where sample size or range of densities is limited, may be necessary for further analyses.

Estimates generated during snorkel surveys RSTs are considered to be conservative. During snorkel surveys only a portion of the fish in a transect are observed due to partial detectability; therefore, estimates from snorkel surveys are a minimum value. Likewise for RSTs, we operate our traps only when flow and ice conditions allow, and do not extrapolate to days where they were not in operation. Thus, the values for RSTs are also conservative. In both cases, techniques could be employed to correct for these estimates. For snorkel surveys, partial detectability is being examined which could lead to a correction factor allowing estimation of complete reach populations (Chapter 1; Staton et al. *in review*). For RSTs, Oldemeyer et al 2016 created a time stratified hierarchical Bayesian model that utilized multiple years of data to inform abundance estimates during time periods RSTs did not operate. Neither of these frameworks have been fully developed or implemented for our data; however, by applying these correction factors as they are developed, and reconducting the analysis presented here, additional variation in the model will likely be explained. This method could also be used to fill gaps in our trap data where estimates could not be made to increase our degrees of freedom.

The application at this stage of development is limited to particular locations where intensive surveys have been conducted and RSTs estimate emigrant abundance; however, the application should be expanded in the future. Several options exist to make this analysis more robust. These include conducting model selection processes to test alternative model structures, applying correction factors to fill in gaps in data and increase sample size, and applying snorkel densities into a composite index through different techniques such as weighting densities based on distance from the trap or adding sites in a stepwise fashion until maximal correlation to the dependent variable is achieved (Falcy et al. 2016). Additionally, adding covariates, such as watershed size and intrinsic rearing habitat could help explain some of the variation in future model iterations.

The analysis to this point achieves the goal set forth in Chapter 1 to determine the relationship between production of juvenile emigrants estimated from screw traps to parr densities from GRTS intensive snorkel surveys for each of the eight target basins. However, the long-term goal of this research is to understand how snorkel surveys could be used outside of the eight intensive drainages to predict juvenile emigrant production in areas without RSTs. Operating RSTs is more costly, time-consuming, and difficult than snorkel surveys and is not possible in certain basins; therefore, a model capable of predicting emigration based only on snorkel surveys would be ideal. Understanding how this or another model could be adapted to provide that information remains an objective of the snorkel program.

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ACKNOWLEDGEMENTS

We are grateful to the Bonneville Power Administration and Russell Scranton, our contracting officer's technical representative, for support and partial funding of this work through project 1990-055-00: Idaho Salmon and Steelhead Monitoring and Evaluation Studies. Electronic data entry materials and development was provided through StreamNet. Tony Lamansky assisted with managing and organizing snorkel data and databases. As always, the snorkel report is fueled by our field crews. We would like to thank everyone who has spent time hiking to sites, snorkeling, and searching for waypoints. This report benefited from reviews by Tim Copeland and Bill Schrader. Cheryl Leben helped format and edit the document. Josh McCormick provide statistical advice for Chapter 2.

TABLES

Table 1. Model coefficients from the linear model.

Model Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	Signif. codes
(Intercept)	148.1738	54.6287	2.712	0.0090	**
log(Mean Snorkel Density)	0.2440	0.1435	1.700	0.0951	.
Crooked River Trap	-2.1501	0.4049	-5.310	2.30E-06	***
East Fork Potlatch Trap	-0.0029	0.4106	-0.007	0.9943	
Fish Creek Trap	0.4942	0.3411	1.449	0.1534	
Marsh Creek Trap	-0.5874	0.3582	-1.640	0.1071	
North Fork Salmon Trap	-0.2094	0.3905	-0.536	0.5941	
Rapid River Trap	-1.4808	0.3254	-4.551	3.24E-05	***
South Fork Salmon Trap	1.0054	0.4017	2.503	0.0155	*
Year	-0.0690	0.0271	-2.550	0.0138	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5843 on 52 degrees of freedom

Multiple R-squared: 0.8178, Adjusted R-squared: 0.7862

F-statistic: 25.92 on 9 and 52 DF, p-value: 3.134e-16

FIGURES

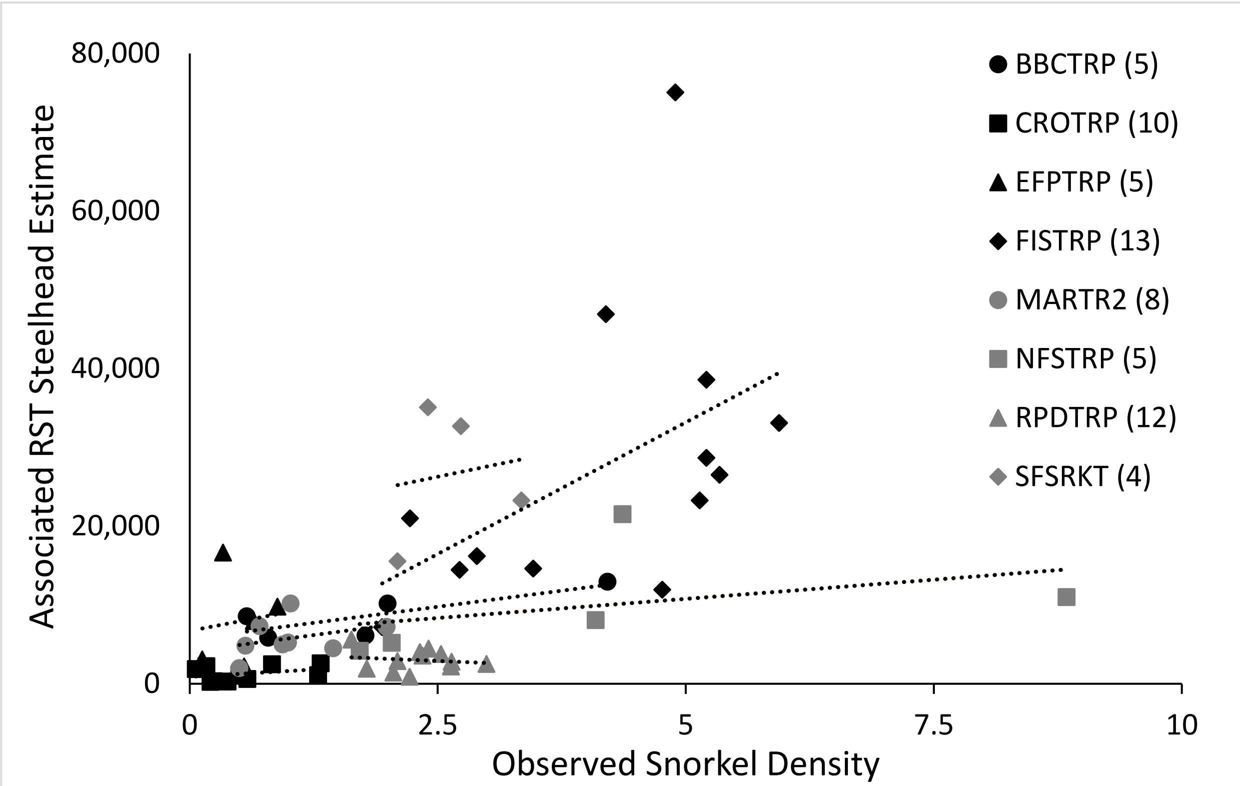

Figure 1. Scatterplot of observed snorkel survey steelhead parr densities paired with the associated rotary screw trap steelhead emigrant abundance estimate from the following migration period. Sample sizes are next to the trap name in the legend.

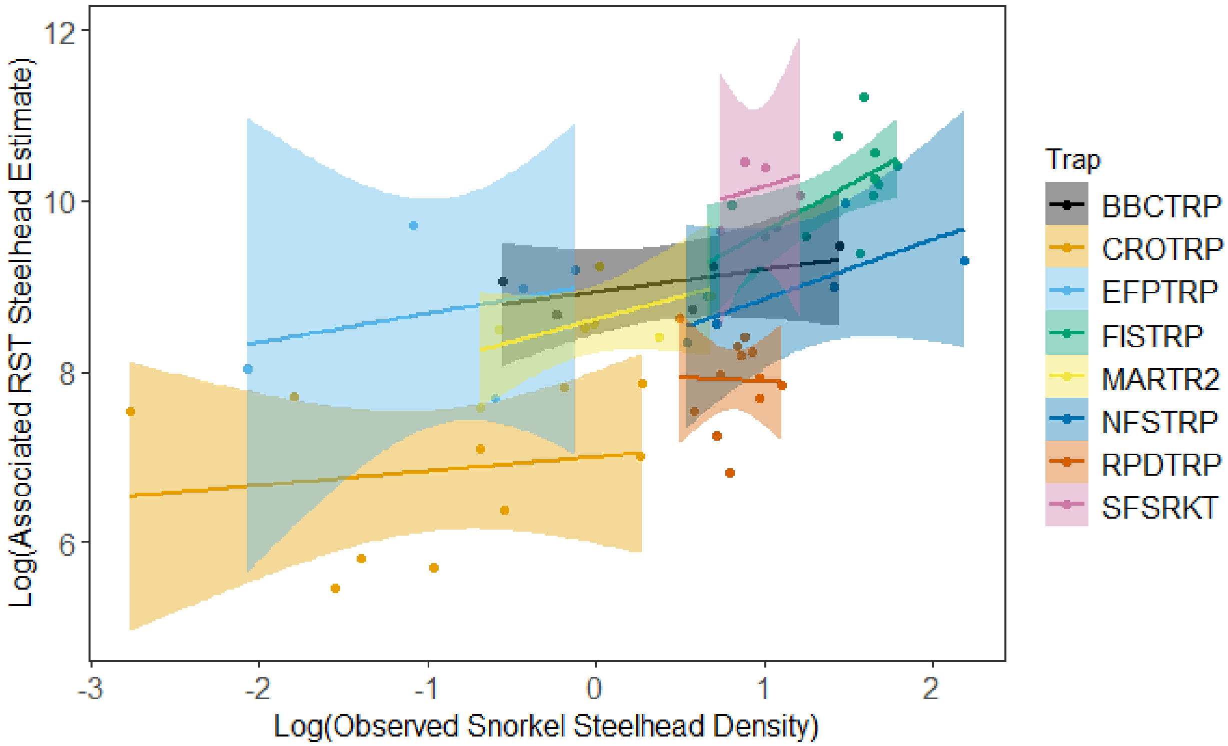

Figure 2. Scatterplot of logged snorkel survey steelhead densities paired with the logged rotary screw trap steelhead abundance estimate from the following migration period with linear model regression lines and error added.

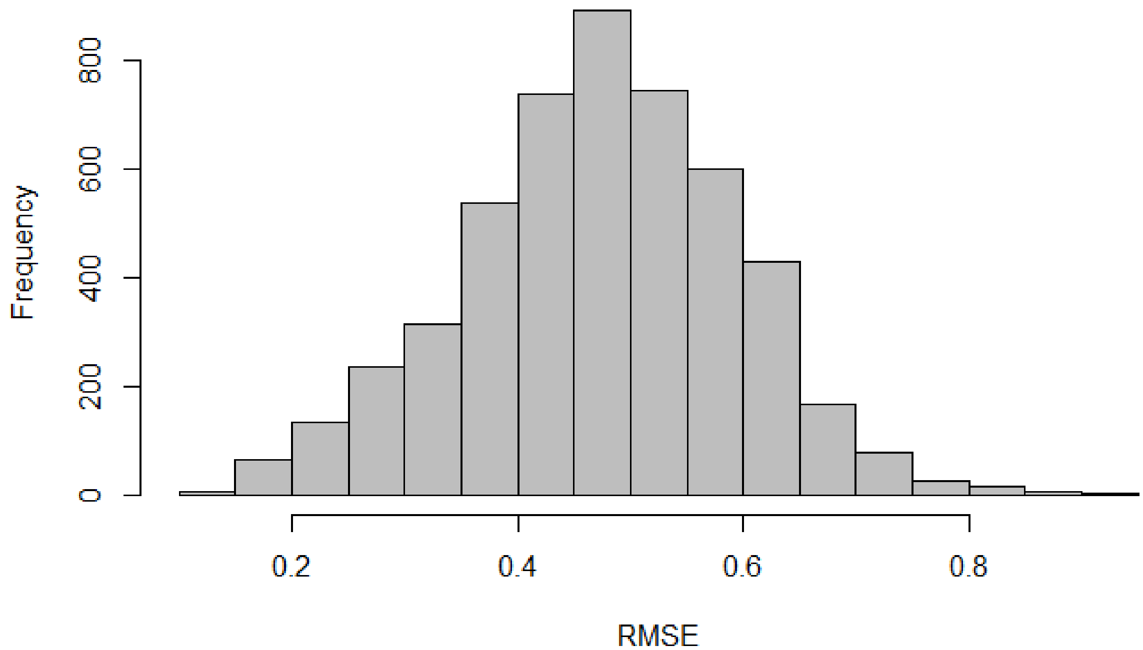

Figure 3. Histogram of relative mean squared error (RMSE) for 5,000 iterations of model testing using the caret package in R statistical software.

APPENDICES

APPENDIX A: IDFG CORE, NON-CORE, AND RESIDENT FISH SNORKEL TRANSECT DETAILS

Appendix A1. IDFG core trend snorkel survey transects n = 217 by Snake River Steelhead major and independent population. Middle Fork Salmon River and its tributaries are surveyed by regional management crews funded by the Dingell-Johnson Act and License funds.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
Hells Canyon Tributaries						
Hells Canyon (SNHCT-s)	Granite Creek	---	1	Annual	2018	2021
	Granite Creek	---	3	Annual	2018	2021
	Sheep Creek	---	1	Annual	2018	2021
	Sheep Creek	---	2	Annual	2018	2021
Independent Population Total:			4			
MPG Total:			4			
Clearwater River						
Lower Clearwater River (CRLMA-s)	Big Canyon Creek	---	1	Annual	2019	2021
Independent Population Total:			1			
South Fork Clearwater River (CRSFC-s)	American River	2	1	Annual	2019	2020
	American River	3	2	Triennial	2019	2022
	Crooked River	1	BOULDER-A	Annual	2019	2020
	Crooked River	1	BOULDER-B	Triennial	2018	2021
	Crooked River	1	SILL-LOG-B	Triennial	2018	2021
	Crooked River	2	CONTROL1	Triennial	2017	2020
	Crooked River	2	CONTROL2	Triennial	2018	2021
	Crooked River	2	TREAT2	Annual	2019	2020
	Crooked River	3	NATURAL1	Annual	2019	2020
	Crooked River	C	CAN2	Triennial	2018	2021
	Crooked River	C	CAN3	Annual	2019	2021
	East Fork Crooked River	H	EF1	Annual	2019	2021
	East Fork Crooked River	H	EF2	Triennial	2017	2021
	Johns Creek	1	1	Triennial	2019	2022
	Johns Creek	1	2	Triennial	2018	2021
	Johns Creek	2	3	Triennial	2019	2022
	Red River	1	CNTL 1	Annual	2019	2021
	Red River	1	CNTL 2	Annual	2019	2021
	Red River	2	CNTL 2	Annual	2019	2021
	Red River	2	TREAT 2	Annual	2019	2021
	Red River	4	CNTL 2	Annual	2019	2021
	Red River	4	TREAT 2	Annual	2019	2021
	Red River	5	CNTL 2	Annual	2019	2021
	Red River	5	TREAT 2	Annual	2019	2021
	Relief Creek	1	1A	Triennial	2018	2021
	Relief Creek	1	1B	Triennial	2018	2021
	Tenmile Creek	---	1	Triennial	2018	2021

Appendix A1. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	West Fork Crooked River	H	WF1	Annual	2019	2021
	West Fork Crooked River	H	WF2	Triennial	2019	2022
Independent Population Total:			29			
Lochsa River (CRLOC-s)	Brushy Fork	3	1	Biennial	2019	2021
	Brushy Fork	3	2	Annual	2019	2021
	Colt Creek		BRIDGE	Biennial	2019	2021
	Crooked Fork Creek	1	2A	Biennial	2019	2021
	Crooked Fork Creek	2	3A	Biennial	2019	2021
	Crooked Fork Creek	2	4A	Biennial	2019	2021
	Crooked Fork Creek	3	1	Biennial	2019	2021
	Crooked Fork Creek	3	2	Biennial	2019	2021
	Crooked Fork Creek	3	2B	Annual	2019	2021
	Crooked Fork Creek	4	1B	Annual	2019	2021
	Fish Creek	---	1	Annual	2019	2021
	Fish Creek	---	2	Annual	2019	2021
	Lochsa River	---	L1	Annual	2019	2021
	Lochsa River	---	L2	Biennial	2019	2021
	Lochsa River	---	L3	Biennial	2019	2021
	Lochsa River	---	L4	Annual	2019	2021
	Old Man Creek	---	1	Triennial	2018	2021
	Postoffice Creek	---	1	Triennial	2019	2022
	Postoffice Creek	---	2	Triennial	2019	2022
	Warm Springs Creek	---	1	Biennial	2019	2021
	White Sands Creek	---	LWRMONITOR	Biennial	2018	2021
Independent Population Total:			21			
Selway River (CRSEL-s)	Bear Creek	---	1	Annual	2017	2021
	Bear Creek	---	2	Annual	2017	2021
	Deep Creek	---	CACTUS	Annual	2019	2021
	Deep Creek	---	SCIMITAR	Annual	2019	2021
	East Fork Moose Creek	---	3	Annual	2015	2021
	Meadow Creek	---	1	Annual	2019	2021
	Moose Creek	---	1	Annual	2017	2021
	Moose Creek	---	2	Annual	2017	2021
	Running Creek	---	1	Annual	2017	2021
	Running Creek	---	2	Annual	2017	2021
	Selway River	---	HELLSHALF	Annual	2019	2021
	Selway River	---	LITTLE-CW	Annual	2019	2021
	Selway River	---	MAG-XING	Annual	2019	2021
	Selway River	---	RUNNING CR	Annual	2017	2021
	Three Links Creek	---	1	Annual	2017	2021
	White Cap Creek	3	1	Annual	2019	2021

Appendix A1. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	White Cap Creek	3	2	Annual	2019	2021
	White Cap Creek	3	3	Annual	2019	2021
Independent Population Total:			18			
MPG Total:			69			
Salmon River						
Little Salmon River (SRLSR-s)	Boulder Creek	ABOVE	1	Annual	2019	2021
	Boulder Creek	ABOVE	2	Annual	2019	2021
	Boulder Creek	BELOW	3	Annual	2019	2021
	Boulder Creek	BELOW	5	Annual	2019	2021
	Hazard Creek	---	HAZ1	Annual	2019	2021
	Little Salmon River	---	1	Annual	2019	2021
	Little Salmon River	---	2	Annual	2019	2021
	Rapid River	BLW W FK	RAP2	Annual	2019	2021
	Slate Creek	---	1	Triennial	2019	2022
	Slate Creek	---	2	Triennial	2019	2022
	Slate Creek	---	3	Triennial	2019	2022
	Slate Creek	---	4	Triennial	2019	2022
	Slate Creek	---	6	Triennial	2019	2022
	South Fork White Bird Creek	---	SF-#2	Triennial	2019	2022
	South Fork White Bird Creek	---	SF-#3	Triennial	2019	2022
	West Fork Rapid River	BLW FALLS	RAP1	Annual	2019	2021
	White Bird Creek	---	1	Triennial	2019	2022
Independent Population Total:			17			
South Fork Salmon River (SFMAI-s)	East Fork South Fork Salmon	ABV JHNSN	3	Biennial	2018	2021
	East Fork South Fork Salmon	BLW JHNSN	6	Biennial	2018	2021
	East Fork South Fork Salmon	BLW JHNSN	7	Biennial	2018	2021
	Johnson Creek	LOWER IV	L2	Triennial	2019	2022
	Johnson Creek	LOWER IV	L3	Triennial	2019	2022
	Johnson Creek	MID LOWIII	PW3B	Triennial	2019	2022
	Johnson Creek	MID UPR II	PW3A	Triennial	2019	2022
	Johnson Creek	UPPER I	M1	Triennial	2019	2022
	Johnson Creek	UPPER I	M2	Triennial	2019	2022
	Johnson Creek	UPPER I	M3	Triennial	2019	2022
	Johnson Creek	UPPER I	PW1A	Triennial	2019	2022
	Rock Creek	UPPER I	M1	Triennial	2019	2022
	Sand Creek	UPPER I	M2	Triennial	2019	2022
	South Fork Salmon River	---	11	Annual	2019	2021
	South Fork Salmon River	---	14	Annual	2019	2021
	South Fork Salmon River	---	16	Annual	2019	2021
	South Fork Salmon River	---	5	Annual	2019	2021
	South Fork Salmon River	---	7	Annual	2019	2021
	South Fork Salmon River	---	POVERTY	Annual	2019	2021

Appendix A1. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	South Fork Salmon River	---	STOLLE1	Annual	2019	2021
	South Fork Salmon River	---	STOLLE2	Annual	2019	2021
Independent Population Total:			21			
Secesh River (SFSEC-s)	Lake Creek	---	BURGDORF	Annual	2019	2021
	Lake Creek	---	WILLOW CR	Annual	2019	2021
	Lick Creek	---	L3	Annual	2019	2021
	Secesh River	---	GROUSE	Annual	2019	2021
	Secesh River	---	LONG-GULCH	Annual	2019	2021
Independent Population Total:			5			
Chamberlain Creek (SRCHA-s)	Bargamin Creek	---	1	Biennial	2018	2021
	Bargamin Creek	---	2	Biennial	2018	2021
	Chamberlain Creek	---	CHA1	Biennial	2020	2022
	Chamberlain Creek	---	CHA4	Biennial	2020	2022
	Sheep Creek	---	L1	Biennial	2018	2021
	Sheep Creek	---	L2	Biennial	2018	2021
	West Fork Chamberlain Cr.	---	CHA2	Biennial	2020	2022
	West Fork Chamberlain Cr.	---	CHA3	Biennial	2020	2022
Independent Population Total:			8			
Lower Middle Fork Salmon River (Loon Creek and below; MFBIG-s)	Big Creek	LOWER	L1	Annual	2017	2021
	Big Creek	MIDDLE	Cabin Cr	Biennial	2019	2021
	Big Creek	MIDDLE	TAYLOR 1	Biennial	2019	2021
	Big Creek	UPPER	LOGAN CR	Biennial	2018	2021
	Camas Creek	---	2	Biennial	2018	2021
	Camas Creek	---	CAM1	Biennial	2018	2021
	Loon Creek	C CHANNEL	2	Biennial	2018	2021
	Loon Creek	LNM1	3	Biennial	2018	2021
	Loon Creek	PACK BR	1	Biennial	2018	2021
	Middle Fork Salmon River	2	HOSPPL	Annual	2019	2021
	Middle Fork Salmon River	2	HOSPRUN	Annual	2019	2021
	Middle Fork Salmon River	2	TAPPANPOOL	Annual	2019	2021
	Middle Fork Salmon River	2	TAPPANRUN	Annual	2000	2021
	Middle Fork Salmon River	3	AIRSTRIP	Annual	2019	2021
	Middle Fork Salmon River	3	FLYING-B	Annual	2019	2021
	Middle Fork Salmon River	3	SURVEY	Annual	2019	2021
	Middle Fork Salmon River	4	BIG-CR-BR	Annual	2019	2021
	Middle Fork Salmon River	4	GOATPOOL	Annual	2019	2021
	Middle Fork Salmon River	4	GOATRUN	Annual	2019	2021
	Middle Fork Salmon River	4	LITOUZEL	Annual	2019	2021
	Middle Fork Salmon River	4	LOVEBAR	Annual	2019	2021
	Middle Fork Salmon River	4	OTTERBAR	Annual	2019	2021
	Middle Fork Salmon River	4	SHIPISLAND	Annual	2019	2021

Appendix A1. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	Monumental Creek	---	MON1	Triennial	2019	2022
	Monumental Creek	---	MON2	Triennial	2019	2022
	Monumental Creek	---	MON3	Triennial	2019	2022
	Monumental Creek	---	MON5	Triennial	2019	2022
	West Fork Monumental Creek	---	MON4	Triennial	2019	2022
Independent Population Total:			28			
Upper Middle Fork Salmon River	Beaver Creek	---	A	Annual	2019	2021
(above Loon Creek; MFUMA-s)	Beaver Creek	---	B	Annual	2019	2021
	Cape Horn Creek	1	A	Annual	2019	2021
	Cape Horn Creek	2	B	Annual	2019	2021
	Elk Creek	---	1A	Annual	2019	2021
	Elk Creek	---	1B	Annual	2019	2021
	Elk Creek	---	2A	Annual	2019	2021
	Elk Creek	---	2B	Annual	2019	2021
	Knapp Creek	1	A	Annual	2019	2021
	Knapp Creek	1	B	Annual	2019	2021
	Knapp Creek	1	LCKD FENCE	Annual	2019	2021
	Marble Creek	UPPER	MAR1	Biennial	2018	2021
	Marble Creek	UPPER	MAR1B	Biennial	2018	2021
	Marble Creek	UPPER	MAR2	Biennial	2018	2021
	Marsh Creek	1	A	Annual	2019	2021
	Marsh Creek	1	B	Annual	2019	2021
	Marsh Creek	3	A	Annual	2019	2021
	Marsh Creek	4	B	Annual	2019	2021
	Marsh Creek	5	A	Annual	2019	2021
	Middle Fork Salmon River	1	BOUNDARY	Annual	2019	2021
	Middle Fork Salmon River	1	ELKHORN	Annual	2019	2021
	Middle Fork Salmon River	1	GRDLHOLE	Annual	2019	2021
	Middle Fork Salmon River	1	GREYHOUND	Annual	2019	2021
	Middle Fork Salmon River	1	INDIAN	Annual	2019	2021
	Middle Fork Salmon River	1	RAPID-R	Annual	2019	2021
	Middle Fork Salmon River	1	SHEEPEATER	Annual	2019	2021
	Middle Fork Salmon River	1	VELVET	Annual	2019	2021
	Middle Fork Salmon River	2	COUGAR	Annual	2019	2021
	Middle Fork Salmon River	2	LJACKASS	Annual	2019	2021
	Middle Fork Salmon River	2	MARBLPL	Annual	2019	2021
	Middle Fork Salmon River	2	PUNGO	Annual	2019	2021
	Middle Fork Salmon River	2	ROCK IS	Annual	2019	2021
	Middle Fork Salmon River	2	SKIJUMP	Annual	2019	2021
	Middle Fork Salmon River	2	WHITEYCX	Annual	2019	2021
Independent Population Total:			34			
Panther Creek (SRPAN-s)	Horse Creek	---	L1	Triennial	2018	2021

Appendix A1. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	Horse Creek	---	L2	Triennial	2018	2021
	Panther Creek	ABOVE	PC9	Annual	2019	2021
	Panther Creek	DS-BIGD	PC4	Annual	2019	2021
	Panther Creek	DS-BLACKB	PC6	Annual	2019	2021
	Panther Creek	DS-CLEAR	PC1	Annual	2019	2021
Independent Population Total:			6			
North Fork Salmon River (SRNFS-s)	North Fork Salmon River	2	DAHLONEGA	Annual	2019	2021
	Pine Creek	---	BRIDGE	Annual	2019	2021
	Pine Creek	---	SAWMILL CR	Triennial	2019	2022
	North Fork Salmon River	2	HUGHES	Triennial	2019	2022
Independent Population Total:			4			
Lemhi River (SRLEM-s)	Big Springs Creek	LEM1	A	Biennial	2018	2021
	Hayden Creek	HC2	B	Biennial	2018	2021
	Hayden Creek	HC3	B	Biennial	2018	2021
	Lemhi	1	LEM3A	Biennial	2018	2021
Independent Population Total:			4			
Pahsimeroi River (SRPAH-s)	Pahsimeroi River	LOWER	DWTNLANE	Biennial	2018	2021
Independent Population Total:			1			
East Fork Salmon River (SREFS-s)	East Fork Salmon River	ABOVE-WEIR	2	Biennial	2018	2021
	East Fork Salmon River	ABOVE-WEIR	3	Biennial	2018	2021
	Morgan Creek	UPPER	BLM CAMP	Triennial	2019	2022
Independent Population Total:			3			
Upper Salmon River (SRUMA-s)	Alturas Lake Creek	2	2B	Annual	2019	2021
	Redfish Lake Creek	---	LOWER	Annual	2019	2021
	Redfish Lake Creek	---	WEIR DS	Annual	2019	2021
	Salmon River	1	RBNSN-BAR	Annual	2019	2021
	Salmon River	2	2B	Annual	2019	2021
	Salmon River	3	3B	Annual	2019	2021
	Salmon River	3	3BRA	Annual	2019	2021
	Salmon River	4	4B	Annual	2019	2021
	Salmon River	7	7A	Annual	2019	2021
	Valley Creek	1	B	Annual	2019	2021
	Valley Creek	3	A	Annual	2019	2021
	Valley Creek	3	B	Annual	2019	2021
	Valley Creek	6	B	Annual	2019	2021
Independent Population Total:			13			
MPG Total:			144			
Snake River DPS Total:			217			

Appendix A2. IDFG non-core trend snorkel survey transects n = 103 by Snake River Steelhead major and independent population. Middle Fork Salmon River and its tributaries are surveyed by regional management crews funded by the Dingell-Johnson Act and License funds.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
Hells Canyon Tributaries						
Hells Canyon (SNHCT-s)	Granite Creek	---	2	Opportunistic	2013	
Independent Population Total:			1			
MPG Total:			1			
Clearwater River						
Lower Clearwater River (CRLMA-s)	East Fork Potlatch River	---	PFI4	Opportunistic	2019	2021
	East Fork Potlatch River	---	PFI5	Opportunistic	2019	2021
	East Fork Potlatch River	---	PFI6	Opportunistic	2019	2021
	East Fork Potlatch River	---	PFI7	Opportunistic	2019	2021
	East Fork Potlatch River	---	PFI8	Opportunistic	2019	2021
	East Fork Potlatch River	---	PFI9	Opportunistic	2019	2021
	East Fork Potlatch River	---	1	Opportunistic	2019	2021
	East Fork Potlatch River	---	2	Opportunistic	2019	2021
	East Fork Potlatch River	---	3	Opportunistic	2019	2021
Independent Population Total:			9			
South Fork Clearwater River (CRSFC-s)	American River	2	1/8MABVEFK	Opportunistic	2018	
	American River	2	ABV CATTLE GRD	Variable	2018	
	American River	2	FLAT IRON RIDGE	Variable	2018	
	American River	2	GUNTLEYS	Variable	2018	
	American River	3	STOCK SIGN	Variable	2018	
	American River	1	2.25U	Variable	2018	
	American River	1	2.65U	Variable	2018	
	American River	1	GRAVEL PIT	Variable	2018	
	American River	3	.5MI BELOW BOXSING	Variable	2018	
	American River	3	BUFFALO PIT	Variable	2018	
	Crooked River	3	NATURAL3	Variable	2012	
	Crooked River	4	MEANDER2	Variable	2011	
	Crooked River	1	CONTROL2	Variable	2009	
	Johns Creek	2	4	Variable	2013	
	Red River	1	SHISSLER CR	Variable	2018	
	Red River	1	UPPER SHISSLER	Variable	2018	
	Red River	3	BELOW WEIR	Variable	2018	
	Red River	3	OLD BRIDGE	Variable	2018	
	Red River	4	BOULDER POOL	Variable	2018	
	Red River	6	CSUP 3	Variable	2011	

Appendix A2. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	Red River	6	CSUP 5	Opportunistic	2011	
	Relief Creek	2	2A	Opportunistic	2011	
	Relief Creek	2	2B	Opportunistic	2011	
	South Fork Clearwater River	---	103.2KM	Opportunistic	2009	
	South Fork Clearwater River	---	83.9KM	Opportunistic	2009	
	South Fork Clearwater River	---	88.7KM	Opportunistic	2009	
	South Fork Clearwater River	---	93.9KM	Opportunistic	2009	
	South Fork Clearwater River	---	98.7KM	Opportunistic	2009	
	Tenmile Creek	---	2	Opportunistic	2013	
Independent Population Total:			30			
Lochsa River (CRLOC-s)	Colt Killed Creek	---	LWRMONITOR	Opportunistic	2016	
	Fire Creek	---	1	Opportunistic	2017	
	Fire Creek	---	2	Opportunistic	2017	
	Hopeful Creek	1	1-BOOGIEDN	Opportunistic	2011	
	Split Creek	---	1	Opportunistic	2017	
	Split Creek	---	2	Opportunistic	2017	
Independent Population Total:			6			
Selway River (CRSEL-s)	East Fork Moose Creek	---	2	Opportunistic	2015	
	Gedney Creek	---	2	Opportunistic	2018	
	Marten Creek	---	1	Opportunistic	2017	
	Meadow Creek	---	2	Opportunistic	2018	
	OHara Creek	---	1	Opportunistic	2011	
	OHara Creek	---	2	Opportunistic	2011	
	Selway River	---	abv rodeo rapid	Opportunistic	2017	
	Selway River	---	above wolf cr. Rpd	Opportunistic	2017	
	Selway River	---	blw Rodeo rapid	Opportunistic	2017	
	Selway River	---	blw 3 links rpd	Opportunistic	2017	
	Selway River	---	Moose creek confluence	Opportunistic	2017	
	Selway River	---	Selway lodge	Opportunistic	2017	
	Selway River	---	1 mi. blw wt cap	Opportunistic	2017	
	Selway River	---	½ mile below Running	Opportunistic	2017	
	Selway River	---	½ mi. blw wt cap	Opportunistic	2017	
	Selway River	---	Abv goat cr	Opportunistic	2017	
	Selway River	---	Archer	Opportunistic	2017	
	Selway River	---	below ham rapid	Opportunistic	2017	
	Selway River	---	Blw pettibone cr	Opportunistic	2017	
	Selway River	---	cougar bluff	Opportunistic	2017	

Appendix A2. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	Selway River	---	DIVIDE	Opportunistic	2017	
	Selway River	---	dry bar	Opportunistic	2017	
	Selway River	---	rattlesnake	Opportunistic	2017	
	Selway River	---	BadLuck CR	Annual	2017	2021
	Selway River	---	@ Lower Tango	Annual	2017	2021
	Selway River	---	Big bend	Annual	2017	2021
	Selway River	---	Osprey Is	Opportunistic	2017	
Independent Population Total:			28			
MPG Total:			73			
Salmon River						
Little Salmon River (SRLSR-s)	Hazard Creek	---	HAZ2	Opportunistic	2019	
	Rapid River	ABV W FK	4	Annual	2019	2021
	Rapid River	ABV W FK	CASTLE CR	Annual	2019	2021
	Rapid River	ABV W FK	COPPER CR	Annual	2019	2021
	Rapid River	ABV W FK	CORA CLIFF	Annual	2019	2021
	Rapid River	ABV W FK	PARADISE	Annual	2019	2021
	Rapid River	BLW W FK	CLIFF HANG	Annual	2019	2021
Independent Population Total:			7			
	South Fork Salmon River	---	BLW HAMILTON	Opportunistic	2019	
Independent Population Total:			1			
Secesh River (SFSEC-s)	Lick Creek	---	L1	Opportunistic	2019	
Independent Population Total:			1			
Lower Middle Fork Salmon River	Camas Creek	---	Upper	Annual	2019	2021
(Loon Creek and below; MFBIG-s)	Middle Fork Salmon River	Lower	CLIFPL	Annual	2019	2021
	Middle Fork Salmon River	Lower	HANPOL	Annual	2019	2021
	Middle Fork Salmon River	Middle	AIRSTP	Biennial	2019	2021
Independent Population Total:			4			
Upper Middle Fork Salmon River	Indian Creek	---	Lower	Annual	2019	2021
(above Loon Creek; MFUMA-s)	Indian Creek	---	Upper	Annual	2019	2021
	Middle Fork Salmon River	Upper	Mahoney Camp	Annual	2019	2021
	Middle Fork Salmon River	Middle	WCPB	Annual	2019	2021
	Middle Fork Salmon River	Upper	LICRGS	Annual	2019	2021
Independent Population Total:			5			
Panther Creek (SRPAN-s)	Panther Creek	DS Clear	PC-1	Opportunistic	2019	

Appendix A2. Continued.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
	Panther Creek	Above	US Cabin Cr	Opportunistic	2009	
Independent Population Total:			2			
Lemhi River (SRLEM-s)	Big Springs Creek	---	BSC BRIDGE	Annual	2019	2021
	Lemhi River	LEM2	B	Biennial	2018	2021
Independent Population Total:			2			
Pahsimeroi River (SRPAH-s)	Pahsimeroi River	1	Ponds	Annual	2019	2021
	Pahsimeroi River	Weir	Weir	Annual	2019	2021
Independent Population Total			2			
Upper Salmon River (SRUMA-s)	Hannah Slough	---	UPS Garden Cr	Annual	2019	2021
	Thompson Creek	Below	1	Opportunistic	2019	
Independent Population Total:			2			
MPG Total:			27			
Snake River DPS Total			104			

Appendix A3. IDFG resident fish trend snorkel survey transects n = 26 by Snake River Steelhead major and independent population. Middle Fork Salmon River and its tributaries are surveyed by regional management crews funded by the Dingell-Johnson Act and License funds.

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
Clearwater River						
South Fork Clearwater River (CRSFC-s)	Crooked River	1	SILL-LOG-A	Triennial	2018	2021
	Moores Creek	---	2	Triennial	2019	2022
Independent Population Total:			2			
Lochsa River (CRLOC-s)	Squaw Cr (Waw'aalamnime)	---	7	Annual	2019	2021
Independent Population Total:			1			
Selway River (CRSEL-s)	Little Clearwater River	---	1	Annual	2019	2021
	Little Clearwater River	---	2	Annual	2019	2021
	North Fork Moose Creek	---	4	Annual	2015	2021
	Selway River	---	BEAVERPT	Annual	2019	2021
Independent Population Total:			4			
MPG Total:			7			
Salmon River						
South Fork Salmon River (SFMAI-s)	East Fork South Fork Salmon	ABV JHNSN	SUGAR CR	Biennial	2017	2021
	East Fork South Fork Salmon	BLW JHNSN	MP 35.8	Biennial	2017	2021
Independent Population Total:			2			
Secesh River (SFSEC-s)	Secesh River	---	U-SCSH-MDW	Annual	2019	2021
Independent Population Total:			1			
Lower Middle Fork Salmon River (Loon Creek and below; MFBIG-s)	Big Creek	UPPER	NEAR FORD	Biennial	2018	2021
	Camas Creek	---	1	Triennial	2016	2021
	Camas Creek	---	L1-MOUTH	Annual	2019	2021
	Loon Creek	---	L1-BRIDGE	Annual	2019	2021
	Loon Creek	---	L2-RUN	Annual	2019	2021
Independent Population Total:			5			
Upper Middle Fork Salmon River (above Loon Creek; MFUMA-s)	Bear Valley Creek	1	A	Triennial	2018	2021
	Bear Valley Creek	2	B	Triennial	2018	2021
	Bear Valley Creek	3	A	Triennial	2018	2021
	Bear Valley Creek	9	B	Triennial	2018	2021
	Marble Creek	Lower	L1	Annual	2019	2021
	Pistol Creek	---	L1/Lower	Annual	2019	2021
	Pistol Creek	---	L2/Upper	Annual	2019	2021
Independent Population Total:			7			
Panther Creek (SRPAN-s)	Panther Creek	Above	PC10	Annual	2019	2021

Appendix A3. Continued

Steelhead Major and Independent Population	Stream Name	Stratum	Transect Name	Survey Frequency	Last Surveyed	Next Scheduled Survey
Independent Population Total:			1			
Lemhi River (SRLEM-s)	Bear Valley Creek	HC1	B-LOWER	Triennial	2017	2021
	Bear Valley Creek	HC1	CAMP	Triennial	2017	2021
Independent Population Total:			2			
Upper Salmon River (SRUMA-s)	Thompson Creek	ABOVE	TWO-POLE	Biennial	2019	2021
Independent Population Total:			1			
MPG Total:			19			
Snake River DPS Total:			26			

APPENDIX B: SALMONID DENSITIES OBSERVED BY SNORKELING IN 2020

Appendix B1. Densities (fish/100 m^2) of salmonids observed in 2020 at 4 core transects snorkeled throughout Chamberlain Basin, Idaho. Trout fry = all trout <50 mm that could not be distinguished between steelhead and Westslope Cutthroat Trout. Dashes represent transects in which no fish of a given type were observed.

		Density (Fish/100m^2)								
Stream	Transect	Trout Fry	Steelhead	Chinook Salmon	Westslope Cutthroat Trout	Bull Trout	Brook Trout	Whitefish	Visibility (m)	Temp (°C)
Chamberlain Creek	CHA1	0.00	1.57	0.55[a]	0.00	0.00	0.00	0.48	3.0	16.0
Chamberlain Creek	CHA4	0.00	2.66	0.09[b]	0.00	0.00	0.00	0.00	3.1	14.0
West Fork Chamberlain Creek	CHA2	0.00	1.44	0.36[c]	0.00	0.36	0.00	0.00	2.7	13.0
West Fork Chamberlain Creek	CHA3	0.00	1.92	0.00	0.00	0.00	0.00	0.00	3.2	11.0
	Mean	**0.0**	**1.9**	**0.3**	**0.0**	**0.1**	**0.0**	**0.1**	**3.0**	**13.5**
	Standard Deviation (SD)	**0.0**	**0.6**	**0.3**	**0.0**	**0.2**	**0.0**	**0.2**	**0.2**	**2.0**
	Proportion Occupied	**0.0**	**1.0**	**0.8**	**0.0**	**0.3**	**0.0**	**0.3**		

[a] Age-1 and adult Chinook observed
[b] Adult Chinook observed
[c] Age-1 Chinook observed

Appendix B2. Densities (fish/100 m^2) of salmonids observed in 2020 at 18 Screen Shop Assessment snorkel transects throughout the Pahsimeroi River Basin, Idaho. Trout fry = all trout <50 mm that could not be distinguished between steelhead and Westslope Cutthroat Trout. Dashes represent transects in which no fish of a given type were observed.

Stream	Transect	Trout Fry	Steelhead	Chinook Salmon	Westslope Cutthroat Trout	Bull Trout	Brook Trout	Whitefish	Visibility (m)	Temp (C)
Pahsimeroi River	PAH-03	0.00	1.69	0.19	0.00	0.00	1.88	8.83	1.5	19.0
Pahsimeroi River	PAH-02	28.85	0.77	0.04	0.00	0.00	3.85	0.38	2.3	12.0
Patterson Big Springs	PBSC-04	0.00	0.00	0.00	0.00	0.00	0.15	0.92	2.1	11.5
Patterson Big Springs	PBSC-01	0.00	0.18	0.00	0.00	0.00	0.00	0.18	1.0	12.0
Patterson Big Springs	PBSC-02	0.00	0.99	0.00	0.00	0.00	0.82	3.29	4.0	15.0
Patterson Big Springs	PBSC-05	0.00	0.17	0.00	0.00	0.00	0.86	0.52	1.9	12.0
Patterson Big Springs	PBSC-05A	0.00	1.85	0.00	0.19	0.00	3.15	0.19	1.9	14.0
Patterson Big Springs	PBSC-06	0.70	0.35	1.22	0.00	0.00	0.35	0.00	4.0	15.0
Patterson Big Springs	PBSC-06A	0.00	0.96	1.28	0.00	0.00	1.92	5.11	1.1	12.0
Patterson Big Springs	PBSC-06B	3.70	0.00	0.41	0.00	0.00	2.88	0.41	1.5	16.0
Patterson Big Springs	PBSC-07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.3	16.0
Patterson Big Springs	PBSC-08	0.00	2.47	2.47	0.00	0.00	1.59	0.00	3.4	13.0
Patterson Big Springs	PBSC-09	0.00	1.49	0.00	0.00	0.00	5.64	0.00	2.0	16.0
Patterson Big Springs	PBSC-10	0.00	0.00	0.00	0.00	0.00	21.16	0.00	1.1	14.0
Patterson Big Springs	PBSC-11	0.00	0.00	0.00	0.00	0.00	15.28	0.00	-	17.0
Patterson Little Springs	PLSC-01	0.00	0.39	0.20	0.00	0.00	0.39	0.00	1.7	11.0
Patterson Little Springs	PLSC-02	0.00	0.00	0.78	0.00	0.00	0.20	0.00	1.4	14.0
Patterson Little Springs	PLSC-03	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.8	15.0
	Mean	**1.8**	**0.6**	**0.4**	**0.0**	**0.0**	**3.4**	**1.1**	**1.9**	**14.1**
	Standard Deviation (SD)	**7.0**	**0.8**	**0.7**	**0.0**	**0.0**	**5.8**	**2.4**	**1.0**	**2.2**
	Proportion Occupied	**0.2**	**0.6**	**0.5**	**0.1**	**0.0**	**0.9**	**0.5**		

APPENDIX C: MEAN SNORKEL DENSITY AND ROTARY SCREW TRAP COHORT ESTIMATES USED FOR ANALYSIS IN CHAPTER 2

Appendix C1. Mean densities (fish/100 m^2) of steelhead observed in snorkel surveys and rotary screw trap (RST) cohort estimates by year and trap location.

Location	Year	Mean Snorkel Steelhead Density (fish/100 m^2)	RST Cohort Estimate
BBCTRP	2015	0.79	5,854
BBCTRP	2016	4.21	12,960
BBCTRP	2017	2.00	10,183
BBCTRP	2018	1.77	6,149
BBCTRP	2019	0.58	8,589
CROTRP	2008	1.30	1,115
CROTRP	2009	0.50	1,211
CROTRP	2010	0.58	592
CROTRP	2011	0.83	2,491
CROTRP	2012	0.17	2,242
CROTRP	2013	1.32	2,589
CROTRP	2014	0.38	300
CROTRP	2016	0.06	1,869
CROTRP	2017	0.25	338
CROTRP	2019	0.21	238
EFPTRP	2015	0.65	7,965
EFPTRP	2016	0.34	16,664
EFPTRP	2017	0.89	9,781
EFPTRP	2018	0.13	3,100
EFPTRP	2019	0.55	2,184
FISTRP	2007	5.14	23,261
FISTRP	2008	2.72	14,457
FISTRP	2009	3.46	14,619
FISTRP	2010	5.21	28,661
FISTRP	2011	4.20	46,917
FISTRP	2012	5.34	26,502
FISTRP	2013	5.94	33,116
FISTRP	2014	2.89	16,201
FISTRP	2015	2.22	20,993
FISTRP	2016	4.90	75,043
FISTRP	2017	5.21	38,569
FISTRP	2018	4.77	11,936
FISTRP	2019	1.94	7,176
MARTR2	2010	0.94	4,996
MARTR2	2011	0.56	4,850
MARTR2	2012	1.45	4,493
MARTR2	2013	1.98	7,246
MARTR2	2014	1.02	10,206

Appendix C1. Continued

Location	Year	Mean Snorkel Steelhead Density (fish/100 m^2)	RST Cohort Estimate
MARTR2	2015	0.70	7,310
MARTR2	2016	0.99	5,256
MARTR2	2017	0.50	1,972
NFSTRP	2015	4.36	21,542
NFSTRP	2016	8.84	11,004
NFSTRP	2017	4.09	8,086
NFSTRP	2018	2.04	5,199
NFSTRP	2019	1.71	4,200
RPDTRP	2008	2.53	3,769
RPDTRP	2009	2.41	4,457
RPDTRP	2010	2.64	2,801
RPDTRP	2011	1.79	1,890
RPDTRP	2012	1.63	5,587
RPDTRP	2013	2.35	3,587
RPDTRP	2014	2.09	2,872
RPDTRP	2015	2.32	4,004
RPDTRP	2016	2.63	2,205
RPDTRP	2017	2.99	2,528
RPDTRP	2018	2.05	1,406
RPDTRP	2019	2.22	910
SFSRKT	2016	2.40	35,087
SFSRKT	2017	2.73	32,696
SFSRKT	2018	3.34	23,275
SFSRKT	2019	2.10	15,558

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