FISHERY RESEARCH

IDAHO ANADROMOUS EMIGRANT MONITORING

2021 ANNUAL REPORT

Photo: Stacey Meyer, IDFG

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2021 Annual Report

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Definition
BY	Brood Year
DPS	Distinct Population Segment
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
ICTRT	Interior Columbia (River Basin) Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IFWIS	Idaho Fish and Wildlife Information System
LGR	Lower Granite Dam
MPG	Major Population Group
PIT	Passive Integrated Transponder
RST	Rotary Screw Trap(s)

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CHAPTER 1

ANADROMOUS EMIGRANT MONITORING IN IDAHO USING ROTARY SCREW TRAPS

ABSTRACT

During 2021, Idaho Department of Fish and Game monitored emigration of wild juvenile Chinook Salmon and steelhead at ten rotary screw traps (RST) in the Salmon River basin and five in the Clearwater River basin. In the Salmon basin, with the exception of Rapid River where abundance could not be estimated, total estimated abundance of Chinook Salmon emigrants varied from 14,701 to 156,466 fish. In the Clearwater River basin, abundance of Chinook Salmon emigrants could only be estimated for fall age-0 fish at the Crooked River RST (320 fish) and for spring age-1 fish at the Lochsa River RST (10,725 fish). Abundance of juvenile steelhead emigrants were estimated for at least one season for all RSTs that operated in 2021. Abundance estimates of juvenile steelhead varied from 1,929 to 23,013 fish in the Salmon River basin and from 42 to 107,744 fish in the Clearwater River basin. Productivity of juvenile Chinook Salmon emigrants at RSTs and of smolts that survived to Lower Granite Dam (LGR) were estimated at all except the Rapid River site in the Salmon River basin but could not be estimated for any RST sites in the Clearwater River basin. Productivity of Chinook juveniles in the Salmon River basin at RSTs for BY2019 varied from 222 emigrants per female spawner in the Pahsimeroi River to 3,544 emigrants per female spawner in Big Creek. Productivity of smolts from the Salmon River basin at LGR for BY2019 varied from 98 smolts per female spawner from the upper Salmon River to 1,832 smolts per female spawner from Big Creek. Juvenile steelhead productivity for BY2016 at trapping sites in the Salmon River basin varied from 56 emigrants per female spawner in the lower Lemhi River to 388 emigrants per female spawner in the upper Lemhi River. Juvenile steelhead productivity for BY2016 in the Clearwater River basin varied from 161 emigrants per female spawner in Fish Creek to 372 emigrants per female spawner in Crooked River. The pairing of adult and juvenile abundance data provided insight into the variation in habitat and stock characteristics for Chinook Salmon and steelhead populations throughout Idaho.

Strength of the density dependent mechanisms influence the abundance of Chinook Salmon smolts estimated to survive to LGR and vary by population.

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INTRODUCTION

Chinook Salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss,* the anadromous form of Rainbow Trout, 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 spring-summer Chinook Salmon (hereafter Chinook Salmon) and steelhead from the Snake River following the construction of dams on the lower Snake River during the late 1960s and early 1970s. Adult Chinook Salmon and steelhead abundances over Lower Granite Dam (LGR) into the Snake River increased slightly in the early 1980s (Busby et al. 1996), declined in the 1990s, and noticeably increased again starting in 2000. As a result of critically low adult abundances in the 1990s, Snake River spring-summer Chinook Salmon were classified as threatened in 1992 and Snake River steelhead were classified as threatened under the Endangered Species Act (ESA) in 1997. Since 2015, abundance declined to levels similar to the mid-1990s.

Within the Snake River spring-summer Chinook Salmon evolutionarily significant unit (ESU), there are seven major population groups (MPGs): Lower Snake River, Grande Ronde and Imnaha rivers, South Fork Salmon River, Middle Fork Salmon River, Upper Salmon River, Dry Clearwater River, and the Wet Clearwater River (Table 1). The Dry Clearwater River and the Wet Clearwater River MPGs are considered to be extirpated, but have been reestablished with stocks from other MPGs. The Panther Creek population in the Upper Salmon MPG was also extirpated and re-established. Currently there are 28 extant or re-established populations across all 5 Idaho MPGs.

Within the Snake River steelhead distinct population segment (DPS), there are six MPGs: Lower Snake River, Grande Ronde River, Imnaha River, Clearwater River, Salmon River, and Hells Canyon Tributaries (ICTRT 2003, 2005; NMFS 2011). However, the Hells Canyon MPG is considered to be extirpated. A total of 24 extant demographically independent populations have been identified.

Anadromous fish management programs in the Snake River basin include large-scale hatchery programs (intended to mitigate for the impacts of hydroelectric dam construction and operation to fisheries in the basin) and recovery planning and implementation (aimed at recovering ESA-listed wild salmon and steelhead stocks). The Idaho Department of Fish and Game anadromous fish program's long-range goal, consistent with basin-wide mitigation and recovery programs, is to preserve Idaho's Chinook Salmon and steelhead runs and recover them to provide benefit to all users (IDFG 2019). Management to achieve these goals requires an understanding of how salmonid populations function as well as periodic status assessments (McElhany et al. 2000). Specific data necessary to achieve these goals on some Snake River steelhead and Chinook Salmon populations were lacking in the past, particularly key parameters such as abundance, age composition, genetic diversity, recruits per spawner, and survival rates (ICTRT 2003).

Idaho Department of Fish and Game (IDFG) provides long-term continuous research, monitoring, and evaluation of the status of the state's populations of anadromous salmon and steelhead. Recommendations for monitoring to address population status assessments across the Columbia River basin include: 1) annual estimation of juvenile emigrant abundance across major populations, and 2) estimation of the adult-to-juvenile productivity of both tributary emigrants and smolts through the Columbia River basin hydrosystem (Crawford and Rumsey 2011), which provides insight into survival throughout the life cycle. These are two of several critical metrics necessary to assess overall trends in abundance and productivity.

Freshwater rearing of anadromous salmonids in Idaho is spatially extensive and emigration is protracted, especially for steelhead. Chinook Salmon and steelhead may rear from headwater spawning areas to the lower Snake River throughout the year, with spatial distribution of multiple cohorts often overlapping temporally. Cohorts of Chinook Salmon are relatively easy to distinguish, with a few exceptions (e.g., Pahsimeroi River, where a significant proportion of age-0 emigrants smolt; Copeland and Venditti 2009). Extensive ageing of steelhead emigrants is necessary to estimate population productivity because several cohorts emigrate together and overlap in size. Ideal locations to estimate abundance of juvenile emigrants at the population scale are downstream from most spawning and early-rearing habitat, yet upstream enough in the drainage to allow efficient population-specific sampling. If traps are located appropriately downstream of important spawning and rearing habitats, standardized sampling through time and across locations can allow long-term evaluations and comparisons of population trends. Rotary screw traps (hereafter RSTs or traps) have been the primary tool used by IDFG since the early 1990s to address the following objectives: 1) estimation of juvenile emigrant abundance for select populations, and 2) implanting passive integrated transponder (PIT) tags in emigrants to evaluate hydrosystem passage (Venditti et al. 2015a; Copeland et al. 2015; Bowersox and Biggs 2012; Apperson et al. 2016 and 2017; Uthe et al. 2017; McCann et al. 2015).

A collaborative effort across the Columbia River basin offered guidance to standardize monitoring of juvenile emigrants and to coordinate and prioritize monitoring work (i.e., Anadromous Salmonid Monitoring Strategy, http://www.nwcouncil.org/fw/am/monitoring/monitoring-strategies). Since that collaborative process began, IDFG has continued some previous RST operations and strategically implemented new RST operations to contribute to the monitoring of the Major Population Groups (MPGs) and populations most important to overall recovery goals. Most monitoring restructuring was delayed until the completion of Idaho Supplementation Studies (Venditti et al. 2015b). However, monitoring in Marsh Creek downstream of the Beaver Creek confluence was implemented in 2010. The current monitoring configuration began in 2015. Our goal with this report is to consolidate all information generated by means of RSTs operated by IDFG to assess trends in abundance and productivity of juvenile Chinook Salmon and steelhead populations. Additionally, juvenile Pacific Lamprey *Entosphenus tridentatus*, a species of greatest conservation need in Idaho (IDFG 2017), are captured at some locations, providing us the opportunity to monitor both supplemented and non-supplemented populations.

We continuously strive to sample populations efficiently and minimize potential harm to individual fish. Tagging and information derived from sampling is coordinated with and used among multiple projects (e.g., Copeland et al. 2015; Venditti et al. 2015b; McCann et al. 2015; Uthe et al. 2017). Take associated with trapping ESA-listed species is permitted under a State of Idaho 4d research permit issued by NMFS. A detailed take report is submitted to NMFS at the end of each year, which also outlines the measures we take to minimize stress or harm to fish.

We have four objectives for this report: 1) report estimates of emigrant abundance at RSTs by season and cohort for Chinook Salmon and steelhead, 2) estimate emigrant survival rate to Lower Granite Dam (LGR) by season and cohort for Chinook Salmon, 3) present current estimates of adult-to-juvenile freshwater productivity for Chinook Salmon using the Beverton-Holt stock-recruit relationship and for steelhead using brood tables (Beverton and Holt 1957), and 4) present results of relevant side projects associated with operation and data analysis of rotary screw traps.

STUDY AREA

The Salmon River and Clearwater River basins include portions of the Idaho Batholith, the Middle Rockies, and the Northern Rockies ecoregions (McGrath et al. 2002; Kohler et al. 2013). Most study streams drain in areas with sterile granitic parent material associated with the Idaho Batholith, resulting in relatively low-nutrient systems (McGrath et al. 2002; Sanderson et al. 2009). Three exceptions are the Potlatch River in the Clearwater River basin and the Lemhi and Pahsimeroi rivers in the Salmon River basin, all of which flow through predominately fertile basaltic geologies. In both the Clearwater and the Salmon river basins, water quality is good and substrates range from sand and small gravels to cobbles and large boulders. Winters are harsh and growing seasons are short (45-100 d). This area is also relatively dry with annual precipitation (primarily snowfall during spring, fall, and winter) ranging from 31 cm to 203 cm. Snowmelt influences most flow regimes with peak spring flows occurring during May and June and base flows occurring for the remainder of the year. Groundwater recharge heavily influences base flows in the Lemhi River and Pahsimeroi River. All waterbodies discussed in this report are inhabited by anadromous fishes.

Idaho Chinook Salmon and steelhead migrate long distances during their life cycle. They travel 1,451 km from the Pacific Ocean to the highest reaches of their spawning grounds in the Sawtooth National Recreation Area and climb from sea level to elevations over 2,000 m. Eight dams lie between Idaho and the Pacific Ocean including four Snake River dams and four Columbia River dams. The first dam Idaho Chinook Salmon and steelhead encounter during emigration is LGR on the Snake River, 695 km from the Pacific Ocean. In the Salmon River basin, juveniles migrate between 283 km and 747 km from their respective RST before encountering LGR. In the Clearwater River basin, juveniles migrate between 98 km and 324 km before encountering LGR. Juvenile Chinook Salmon and steelhead rear in a variety of locations ranging from natal tributaries to downstream mainstem rivers (Copeland et al. 2014).

Rotary screw traps operated by IDFG to sample wild juvenile Chinook Salmon and steelhead are distributed throughout the Salmon River and Clearwater River basins, Idaho (Figures 1 and 2). Traps were located to sample emigration from selected populations for either or both species. Details about trap coverage are given in Appendix A.

METHODS

Rotary Screw Trap Operations and Sampling Process

Methods applied to operate traps, handle and tag fish, manage data, and estimate emigrant abundance and smolt survival were primarily adapted from Venditti et al. (2015a). Volkhardt et al. (2007) provides much detail regarding RST design/construction and recommendations regarding river placement and general trap operations in a wide range of stream sizes. Biologists with IDFG spent a great deal of time since the early 1990s refining all protocols associated with operating RSTs in Idaho rivers to ensure 1) consistent information was collected and archived, 2) fish were handled appropriately to minimize stress, and 3) personnel safety. A formal manual was published in March of 2021 and these detailed and updated methods will be used as a reference for this and future reports (Copeland et al. 2021).

Traps were operated as much of the year as possible and operation was generally discontinued only when conditions jeopardize safety of personnel, fish, or the trap. While some low elevation traps are operated from late February into December, most traps are higher in

elevation and are operated from the middle of March into the middle of November. Trap operations in some Clearwater River basin streams (Potlatch and Lochsa rivers, Big Bear Creek) are routinely unable to operate past June, limited by low stream flow and high stream temperatures (>17°C). Additionally, trap operation in Hayden Creek trap can be limited due to irrigation withdrawals. Traps are not operated in the winter due to icing and the lack of fish movement (Bjornn 1978). When flow conditions allow, RSTs were positioned in the thalweg (region of the stream that has most of the flow by volume) to maximize capture efficiency. Program personnel check traps and process fish at least once daily during daylight hours. High water flows, debris, and ice have inhibited trap operations and have caused the traps to be inoperable for short time periods (Appendix B). When we anticipated such problems or when unusually high numbers of hatchery juveniles were passing (generally immediately following hatchery releases), we checked the traps several times throughout the day and night, moved traps out of the thalweg, or ceased trapping as was necessary to avoid harm to fish and avoid damage or loss of the RST. Once conditions were improved and it was safe for personnel and equipment normal trapping operations resumed.

Fish collected in RSTs were processed using standard protocols (Copeland et al. 2021). All fish were removed from the trap box and placed in aerated holding containers. Chinook Salmon and steelhead were anesthetized in buffered Tricaine Methanesulfonate (MS-222) solution, scanned for PIT tags, weighed to the nearest 0.1 g, and measured to the nearest 1 mm fork length (FL). We anesthetized no more than 20 juvenile fish at one time to reduce exposure time to the anesthetic. Lengths and weights were recorded for all Chinook Salmon age-1 smolts but subsampled on age-0 fry, parr, and presmolts depending on the number captured in the trap and time/temperature constraints. Lengths and weights were recorded on all steelhead unless high abundances forced crews to subsample. Target species (Chinook Salmon and steelhead) were marked and sampled for biological data (e.g., PIT tags, scales).

Chinook Salmon ≥60 mm FL and steelhead ≥80 mm FL were implanted with 12 mm x 2.05 mm PIT tags. Effort was made to tag all steelhead and all Chinook Salmon age-1 smolts. Young of the year Chinook Salmon were subsampled based on the minimum number of tags needed to obtain abundance, survival, and smolt-to-adult survival rates (SARs; LGR to LGR) while not exceeding permitted take limits (Copeland et al. 2021). The number of tags placed to estimate trap efficiency was controlled by the number needed for statistical estimation of abundance with desired precision and the concurrent efficiency of the trap (Copeland et al. 2021). All PIT tagging followed established protocols (Kiefer and Forster 1991; PIT Tag Steering Committee 1992; CBFWA 1999). Single-use injectors were used at most traps (Venditti et al. 2013). Chinook Salmon <60 mm FL were generally not tagged; however, in locations where Chinook Salmon <60 mm make up a substantial proportion of the total emigrants, we used Bismarck Brown Y stain to mark subsamples of fish that were 35-59 mm FL for mark-recapture abundance estimates (Venditti et al. 2015a). Bismarck brown staining was done at Marsh and Hayden creeks and the Lemhi River traps in 2021. Steelhead <80 mm FL captured in the Potlatch River were marked with a ventral fin clip and included with PIT-tagged fish in mark-recapture abundance estimates. At the Hayden Creek, Upper Lemhi River, and Lower Lemhi River traps, steelhead 60-79 mm FL were implanted with 9-mm PIT tags. Tagging of Chinook Salmon and steelhead at the Potlatch River, Lemhi River, and Hayden Creek traps differed from other traps because of the need for monitoring fish at various life stages as part of Intensively Monitored Watershed studies (Uthe et al. 2017). Fish recovered from handling in large, lidded perforated plastic containers placed in the stream with sufficient free flow of water or in buckets of water with aeration and temperature control prior to release into the stream.

Incidental catches of other non-target species were enumerated, a subsample was measured for length and weight depending on catch, and all were then released downstream of RSTs. Depending on the location, the target species is Chinook Salmon, steelhead, or both (Copeland et al. 2021). All ESA-listed species were processed first to minimize duration of stress. Juvenile Pacific Lamprey were anesthetized with MS-222, counted, measured to the nearest 1-mm total length (TL), identified as ammocoetes or macrophthalmia based on the presence or absence of visible eyes, and subsampled for genetic tissue with a fin clip. Protocols for collecting data and samples from Pacific Lamprey were adapted from the Nez Perce Tribe (Mike Kosinski, Nez Perce Tribe, personal communication).

Trap efficiency was estimated using fish that were newly marked with either PIT tags, stain, or fin clips by releasing those fish upstream from the trap on a daily basis. Subsequent recaptures of marked fish were used to estimate daily trap efficiency. Efficiencies were based on marked salmonids that were recaptured ≤5 days after release depending on the RST site. To meet an assumption of a single capture-recapture method for a closed population, we selected release sites approximately 0.5 km or at least two riffles and a pool upstream of the trap to maximize the probability that marked fish would mix randomly with the general population prior to their recapture. Release locations had adequate holding habitat to reduce immediate predation risk.

Scale samples were collected from steelhead ≥80 mm FL at most RSTs for ageing. We followed established protocols using either a systematic random sampling method for large abundances (>150 fish in a given season; spring, summer/fall) or sampling all individuals for small abundances (<150 fish in a given season) to collect scales. We attempted to sample up to 150 steelhead at each RST site for each season, and subsequently assign ages to those fish using methods by Wright et al*.* (2015). Fish that were aged were used to estimate proportional age composition of the emigrating cohort by respective season.

Data Management

Tagging data from RST operations are stored in the PTAGIS P4 database locally then uploaded to the PIT Tag Information System (PTAGIS) database (https://www.ptagis.org). All PIT-tagged and non-PIT-tagged fish data, along with metadata, are uploaded to the Idaho Fish and Wildlife Information System (IFWIS) database (https://fishandgame.idaho.gov/ifwis/portal/page/juvenile-fish-trapping) via the J-Trap application. Data were queried from the IFWIS database for analysis. Steelhead age data were archived in the IDFG BioSamples database (https://collaboration.idfg.idaho.gov/gci/default.aspx). Interested parties can access raw data with permission from IFWIS. Data were checked for accuracy and completeness at several stages (e.g., trap tender prior to initial uploading, trap supervisors, IDFG data coordinators, PTAGIS database managers). After analysis, juvenile abundance and productivity estimates are publicly available via the Coordinated Assessments data exchange website.

Chinook Salmon Cohort Abundance and Productivity

Abundance at RSTs

Age-specific abundances of Chinook Salmon emigrants passing the trap were estimated by season/life stage. Body size and date were used to distinguish cohorts (age-0 from age-1 fish) as two ages could be captured simultaneously, especially in the spring. There are four distinct life stages designated for juvenile Chinook Salmon at RSTs: fry, parr, presmolts, and smolts and are based on age and standard calendar periods that are described in the Protocols For Trapping

Anadromous Emigrants in Idaho (Copeland et al. 2021). The spring period is defined as trap deployment through June 30, a period of time dominated by catch of age-1 fish (i.e., smolts) that will be emigrating past LGR that same spring. Age-0 fry are also captured in the spring, depending on the trap site, but are often too small to mark for evaluation. The summer parr period is July 1 through August 31, a period of time when age-0 fish grow large enough to be marked with PIT tags. The fall presmolt period is September 1 through the end of the trapping year, a period of time when age-0 fish appear to actively emigrate out of upper tributary rearing reaches (Chapman 1966; Venditti et al. 2015b). Seasonal life stage abundances are calculated by stratifying fish by seasons, summing by complete BY, and processing the strata in R statistical software (R Development Core Team 2021). Abundance estimates of age-0 fish captured in 2020 and age-1 smolts captured in the spring of 2021 were used to complete the total estimate for brood year (BY) 2019.

We calculated emigrant abundance estimates from trap operations with the stratified Lincoln-Petersen estimator with Bailey's modification:

$$N = \sum_{i=1}^{k} c_i (m_i + 1)/(r_i + 1),$$

where N is abundance of juveniles emigrating in a given season or year, i is season (defined below for each species), c_i is the number of all unique fish captured in season i, m_i is the number of tagged fish released in season i, and r_i is number of recaptures in season i. (Bailey 1951). The estimator is computed using an iterative maximization of the log likelihood (Steinhorst et al. 2004), using R statistical software (R Development Core Team 2021) and is located at the following webpage location: http://ifwisshiny.idfg.state.id.us:3838/JLM/IDFGStatApps/. The method assumes that fish are captured independently with probability p (equivalent to trap efficiency) and tagged fish mix thoroughly with untagged fish. We computed 95% confidence intervals with the bootstrap option (10,000 iterations).

Survival and Abundance at LGR

We estimated survival rates of PIT-tagged Chinook Salmon emigrants from each RST to LGR by life stage, BY, and season and used the survival rates to calculate the abundance of smolts at LGR. Estimates were made separately for each life stage described in the Abundance methods because of their inherent differences in survival (Copeland et al. 2021). Survival of juvenile Chinook Salmon was estimated using PIT tag detections at juvenile bypass systems on main stem Columbia and Snake river hydrosystem dams (Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, and Bonneville) and the estuary towed PIT tag array. The Lower Granite Spillway PIT tag detection site was included in the analysis and is the first site to detect juvenile fish that pass a main stem dam using a spillway. We assumed that tagged fish represented untagged fish in each group. The data used to calculate survival were queried from the PTAGIS database in Advanced Reporting (https://www.ptagis.org/). Tagging detail data (i.e., the tagged fish from the screw traps) and Interrogation data (i.e., the PIT tag detections at the dams on the Snake and Columbia rivers) were used. The software program PitPro (Westhagen and Skalski 2009) was used to translate raw PTAGIS PIT-tag data into usable capture histories. This program implements a Cormack-Jolly-Seber model to output the basic point estimates of survival (RST to LGR) and detection probabilities at the dams. Cohort abundance of smolts at LGR was calculated by multiplying the seasonal abundance estimates by the survival proportion estimates before summation.

Productivity

Productivity was estimated at the watershed scale where RSTs operated (i.e., juveniles), and at the larger Snake River basin scale at LGR (i.e., smolts). It is important to examine whether productivity is more limited in the tributary watershed versus the migration to LGR to better understand limiting factors and where they occur. In addition to the results of stock-recruit analysis, this report presents the relationship between Chinook Salmon juvenile productivity and adult spawner abundance at ten locations for brood year 2018 (Bowersox and Biggs 2012; Venditti et al. 2015b; Apperson et al. 2016; Uthe et al. 2017). This metric was estimated using either redd counts or the escapement estimate above a weir and the number of smolts that survived to Lower Granite Dam.

Adult-to-smolt productivity was also modeled with stock-recruitment analysis at five RST locations with sufficient completed BYs (i.e., BIG2C, MARTR2, LEMTRP, PAHTRP, SAWTRP) and updated through brood year 2019. Additionally, this analysis was conducted for selected traps that are no longer in operation (i.e., KNOXB, MARTRP, REDTRP, AMERR, CFCTRP, COLTKC) and updated through various brood years depending on trap operations. Estimates of the number of redds (estimated from single or multiple pass surveys) or number of females (estimated from weir passage) above screw traps were taken as a measure of "stock" and estimated number of smolts at LGR were taken as a measure of "recruits." The stock-recruit relationship was modeled using a $\log_e$ transformed Beverton-Holt (Beverton and Holt 1957) model:

$$log_{\mathrm{e}}[R] = log_e\,(\frac{(\lg(\alpha * S))}{(1 + \beta * S)}),$$

where recruits (*R*) is a function of stock (*S*), α is the maximum recruitment rate at low spawner abundance, β is the level of density dependence, and alpha/beta provides an estimate of the asymptote. A Bayesian hierarchical approach was used to estimate global and trap-level parameter estimates. This framework assumes parameters for groups (e.g., populations) are distributed around global or shared parameters (Gelman and Hill 2007). Analysis was conducted using the R2jags package (Su and Yajima 2015) in R statistical software (R Development Core Team 2020), which executes code in Program JAGS (Plummer 2003) from the R statistical software interface.

<u>Steelhead Emigrant Abundance and Productivity</u>

Abundance at RSTs

Age-specific abundances of steelhead emigrants passing RST were estimated by season. Estimated ages based on scale data were used to distinguish the multiple cohorts captured simultaneously. Season designations followed standard calendar periods and are based on the major periods of fish movement, which is consistent with past reports (e.g., Copeland et al. 2015; Apperson et al. 2017; Belnap et al. 2018). Peak migration varies among populations but generally, juveniles either emigrate out of natal systems primarily in the spring or in the fall. The spring period is when traps were installed in late winter or early spring through May 31. The summer period is from June 1 to August 14, and the fall period was from August 15 until trap removal, usually between late October and early December depending on site conditions. Emigration past the screw traps generally increases in the fall period compared to the summer period. The summer and fall periods were ultimately combined for analyses because summer often lacked sufficient recaptures or catch to report a reliable estimate. Mark recapture analyses for steelhead at RSTs are similar to protocols for Chinook (see above) but use these different seasonal strata.

Productivity

The adult-to-juvenile productivity of steelhead at RST was estimated by dividing the sum of estimated juvenile abundances by brood year cohort across seasons and years by the number of adult female spawners that produced them. The number of adult female spawners was obtained from either PIT tag array or weir counts or estimates at sites with both a RST and an array or weir. These adult abundances and the methods used to estimate them are reported annually in our adult steelhead report (Smith et al. 2021). In general, spring emigrant age composition is older than summer and fall emigrant age composition and summer and fall are typically similar. Therefore, age composition for spring samples was calculated separately from combined summer and fall age compositions. Scale sample age proportions were directly applied to the seasonal emigrant abundance estimates. Brood tables were constructed by summing emigrant abundances by cohort, then dividing by the number of female spawners upstream of the RST to calculate brood year productivity. This report provides complete productivity estimates through BY 2016.

RESULTS

Rotary Screw Trap Operations

The RSTs were operated in ten locations in the Salmon River basin and five sites in the Clearwater River basin (Appendix A). Of these traps, 10 have operated annually at the same sites for a minimum of 14 years. Rotary screw traps have operated in Fish Creek for 27 years since 1994, the Lemhi, Upper Salmon, and Pahsimeroi rivers for 29 years since 1992, and Crooked River for 31 years since 1990. Calendar year 2021 represents the seventh complete year of operation for three RSTs included in this report (Lower South Fork Salmon, North Fork Salmon, and Lower Lochsa rivers). In 2021, the North Fork Salmon River trap was moved to a new location approximately 1.11 km upstream from its original location that operated from 2015-2021. The North Fork Salmon River trap is now operated on IDFG property and the move will likely be permanent. All RSTs included here were operated by IDFG.

Most traps were operated during three seasons (spring, summer, and fall). However, streamflow was insufficient to operate the two traps in the Potlatch River basin (Big Bear Creek and East Fork Potlatch River) during summer and fall. Summer flows typically limit RST operations in the Potlatch River; thus, we assumed emigration was negligible during summer. The East Fork Potlatch River, Big Bear Creek, and Fish Creek RSTs did not sample Chinook Salmon in 2021. A couple of traps were inoperable for a few days due to wildfire danger but in general traps were operated for the majority of the trapping season, and therefore, we can report reliable emigrant information for all seasons except winter (Appendix B).

Annual Chinook Salmon Emigrant Abundance at RSTs

Rotary screw trap catches of Chinook Salmon varied greatly among traps, but tended to be higher in the Salmon River basin (Table 2). Chinook Salmon emigrant abundance varied across 9 RSTs in the Salmon basin from 14,701 fish at the upper Salmon River site to 156,466 fish at the Marsh Creek site. No estimate was made in Rapid River due to low numbers of fish captured. In the Clearwater River basin, no estimates for Chinook Salmon were made due to low numbers of fish captured at Big Bear Creek, East Fork Potlatch, and Fish Creek. Chinook Salmon emigrant abundance ranged from 320 fish at Crooked River and 10,725 at the Lower Lochsa

River trap. Almost all of the emigrants captured at the Lochsa trap were spring emigrants migrating directly toward the ocean.

Cohort Chinook Salmon Emigrant Abundance at RSTs

Rotary screw trap catches of BY2019 Chinook Salmon were variable across the RSTs. Chinook Salmon abundance varied across nine RSTs in the Salmon River basin from 8,362 fish at the North Fork salmon River to 146,374 fish at the South Fork Salmon River (Table 3). Abundances of juvenile Chinook Salmon were not estimated at any of the RSTs in the Clearwater River basin due to low numbers of tagged fish and a lack of recaptured fish. The complete time series of abundance and productivity estimates are presented in Appendix D.

Chinook Salmon Survival and Productivity

In general, survival of emigrants from RSTs to LGR by BY was influenced by season at a given RST and increases for each successive seasonal group (from summer age-0 fish to spring age-1; Table 3). However, in the South Fork Salmon River the summer emigrants had higher survival than the fall emigrants. Note that in the Pahsimeroi River, survival of spring age-0 fry was generally not assessed since those fish were too small for PIT tag implantation.

Productivity of Chinook Salmon BY2019 juveniles at RST sites varied from 222 juveniles per female spawner in the Pahsimeroi River to 3,544 juveniles per female spawner in Big Creek in the Salmon River basin. The RST at Crooked River caught no juveniles in the trap so productivity could not be estimated (Table 4).

Productivity of Chinook Salmon BY2019 smolts at LGR varied from 98 smolts per female spawner in the upper Salmon River to 1,832 smolts per female spawner from Big Creek in the Salmon River basin. The RST at Crooked River caught no juveniles in the trap so productivity could not be estimated (Table 4).

Beverton-Holt models have been generated in past reports showing the relationship between smolts at LGR and adult female spawner abundance in places where screw traps currently operate. The Beverton-Holt models suggest that density-dependent mechanisms are influencing production of smolts that survive to LGR more in the Upper Salmon River and Clearwater River MPG, than in the Middle Fork Salmon MPG (Figure 3; Table 7).

Steelhead Emigrant Abundance and Productivity

Juvenile steelhead emigrant abundances were estimated at all RST sites that operated across 10 steelhead populations in the Salmon River basin and five in the Clearwater River basin (Table 5). Estimated abundance of steelhead emigrants varied from 1,929 fish in Rapid River to 23,013 fish in the upper Lemhi River for Salmon River basin populations. In the Clearwater River basin, abundances varied from 42 fish in Crooked River to 107,744 fish in the Lochsa River. The catch of steelhead <80 mm FL, which were generally not marked to estimate trap efficiencies, varied from a low of 2 fish in the East Fork Potlatch River to a high of 2,292 fish in South Fork Salmon River (Appendix C).

Scale samples were collected from juvenile steelhead at all 15 RSTs, with ages assigned to 4,602 fish (Table 6). Juvenile steelhead ages varied from 0 to 5 years, and in general an older age distribution was observed in the spring than the summer/fall period at most RSTs.

Emigrant abundance, juvenile age proportions, and female spawner abundance data were used to produce adult-to-juvenile productivity estimates for BY cohorts at seven trap locations in the Salmon River MPG and four trap locations in the Clearwater River MPG (Appendix E). Productivity for BY2016 steelhead in the Salmon River basin ranged from 56 emigrants per female spawner in Lower Lemhi River to 388 emigrants per female spawner in the Upper Lemhi River. Productivity in the Clearwater River basin varied from 161 emigrants per female spawner in East Fork Potlatch River to 372 emigrants per female spawner in Crooked River. Compared to the mean of previous years, steelhead productivity in the Salmon River basin was low in the Upper Salmon, Pahsimeroi, and Lower Lemhi rivers, and high in Rapid and Lower Lemhi rivers. Steelhead productivity in the Clearwater River basin was low in the East Fork Potlach River, Crooked River, Fish Creek, and high in Big Bear Creek.

Plots of complete cohort estimates through BY2016 were presented in Figures 4 and 5. Even though age-5 emigrants are only complete through BY2016, BY2017 data are included in the plots because so few age-5 emigrants are aged and there is a high likelihood some of these could be resident Rainbow Trout (Appendix E). This adds another data point to each stream's time series and will be adjusted next year if there are any age five emigrants for BY2017. Trend lines indicate that populations in both MPGs generally experience density dependence, with juvenile productivity declining with increasing spawner escapement, with the exception of Crooked River which had an inverse relationship. The weir that operates at Crooked River is ineffective at capturing adult steelhead during spring conditions. However, juvenile fish are still caught in the screw trap occasionally. No females were estimated to return in BY2017 so there was no productivity measure for this year in Crooked River.

Pacific Lamprey Catch

Pacific Lamprey were captured at the South Fork Salmon River and the Lochsa River RSTs (Table 8). A total of 481 Pacific Lamprey were captured at the South Fork Salmon River trap, consisting of 363 ammocoetes and 118 macrophthalmia. The total length of lamprey in the South Fork Salmon River varied from 106 mm to 173 mm. A total of 12 Pacific Lamprey were captured at the Lower Lochsa River trap, all of which were ammocoetes, with total lengths that varied from 67 mm to 130 mm.

DISCUSSION

Adult-to-juvenile productivity estimates provide insight to the quality and quantity of habitat available in Idaho. Adult-to-juvenile productivity estimates for Chinook Salmon at both the watershed scale (i.e., juveniles at RSTs) and at a larger scale (i.e., smolts at LGR) varied widely in 2021. However, productivity estimates were higher in the South Fork and Middle Fork Salmon river major population groups where anthropogenic disturbances are typically less than that of other population groups. The number of emigrants passing each trap was influenced by the habitat quantity and quality upstream from RSTs, intrinsic productivity unique to each stream. Distinct differences in productivity among populations are evident, as expected with large spatial and temporal variability (Table 4). To better understand the differences in productivity among populations, causal factors affecting success of rearing and overwintering of juvenile fish should be further assessed in natal reaches upstream of RSTs. Likewise evaluating downstream rearing habitat and migration corridor habitat between RST sites and LGR will help identify whether limiting factors expand outside of natal stream habitat. The Intensively Monitored Watershed (IMW) studies research, monitor, and evaluate potential limiting factors specific to juveniles rearing in natal tributary habitat and response to habitat restoration actions in the Potlatch and

Lemhi river basins. Information gathered will help guide habitat restoration actions to increase Chinook Salmon and steelhead abundance, survival, and productivity in natal tributary habitat. Not only is this information valuable in these IMW watersheds, but this information is useful for other systems that have received habitat restoration efforts but may not be monitored to the same extent.

The stock-recruit analysis of smolt-to-adult productivity of Chinook Salmon indicated a density-dependent relationship between spawning female abundance and smolts that were estimated to survive to LGR (Figure 3). Density-dependent smolt production has been shown for Snake River spring/summer Chinook Salmon (Walters et al. 2013; Camacho et al. 2019), but the extent to which density dependence regulates smolt production across all populations is variable. Adult-to-juvenile productivity estimates for Chinook Salmon in the Salmon River MPGs and Clearwater River MPGs appear to be more limited by density dependence but the Middle Fork Salmon MPG appears to be less limited. Both Marsh Creek traps (i.e., upper and lower) and the Big Creek trap showed little evidence of reaching asymptotic smolt production over the observed range of female abundance. The specific mechanisms that cause density dependent mortality in juvenile Snake River spring/summer Chinook Salmon are unclear, although we suspect competition among juveniles due to habitat loss from anthropogenic disturbances and/or hatchery influence to be likely contributors.

Life history variation present in natural populations can make comparison of productivity metrics difficult. For example, the Pahsimeroi and Lemhi populations tend to have age-0 Chinook Salmon reaching sufficient size to undergo smoltification and migrate downstream (Lutch et al. 2003; Copeland and Venditti 2009). In 2021, spring age-0 migrants made up approximately 28% of the Chinook that passed the Pahsimeroi River RST. Another example is the differences between steelhead productivities at the upper and lower Lemhi River RSTs. The differences in productivity are likely a function of overwintering between the Lemhi River RSTs. To put the productivity estimates at both traps on the same scale we have to account for differences in survival to LGR.

Steelhead exhibit two characteristics that complicate survival estimation. First, juvenile Idaho steelhead may spend more than one winter rearing downstream of the RST before becoming a smolt. Second, steelhead smolts can vary in age from age-1 up to age-7 (Peven et al. 1994) with overlapping length ranges by age making a CJS model not feasible for estimating survival. A model framework has been created using Basin TribPIT program (see Chapter 2 of Feeken et al. 2020) that allows flexibility for delayed migration and multiple tributary releases (i.e., years tagged at an RST) for a given brood year. The model structure needs to be customized based on the unique characteristics of each steelhead population. Because of time constraints in 2021, evaluating steelhead survival will be implemented in 2022 and in all following reports.

Juvenile emigration estimates in this report are considered conservative (biased low) because no interpolation is attempted for time periods that traps are not operated. However, bias in emigration estimates is likely minimal since there is little indication of significant winter movements (Bjornn 1978; Favrot and Jonasson 2020). Also, the majority of fish emigrate during the fall when RSTs are in operation and trapping efficiencies are high because of low water levels. To ensure the most precise estimates, a multiyear hierarchical Bayesian model has been developed to interpolate abundance during periods of sparse and missing trap data (Oldemeyer 2015). The model will need to be applied on a case-by-case basis, and will need to be customized to each trap. Traps with longer data series (e.g., Pahsimeroi River, upper Lemhi River, Marsh Creek, and Upper Salmon River traps) can use historical data to populate the model. Newer traps (e.g. the North Fork Salmon River, Hayden Creek, Lochsa River traps) will need additional data

to fully realize the benefits of the model. The model is currently not used to supplement emigrant estimates because we need to identify methods of evaluating sub-taggable fry and parr. Venditti et al. (2007) compared capture efficiencies of stained Chinook Salmon <60 mm and ≥60 mm to PIT-tagged fish ≥60 mm in three streams. Differences depended on season and stream. The authors concluded the disparity between recapture rates for the two groups indicated that the PIT-tagged groups were not representative of the entire emigrant population moving past the traps. However, they also observed that when most of the sub-taggable sized fish were between 50 and 60 mm FL, the PIT-tagged group was representative of the entire population moving past the trap. If these groups are not handled appropriately the model overestimates the abundance of subtaggable groups to the point where emigrants/female are unrealistic. A possible solution to this issue would be to eliminate spring age-0s from analysis altogether since the majority of these fish have very poor survival compared to other life stages. As the model is refined, it may be incorporated into future reports.

Consideration of mark-recapture assumptions should be a regular part of trap operation and data analysis (Copeland et al. 2021; Roper and Scarnecchia 2000). Some assumptions may need annual checking but all should be re-visited at regular intervals. Prior to 2021 (see Chapter 2), no assumptions had been tested for steelhead at IDFG's RSTs and it has been many years since assumptions have been checked for Chinook Salmon. Distance of releases upstream of the RST location should be evaluated, especially for newer traps. The number of days for efficiency recaptures at each trap should also be evaluated. For example, Pahsimeroi recapture efficiencies were changed from 5 to 10 days because of distance and habitat between release site and RST. If assumptions are being violated then operations and analysis should be adjusted to produce valid estimates.

RECOMMENDATIONS

The following recommendations would improve our understanding of population status and trends in the juvenile freshwater life stage of Chinook Salmon and steelhead, and would improve reporting efficiency and effectiveness.

- Implement the TribPIT model to estimate juvenile emigrant steelhead survival rates to LGR. Develop this model for all sites included in this report.

- Validate the Oldemeyer (2015) model by populating it with historical data and compare those estimates with estimates obtained from Program R. Refine the model and implement where warranted.

- Continue to add annual information to the historical adult-to-juvenile productivity data series for both Chinook Salmon and steelhead populations presented in this report. Refine historical information as existing datasets are verified and estimation methods are improved.

- Incorporate testing of mark-recapture assumptions as a regular part of trap operations and data analyses.

- Periodically revisit tagging methodology strategy for each trap and across the fleet of RSTs.

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TABLES

Table 1. Major population groups and independent populations within the Snake River steelhead distinct population segment (DPS) and spring-summer Chinook Salmon evolutionary significant unit (ESU; ICTRT 2003, 2005; 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. Lookinglass 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)
	34. Lapwai Creek (extirpated)
	35. Lawyer Creek (extirpated)
	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]

Table 1. Continued.

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

[a] Reintroduced fish exist in extirpated areas.

Table 2. Trap catch and emigrant abundance estimates for juvenile Chinook Salmon by season and age from rotary screw traps (RST) operated in the Salmon River and Clearwater River basins, Idaho during calendar year 2021. Instances where no estimate was made are noted NA.

Major Population Group, RST location and PTAGIS code	Season and age	Trap catch	Point estimate	Lower 95% CI	Upper 95% CI
South Fork Salmon River					
Rapid River	Spring age-1	0	NA	NA	NA
RPDTRP	Spring age-0	2	NA	NA	NA
	Summer age-0	78	NA	NA	NA
	Fall age-0	78	NA	NA	NA
	Total	**158**	**NA**	**NA**	**NA**
Lower South Fork Salmon River	Spring age-1	1,708	26,128	19,858	40,604
SFSRKT	Spring age-0	1,325	9,419	6,829	14,377
	Summer age-0	968	9,119	6,973	12,701
	Fall age-0	5,379	36,289	33,173	40,156
	Total	**9,380**	**80,955**	**66,833**	**107,838**
Middle Fork Salmon River					
Big Creek	Spring age-1	1,011	18,029	14,317	24,339
BIG2CT	Spring age-0	46	NA	NA	NA
	Summer age-0	220	3,284	2,214	6,391
	Fall age-0	1,988	36,126	30,365	46,492
	Total	**3,265**	**57,439**	**46,896**	**77,222**
Lower Marsh Creek	Spring age-1	133	2,274	1,410	5,900
MARTR2	Spring age-0	3,243	24,634	18,332	35,832
	Summer age-0	3,880	70,382	50,753	146,065
	Fall age-0	9,246	59,176	55,966	63,057
	Total	**16,502**	**156,466**	**126,462**	**250,853**
Upper Salmon River					
North Fork Salmon River	Spring age-1	228	2,238	1,736	3,958
NFSTRP	Spring age-0	2	NA	NA	NA
	Summer age-0	158	1,657	1,053	5,547
	Fall age-0	1,900	22,216	17,521	31,155
	Total	**2,288**	**26,111**	**20,310**	**40,660**
Upper Lemhi River	Spring age-1	342	4,299	3,115	8,170
LEMTRP	Spring age-0	173	1,317	768	3,074
	Summer age-0	35	237	132	594
	Fall age-0	2,682	11,204	10,499	12,404
	Total	**3,232**	**17,057**	**14,514**	**24,242**
Hayden Creek	Spring age-1	455	2,123	1,778	3,038
HAYTRP	Spring age-0	2,123	29,805	21,149	55,720
	Summer age-0	166	937	694	1,740
	Fall age-0	182	606	490	806
	Total	**2,926**	**33,471**	**24,111**	**61,304**
Lower Lemhi River	Spring age-1	4,665	13,804	13,081	14,816
LLRTP	Spring age-0	37	418	209	836
	Summer age-0	42	75	54	120
	Fall age-0	1,630	17,024	14,268	22,371
	Total	**6,374**	**31,321**	**27,612**	**38,143**

Table 2. Continued.

Major Population Group, RST location and PTAGIS code	Season and age	Trap catch	Point estimate	Lower 95% CI	Upper 95% CI
Upper Salmon River	Spring age-1	341	1,969	1,568	2,793
SAWTRP	Spring age-0	328	4,195	2,097	16,779
	Summer age-0	315	4,740	3,269	7,900
	Fall age-0	612	3,797	3,208	4,651
	Total	**1,596**	**14,701**	**10,142**	**32,123**
Pahsimeroi River	Spring age-1	255	3,384	2,356	6,521
PAHTRP	Spring age-0	1,004	5,213	4,505	6,226
	Summer age-0	325	3,759	2,820	6,048
	Fall age-0	2,057	15,700	13,919	20,636
	Total	**3,641**	**28,056**	**23,600**	**39,430**
Dry Clearwater River					
Crooked River	Spring age-1	2	NA	NA	NA
CROTRP	Spring age-0	4	NA	NA	NA
	Summer age-0	13	NA	NA	NA
	Fall age-0	91	320	243	471
	Total	**110**	**320**	**243**	**471**
Big Bear Creek	Spring age-1	0	NA	NA	NA
BBCTRP	Spring age-0	0	NA	NA	NA
	Summer age-0	0	NA	NA	NA
	Fall age-0	0	NA	NA	NA
	Total	**0**	**NA**	**NA**	**NA**
East Fork Potlatch	Spring age-1	0	NA	NA	NA
EFPTRP	Spring age-0	0	NA	NA	NA
	Summer age-0	0	NA	NA	NA
	Fall age-0	0	NA	NA	NA
	Total	**0**	**NA**	**NA**	**NA**
Wet Clearwater River					
Fish Creek	Spring age-1	0	NA	NA	NA
FISTRP	Spring age-0	0	NA	NA	NA
	Summer age-0	0	NA	NA	NA
	Fall age-0	0	NA	NA	NA
	Total	**0**	**NA**	**NA**	**NA**
Lower Lochsa River	Spring age-1	275	10,725	6,256	25,024
LOCTRP	Spring age-0	3	NA	NA	NA
	Summer age-0	0	NA	NA	NA
	Fall age-0	0	NA	NA	NA
	Total	**278**	**10,725**	**6,256**	**25,024**

Table 3. Estimated abundance of emigrants at each rotary screw trap (RST), survival to Lower Granite Dam (LGR), and estimated smolt abundance at LGR for brood year 2019 wild juvenile Chinook Salmon from the Salmon River and Clearwater River basins, Idaho. Instances where no estimate was made are noted NA.

Major Population Group, RST location and PTAGIS code	Season and age	Emigrant abundance at RST	Number PIT tagged at RST	Survival rate to LGR (SE)	Smolt abundance to LGR
South Fork Salmon River					
Lower South Fork	Spring age-0	NA	0	NA	NA
Salmon River	Summer age-0	18,376	599	0.470 (0.099)	8,633
SFSRKT	Fall age-0	101,870	4,587	0.352 (0.022)	35,828
	Spring age-1	26,128	1,767	0.483 (0.047)	12,612
	BY Total	**146,374**	**6,953**	**0.390**	**57,073**
Middle Fork Salmon River					
Big Creek	Spring age-0	NA	0	NA	NA
BIGC2T	Summer age-0	2,241	175	0.320 (0.082)	717
	Fall age-0	47,057	5,021	0.461 (0.027)	21,703
	Spring age-1	18,029	998	0.688 (0.086)	12,397
	BY Total	**67,327**	**6,194**	**0.490**	**34,817**
Lower Marsh Creek	Spring age-0	1,556	12	NA	NA
MARTR2	Summer age-0	17,199	583	0.284 (0.044)	4,890
	Fall age-0	25,308	1,571	0.399 (0.046)	10,105
	Spring age-1	2,274	131	0.504 (0.265)	1,145
	BY Total	**46,337**	**2,297**	**0.360**	**16,141**
Upper Salmon River					
North Fork Salmon River	Spring age-0	NA	NA	NA	NA
NFSTRP	Summer age-0	NA	NA	NA	NA
	Fall age-0	6,124	1,496	0.303 (0.035)	1,856
	Spring age-1	2,238	226	0.523[(a)]	1,170
	BY Total	**8,362**	**1,722**	**0.413**	**3,026**
Lemhi River weir	Spring age-0	558	0	NA	NA
LEMTRP	Summer age-0	47	28	0.143 (0.066)	7
	Fall age-0	15,228	1,487	0.409 (0.038)	6,228
	Spring age-1	4,299	374	0.422 (0.058)	1,814
	BY Total	**20,132**	**1,889**	**0.411**	**8,049**
Hayden Creek	Spring age-0	47	2	NA	NA
HAYTRP	Summer age-0	288	34	NA	NA
	Fall age-0	7,344	1,272	0.300 (0.036)	2,203
	Spring age-1	2,123	398	0.873 (0.201)	1,853
	BY Total	**9,802**	**1,706**	**0.416**	**4,057**
Lower Lemhi River	Spring age-0	136	0	NA	NA
LLRTP	Summer age-0	35	13	NA	NA
	Fall age-0	24,366	3,395	0.432 (0.022)	10,526
	Spring age-1	13,804	3,115	0.729 (0.045)	10,063
	BY Total	**38,341**	**6,523**	**0.539**	**20,589**
Upper Salmon River	Spring age-0	NA	15	NA	NA
SAWTRP	Summer age-0	4,648	174	0.092 (0.065)	428
	Fall age-0	2,860	131	0.212[(a)]	606
	Spring age-1	1,969	339	0.673 (0.406)	1,324
	BY Total	**12,757**	**659**	**0.185**	**2,358**

Table 3. Continued.

Major Population Group, RST location and PTAGIS code	Season and age	Emigrant abundance at RST	Number PIT tagged at RST	Survival rate to LGR (SE)	Smolt abundance to LGR
Pahsimeroi River	Spring age-0	4,592	165	0.660 (0.089)	3,031
PAHTRP	Summer age-0	NA	24	NA	NA
	Fall age-0	3,367	100	0.344 (0.135)	1,158
	Spring age-1	3,384	255	0.488 (0.101)	1,651
	BY Total	**11,343**	**646**	**0.515**	**5,840**
Dry Clearwater River					
Crooked River	Spring age-0	NA	NA	NA	NA
CROTRP	Summer age-0	NA	1	NA	NA
	Fall age-0	NA	6	NA	NA
	Spring age-1	NA	2	NA	NA
	BY Total	**NA**	**9**	**NA**	**NA**

[a] Not enough detections below Lower Granite Dam to get a survival. Used an average survival for the life stage.

Table 4. Estimated adult-to-juvenile productivity of wild juvenile Chinook Salmon for brood year 2019, expressed as both emigrants at rotary screw trap (RST) per female spawner and smolts at Lower Granite Dam (LGR) per female spawner. Instances where no estimates were made are noted NE.

Major Population Group and trap location, and PTAGIS site code	Female adults	Emigrants at trap	Emigrants /female	Smolts to LGR	Smolts at LGR / female
		Salmon River Basin			
South Fork Salmon River					
Rapid River					
RPDTRP	NE	NE	NE	NE	NE
Lower South Fork Salmon River					
SFSRKT	189[a][c]	146,374	774	57,073	302
Middle Fork Salmon River					
Big Creek					
BIG2CT	19[a]	67,327	3,544	34,817	1,832
Lower Marsh Creek					
MARTR2	42[b]	46,337	1,103	16,141	384
Upper Salmon River					
North Fork Salmon River					
NFSTRP	14[a]	8,362	597	3,026	216
Lemhi River (upper)					
LEMTRP	51[b]	20,132	395	8,049	158
Hayden Creek					
HYDTRP	28[a]	9,802	350	4,057	145
Lower Lemhi River					
LLRTP	80[a][b]	38,341	479	20,589	257
Upper Salmon River					
SAWTRP	24[c]	12,757	395	2,358	98
Pahsimeroi River					
PAHTRP	51[c]	11,343	222	5,840	115
		Clearwater River Basin			
Dry Clearwater River					
Crooked River					
CROTRP	0	NE	NE	NE	NE

[a] Data source: IDFG index (single pass) redd survey.
[b] Data source: Census (multi-pass) redd surveys.
[c] Data source: Females passed upstream from weir.

Table 5. Rotary screw trap catch and emigrant abundance estimates, with 95% confidence intervals (CI) for wild juvenile steelhead >80 mm FL, by season during 2021. Instances where no estimate was made are noted NE.

Population, trap location and PTAGIS site code	Season	Catch	Emigration estimate	Lower 95% CI	Upper 95% CI
	Salmon River Basin				
Little Salmon River					
Rapid River	Spring	152	871	647	1,332
RPDTRP	Sum/Fall	107	1,058	662	2,117
	Total	**259**	**1,929**	**1,443**	**3,101**
South Fork Salmon River					
Lower South Fork Salmon River	Spring	137	2,385	1,392	5,566
SFSRKT	Sum/Fall	911	9,513	7,663	12,540
	Total	**1,048**	**11,899**	**9,666**	**16,715**
Lower Middle Fork Salmon River					
Big Creek	Spring	104	3,395	1,698	10,185
BIG2CT	Sum/Fall	166	6,555	3,277	26,219
	Total	**270**	**9,950**	**6,282**	**29,614**
Upper Middle Fork Salmon River					
Lower Marsh Creek	Spring	32	198	99	792
MARTR2	Sum/Fall	207	3,605	1,967	10,816
	Total	**239**	**3,803**	**2,231**	**11,014**
North Fork Salmon River					
North Fork Salmon River	Spring	NA	NA	NA	NA
NFSTRP	Sum/Fall	753	11,567	9,061	15,532
	Total	**753**	**11,567**	**9,061**	**15,532**
Lemhi River					
Upper Lemhi River	Spring	167	926	711	1,396
LEMTRP	Sum/Fall	1,627	22,087	18,890	31,528
	Total	**1,794**	**23,013**	**19,601**	**32,924**
Hayden Creek	Spring	455	3,152	2,555	4,172
HYDTRP	Sum/Fall	163	1,454	1,064	2,737
	Total	**618**	**4,606**	**3,619**	**6,909**
Lower Lemhi River	Spring	970	8,603	7,198	11,288
LLRTP	Sum/Fall	202	4,593	2,701	11,178
	Total	**1,172**	**13,196**	**9,899**	**22,466**
Upper Salmon River mainstem					
Upper Salmon River	Spring	576	5,393	4,262	7,341
SAWTRP	Sum/Fall	837	11,606	8,004	19,344
	Total	**1,413**	**17,000**	**13,290**	**24,879**
Pahsimeroi River					
Pahsimeroi River	Spring	225	1,816	1,338	2,676
PAHTRP	Sum/Fall	1,451	10,520	9,310	12,092
	Total	**1,676**	**12,336**	**10,648**	**14,768**

Table 5. Continued

Population, trap location and PTAGIS site code	Season	Catch	Emigration estimate	Lower 95% CI	Upper 95% CI
	Clearwater River Basin				
South Fork Clearwater River					
Crooked River	Spring	11	42	21	84
CROTRP	Sum/Fall	154	NA	NA	NA
	Total	**165**	**42**	**21**	**84**
Lower Clearwater Mainstem					
Big Bear Creek	Spring	415	3,905	3,053	6,095
BBCTRP	Sum/Fall	NA	NA	NA	NA
	Total	**415**	**3,905**	**3,053**	**6,095**
East Fork Potlatch River	Spring	168	2,755	1,722	5,509
EFPTRP	Sum/Fall	NA	NA	NA	NA
	Total	**168**	**2,755**	**1,722**	**5,509**
Lochsa River					
Fish Creek	Spring	4	NA	NA	NA
FISTRP	Sum/Fall	1,939	5,255	4,837	5,752
	Total	**1,943**	**5,280**	**4,860**	**5,780**
Lower Lochsa River	Spring	512	105,422	52,711	210,843
LOCTRP	Sum/Fall	5	NA	NA	NA
	Total	**517**	**107,744**	**53,872**	**215,488**

Table 6. Seasonal age composition estimates of juvenile steelhead >80 mm FL in 2021 from rotary screw traps (RST) operated in the Salmon River and Clearwater River basins, Idaho.

Population, RST location and PTAGIS site code	Season	Total aged	Estimated emigrant abundance by age						Total est
			Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	
Little Salmon River									
Rapid River	Spring	140	0	12	75	597	180	6	**871**
RPDTRP	Sum/Fall	100	0	328	572	159	0	0	**1,058**
South Fork Salmon River									
Lower South Fork Salmon River	Spring	132	0	1,193	614	488	90	0	2,385
SFSRKT	Sum/Fall	164	464	6,265	2,726	0	58	0	9,513
Lower Middle Fork Salmon River									
Big Creek	Spring	85	0	280	1,558	1,438	120	0	3,395
BIG2CT	Sum/Fall	151	260	2,474	3,560	260	0	0	6,555
Upper Middle Fork Salmon River									
Lower Marsh Creek	Spring[(a)]	21	0	19	122	48	8	0	198
MARTR2	Sum/Fall	101	0	2,820	714	71	0	0	3,605
North Fork Salmon River									
North Fork Salmon River	Spring[(b)]	0	NE	NE	NE	NE	NE	NE	NE
NFSTRP	Sum/Fall	391	89	4,970	5,976	473	59	0	11,567
Lemhi River									
Upper Lemhi River	Spring	163	0	767	125	34	0	0	926
LEMTRP	Sum/Fall	290	305	20,335	1,295	152	0	0	22,087
Lower Lemhi River	Spring	379	0	1,158	5,539	1,793	113	0	8,603
LLRTRP	Sum/Fall	84	0	3,226	930	383	55	0	4,593
Hayden Creek	Spring	270	0	1,004	1,062	1,039	35	12	3,152
HYDTRP	Sum/Fall	73	0	856	378	159	60	0	1,454
Upper Salmon River mainstem									
Upper Salmon River									
SAWTRP	Spring	237	0	3,573	1,593	205	23	0	5,393
Pahsimeroi River	Sum/Fall	206	4,789	6,085	676	56	0	0	11,606
Pahsimeroi River									
PAHTRP	Spring	219	0	1,352	431	25	0	8	1,816
	Sum/Fall	172	5,321	4,954	245	0	0	0	10,520
South Fork Clearwater River									
Crooked River	Spring[(a)]	6	0	1	27	13	2	0	42
CROTRP	Sum/Fall[(b)]	79	NE	NE	NE	NE	NE	NE	NE

Table 6. Continued.

Population, RST location and PTAGIS site code	Season	Total aged	Estimated emigrant abundance by age						Total est
			Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	
Lower Clearwater River Mainstem									
East Fork Potlatch River EFPTRP	Spring	161	0	684	1,625	428	17	0	2,755
Big Bear Creek BBCTRP	Spring	173	0	1,512	2,325	45	23	0	3,905
Lochsa River									
Fish Creek FISTRP	Spring[a]	3	NE	NE	NE	NE	NE	NE	NE
	Sum/Fall	387	27	1,969	3,042	217	0	0	5,255
Lochsa River LOCTRP	Spring[b]	411	0	513	44,888	41,553	17,699	770	105,422
	Sum/Fall[a][b]	4	NE	NE	NE	NE	NE	NE	NE

a. Age was determined for fewer than 30 fish, thus age proportions are based off of average of prior years with greater than 30 fish aged.
b. No abundance estimate due to low catch or recaptures.

Table 7. Parameter estimates for wild Chinook Salmon Beverton-Holt stock recruit curves. “Recruits” are represented by smolts at Lower Granite Dam, and “stock” are wild redds above traps or female spawners above traps estimated using mark-recapture techniques. Alpha/beta is the estimated asymptote.

Major population group, trap location, and PTAGIS code	Brood years in analysis	α	β	α/β
Middle Fork Salmon River				
Big Creek BIG2CT	2006-2019	504.0	0.004	141,791
Lower Marsh Creek MARTR2	2009-2019	276.2	0.001	297,449
Upper Marsh Creek MARTRP	1992-2013	292.9	0.002	137,514
Upper Salmon River				
Upper Lemhi River LEMTRP	1991-2019	116.2	0.002	52,683
Pahsimeroi River PAHTRP	1992-2019	167.9	0.006	27,887
Upper Salmon River SAWTRTP	1992-1994, 1996-2019	186.6	0.003	55,865
Lower Lemhi Trap LLTRP	2017-2019	283.7	0.003	110,142
Clearwater River				
American River AMERR	1997-2013	134.7	0.01	9,602
Crooked Fork River CFCTRP	1992-2012	351.9	0.05	7,593
Colt Killed Creek COLTKC	1997-2012	552.9	0.59	952
Red River REDTRP	1992-2013	138.3	0.01	9652
South Fork Salmon River				
KNOXB	1991-2013	149.5	0.003	43,474

Table 8. Season and life stage of Pacific Lamprey captured in rotary screw traps (RST) operated in the Salmon River and Clearwater River basins, Idaho during calendar year 2021. Only RST that captured Pacific Lamprey are included.

Major Population Group, RST location and PTAGIS code	Season	Life stage	Trap catch	Mean length (mm)	Length range (mm)
South Fork Salmon River					
Lower South Fork Salmon River	Spring*	Ammocoete	205	146	106-173
SFSRKT		Macrophthalmia	111	148	140-154
	Summer*	Ammocoete	20	138	122-147
		Macrophthalmia	0	NA	NA
	Fall*	Ammocoete	138	136	122-151
		Macrophthalmia	7	143	136-148
	Total				
Wet Clearwater River	Spring*	Ammocoete	12	103	67-130
Lower Lochsa River		Macrophthalmia	0	NA	NA
LOCTRP	Summer*	Ammocoete	0	NA	NA
		Macrophthalmia	0	NA	NA
	Fall*	Ammocoete	0	NA	NA
		Macrophthalmia	0	NA	NA
	Total				

*Spring = start of trapping-6/30; Summer = 7/1-8/31; Fall = 9/1-end of trapping.
a. Did not take lengths on 22 of 23.

FIGURES

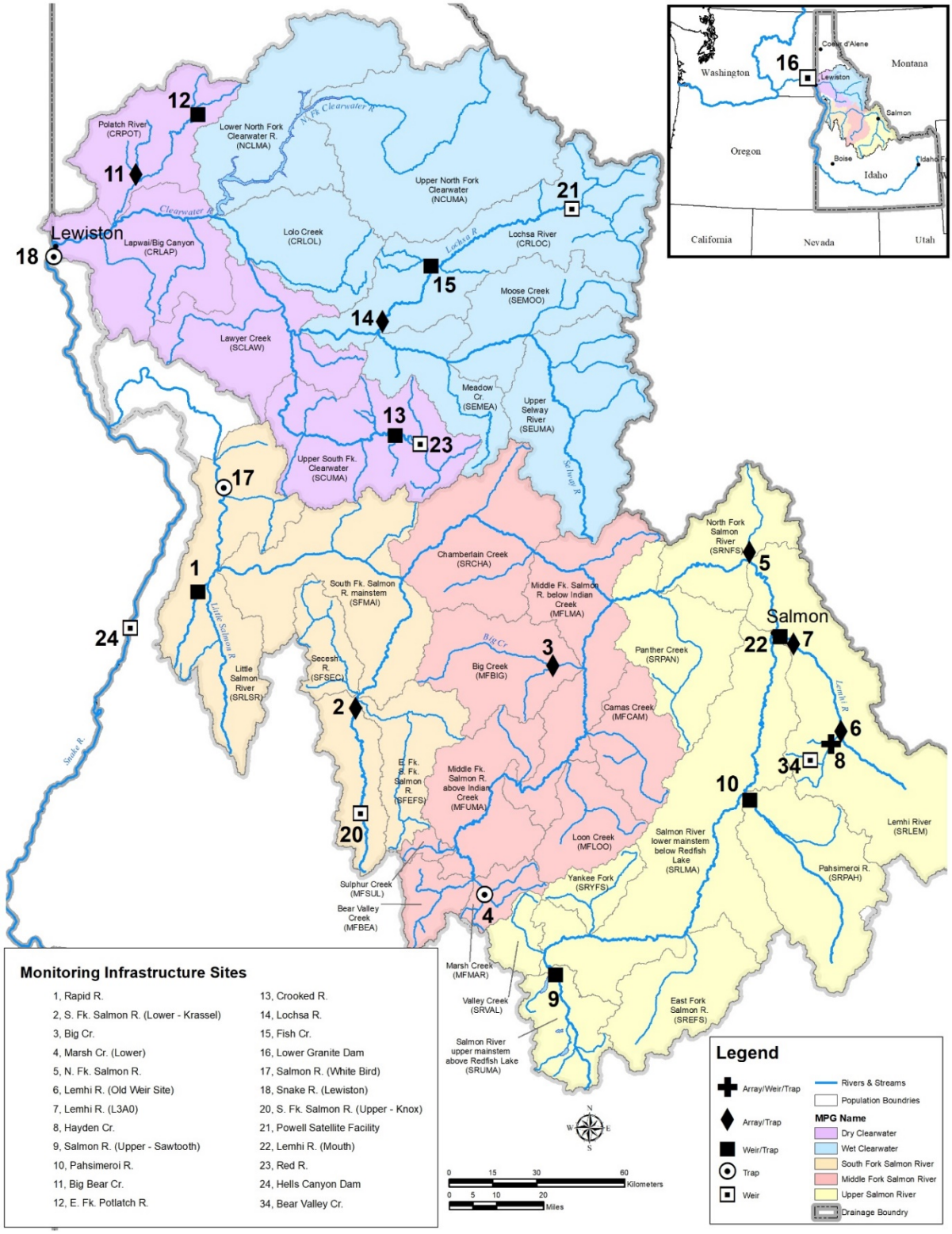

Figure 1. Location of rotary screw traps, weirs, and PIT arrays operated by IDFG in 2021 with reference to spring/summer Chinook Salmon population structure. Numbers correspond to infrastructure sites in the lower left inset. Chinook Salmon major population groups are highlighted and independent populations are delineated.

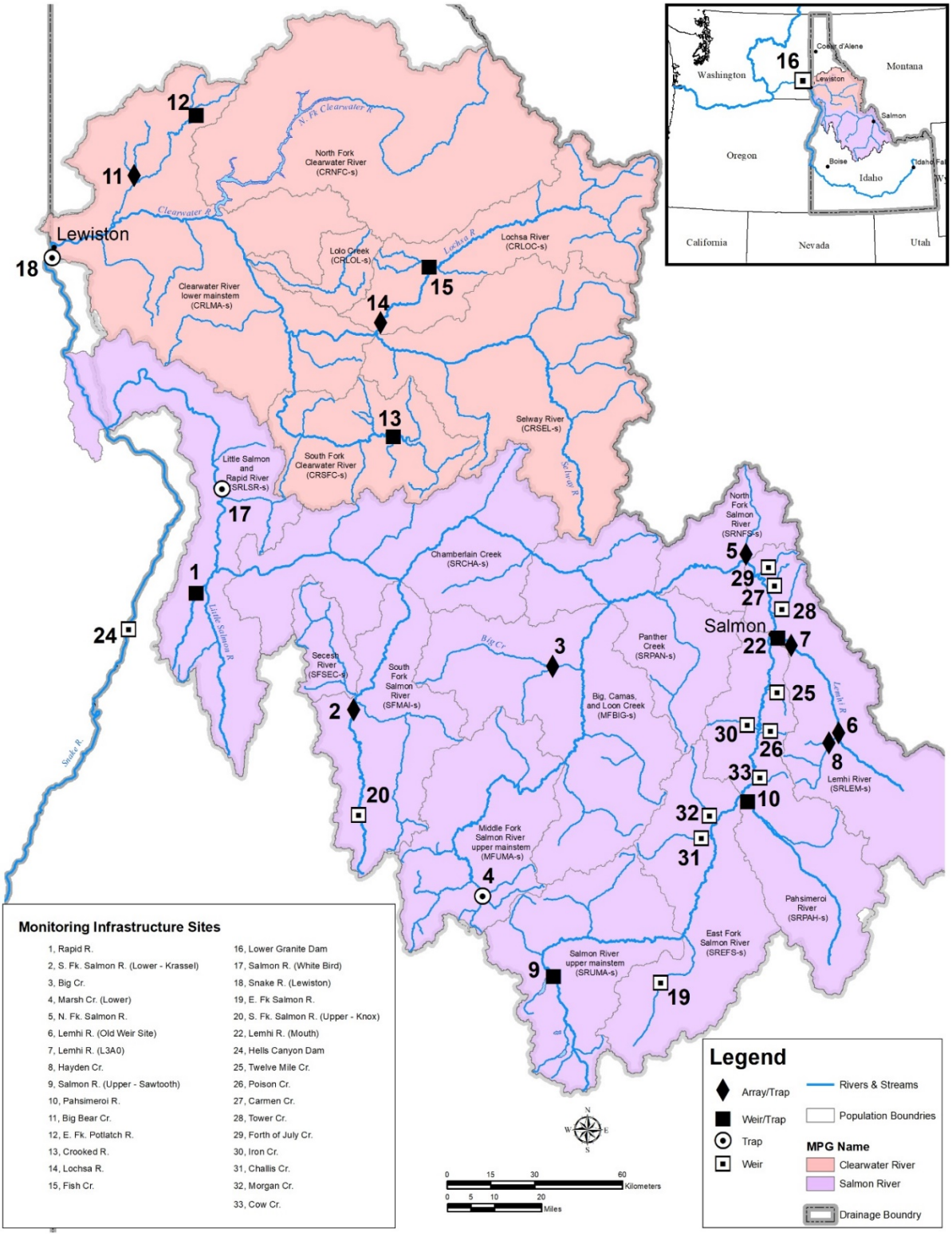

Figure 2. Location of rotary screw traps, weirs, and PIT arrays operated by IDFG in 2021 with reference to steelhead population structure. Numbers correspond to infrastructure sites in the lower left inset. Steelhead major population groups are highlighted and independent populations are delineated.

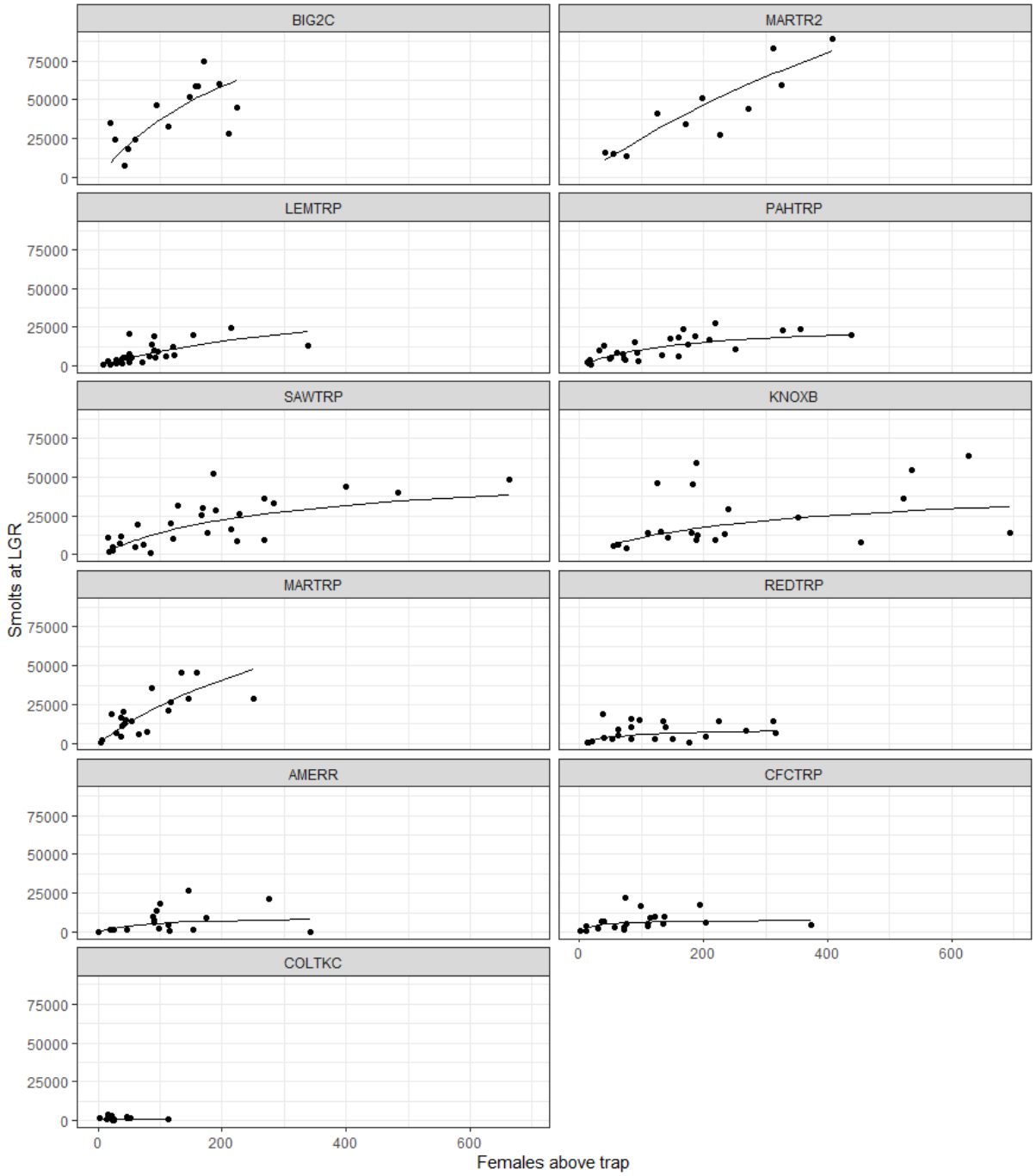

Figure 3. Relationship between wild Chinook Salmon smolts at Lower Granite Dam (LGR) and adult female spawner abundance (all redds above trap) for Chinook Salmon in Big Creek (Brood Years (BY) 2006-2019), Lower Marsh Creek (BY 2009-2019), and Upper Marsh Creek (BY 1992-2013) in the Middle Fork Salmon major population group (mpg). The Upper Lemhi River (BY 1991-2019), Pahsimeroi and Upper Salmon rivers (BY 1992-2019), and the Lower Lemhi (BY 2017-2019) in the Upper Salmon River mpg. Additionally, the American River and Colt Killed Creek (BY 1997-2013), Crooked Fork and Red Rivers (BY 1992-2013) in the Clearwater River mpg, and the South Fork Salmon (KNOXB; BY 1991-2013) in the South Fork Salmon River mpg.

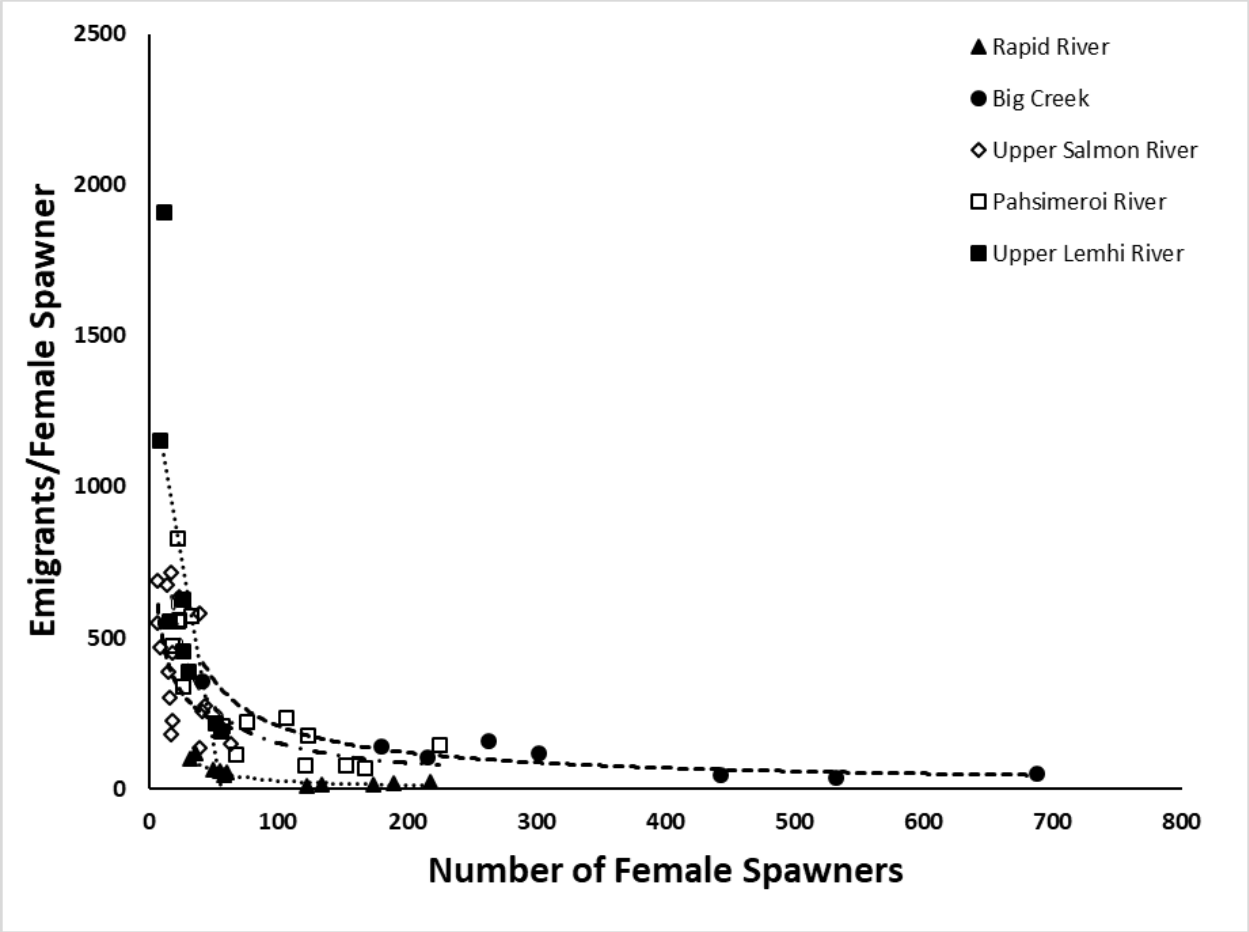

Figure 4. Relationship between wild steelhead emigrant productivity (recruits per spawner expressed as emigrants above the trap/ female spawner above the trap or array) and adult female spawner abundance above the trap or array from Rapid River (brood years 2006-2017), Big Creek (brood years 2010-2017), Upper Salmon River (brood years 2001-2017), Pahsimeroi River (brood years 2001-2017), and Lemhi River (brood years 2010-2017). Trend lines fit with a power function are shown for each data set.

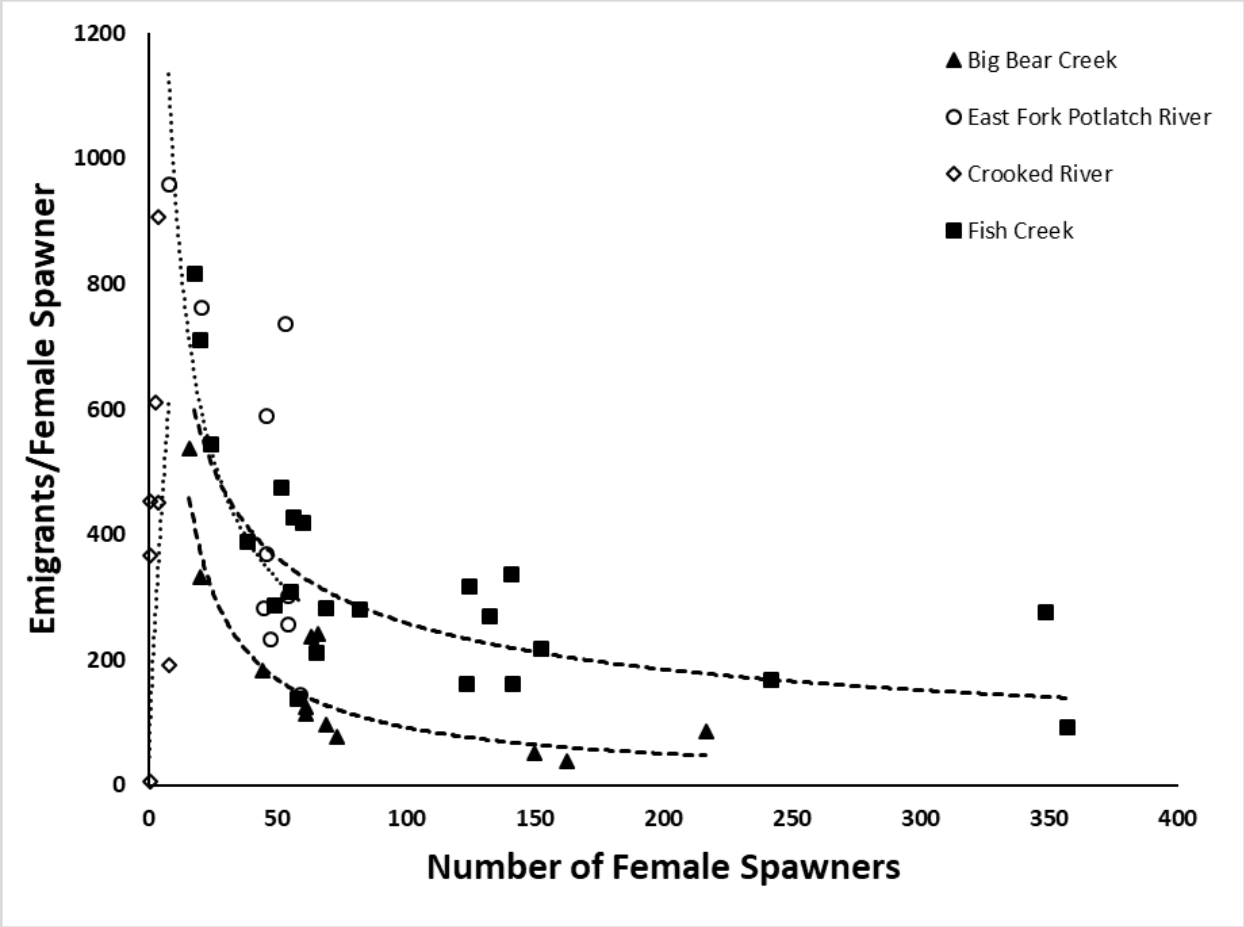

Figure 5. Relationship between wild juvenile steelhead productivity (recruits per spawner expressed as emigrants above the trap/ female spawner) and adult female spawner abundance above the trap or array for steelhead populations from Big Bear Creek (brood years 2005-2017), East Fork Potlatch River (brood years 2008-2017), Crooked River (brood years 2007-2016), Fish Creek (brood years 1996-2017). Trend lines fit with a power function are shown for each data set.

CHAPTER 2

TESTING MARK-RECAPTURE ASSUMPTIONS AT THE SOUTH FORK SALMON RIVER ROTARY SCREW TRAP

ABSTRACT

Rotary screw traps have become a common tool to calculate the abundance of out-migration juvenile salmonids through mark-recapture models. Testing that assumptions in mark-recapture models are not being violated is essential to ensure validity of estimates and steer best management practices for Chinook Salmon, *Oncorhynchus tshawytscha*, and steelhead, *O. mykiss*. We conducted field manipulations and analyzed pre-existing data on Chinook Salmon and steelhead at the South Fork Salmon River rotary screw trap for two assumptions: (1) marked Chinook Salmon and steelhead distribute themselves randomly through the entire population, and (2) all individuals in the population have an equal and independent chance of being captured a second time. For assumption 1, we examined if there was an impact on recapture rate based on location and/or time of marked fish release. Three different release strategies were used to manipulate release location and/or time of release. A total of 2,033 Chinook and 197 steelhead were PIT tagged for this study and 238 Chinook and 17 steelhead were recaptured. Results show there was no significant difference between the release strategies and recapture rate for either Chinook Salmon ($p = 0.419$) or steelhead ($p = 0.421$). For assumption 2, we used the complete record of tagging data from the South Fork Salmon River screw trap to examine if fish fork length impacted the rate of recapture for either species. After compiling and analyzing data from 2015 to 2021, we observed a significant difference with recapture probability and fork length with Chinook ($p < .001$) and steelhead ($p < .001$). Smaller Chinook and larger steelhead were recaptured at lower rates. Each trap setup is unique, thus our findings that release site and time did not have significant bearing on recapture rate, but fork length did, does not necessarily apply to all traps; each unique trap setup should test assumptions independently.

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) anadromous fish program's goal is to preserve Idaho's Salmon and steelhead runs and recover them to provide benefit to all users (IDFG 2019). The Idaho Department of Fish and Game is able to track juvenile production by Chinook Salmon and steelhead populations through the use of rotary screw traps (RSTs), which have become a strongly relied on tool since the 1990s (Venditti et al. 2005). Abundance and productivity trends of out-migrating juvenile Chinook Salmon and steelhead are estimated at rotary screw traps through mark-recapture methods.

All mark-recapture studies have simplifying assumptions (Ricker 1975). The likelihood of violating assumptions can be minimized by training and study design, and departures from assumptions can be detected through appropriate investigations (Copeland et al. 2021). Two assumptions that apply when deriving abundance estimates include: (1) marked Chinook Salmon and steelhead distribute themselves randomly through the entire population, and (2) all individuals in the population have an equal and independent chance of being captured a second time.

We designed a study to investigate if we were violating either of these assumptions at the rotary screw trap located on the South Fork Salmon River. For assumption 1, we examined if there was an impact on recapture rate based on location and/or time of marked fish release. For assumption 2, we used the complete record of tagging data from the South Fork Salmon River RST to examine if fish length impacted the rate of recapture.

METHODS

This study was conducted at the South Fork Salmon River RST (SFSRKT; latitude/longitude 44.9898, -115.7249). All fish for this study were captured and processed using standard RST procedure outlined in Chapter 1. PIT tags were implanted in Chinook Salmon ≥60 mm FL and steelhead ≥80 mm FL following established protocols (Kiefer and Forster 1991; PIT Tag Steering Committee 1992; CBFWA 1999). Marked fish were released upstream at different locations and/or times to estimate trap efficiency for each group to test assumption 1 and 2.

For assumption 1, we conducted active manipulations from September 14, 2021 through October 22, 2021 (39 days). Three release strategies were used to test if location of release or time of release impacts recapture rate: (1) Strategy A – PIT-tagged fish were released during daylight hours at the upstream release site, 0.32 km upstream from trap; (2) Strategy B – PIT-tagged fish were released at the normal release site but in the evening, after the end of civil twilight; and (3) Strategy C - fish were released 1.5 km upstream from the trap (0.08 km upstream of the PIT Tag Array) during daylight hours. Strategy A was our control strategy, where no changes were made from our normal routine, whereas Strategy B tested the impact of time of release on recapture rate and Strategy C tested the impact of location of release on recapture rate. These release strategies were used on a daily rotating schedule. The data collected was analyzed using chi-squared tests to examine whether there was a significant difference between release strategies for both species.

For assumption 2, no on-the-ground manipulation was conducted; we compiled and analyzed all of the SFSRKT Chinook Salmon and steelhead mark-recapture data from 2015–2021. Logistic regression was used to analyze the relationship between recapture probability and fork length for both species.

RESULTS

A total of 2,033 Chinook Salmon and 197 steelhead were PIT tagged during our active manipulation period, and 238 Chinook Salmon and 17 steelhead were recaptured (Figure 6). There was no significant difference between the release strategies and recapture rate for either Chinook Salmon (p = .419) or steelhead (p = .421).

Data from 2015 to 2021 were queried from IDFG's juvenile database to test assumption 2. A total of 31,435 Chinook and 5,594 steelhead were marked with PIT tags (Figure 7) and included in this study; 3,066 Chinook and 279 steelhead were recaptured. We observed a significant difference with recapture probability and fork length for Chinook (p <.001) and steelhead (p <.001). The equations found in Figure 8 described the relationship between recapture probability and fork length for Chinook Salmon and steelhead.

DISCUSSION

We focused on comparing the impact that location of release and time of release may have on the recapture rates to ensure we are not violating the first assumption that all marked individuals distribute themselves randomly through the entire population. Our results indicated that there was not a significant difference between the three release strategies in regards to recapture rate. Thus, we do not recommend any changes with our release strategy at the SFSRKT. We take this as an indication that releasing either species at a different time or location would not have an effect on our abundance estimates. This conclusion has also been observed during previous assumption testing conducted at another location on the South Fork Salmon with Chinook Salmon (Venditti et all. 2005). Another study conducted in Oregon noted similar results when testing recapture rates on steelhead with different release strategies (Tattam et al. 2013). Our steelhead sample size was relatively small, due to low abundance observed at SFSRKT (Figure 6). It may be worth extending the study in duration to capture more steelhead given the low sample size.

We analyzed all of the pre-existing data since the first RST installation to ensure we have not been violating the second assumption. Results of the logistic regression show that fork length influenced recapture rate. We found inverse relationships between juvenile Chinook Salmon and steelhead when examining recapture rates. Both smaller Chinook Salmon and larger steelhead had low recapture rates compared to larger Chinook Salmon and smaller steelhead (Figure 8). Smaller Chinook may be at a higher risk of predation in comparison to the larger Chinook once they are released. Smaller fish may also be disproportionately influenced by tagging. There are several factors that can influence fish's overall health and recovery in a size-specific manner, such as the relative tag burden or the tagger's experience and handling. Also larger steelhead may be able to avoid the trap the second time because of their size. There is also potential the larger steelhead could be resident Rainbow Trout.

Though our long-term dataset may indicate that we are violating assumption 2, it is important to note that we use stratifications and a much shorter timescale when estimating abundances. When we are estimating abundance, we attempt to stratify data by at least the three seasons by year (Steinhorst et al. 2004). When enough data are available, Chinook Salmon are further broken into similar cohorts and sizes based on their migration patterns. Thus, at least for Chinook, we likely are not violating assumption 2. Most RSTs have too few steelhead trapped during the summer so summer and fall data are often pooled. Also, trap efficiencies are not

stratified by size so seasonal strata includes juvenile steelhead of various ages and size. Thus, we may be violating assumption 2 for steelhead if we are disproportionately sampling fish of different sizes within the population. We urge researchers to consider how the size of captured fish may influence abundance estimates, especially for steelhead. The real test of the influence on length would be to estimate abundance with and without the effect of length on capture efficiency and seeing if those estimates are different. Even if the regression is significant, its practical influence may be minimal, as is very likely for Chinook Salmon.

Each RST site and setup is unique. Several site-specific factors can influence the probability of recapturing marked fish such as stream size, flows, trap location, and population-specific early life history strategies of Chinook Salmon and steelhead. Consequently, our study should be expanded to examine individual RSTs to determine if current methods of operation are meeting assumptions for estimating unbiased estimates of juvenile abundances at RSTs using mark-recapture methodology.

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FIGURES

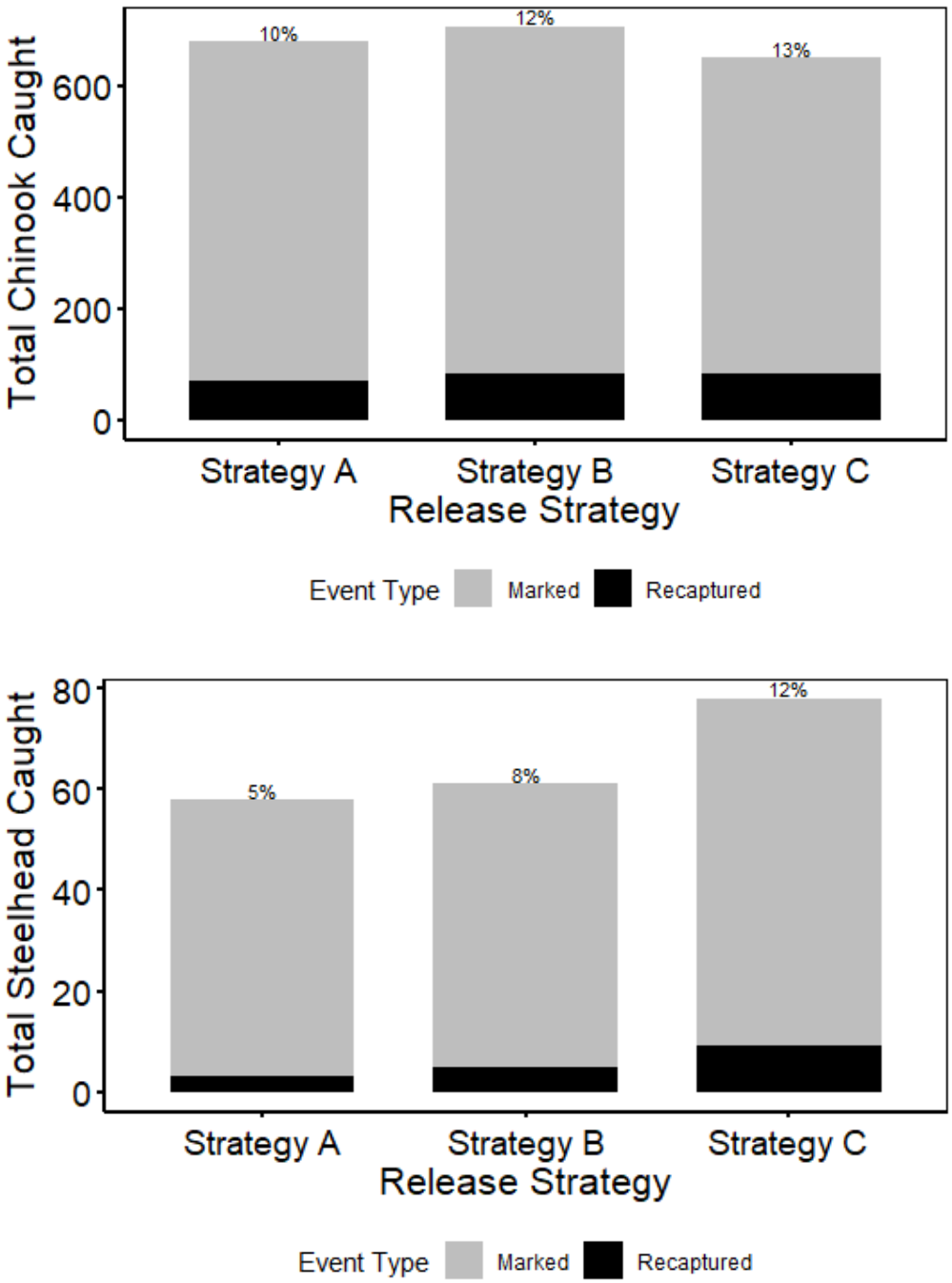
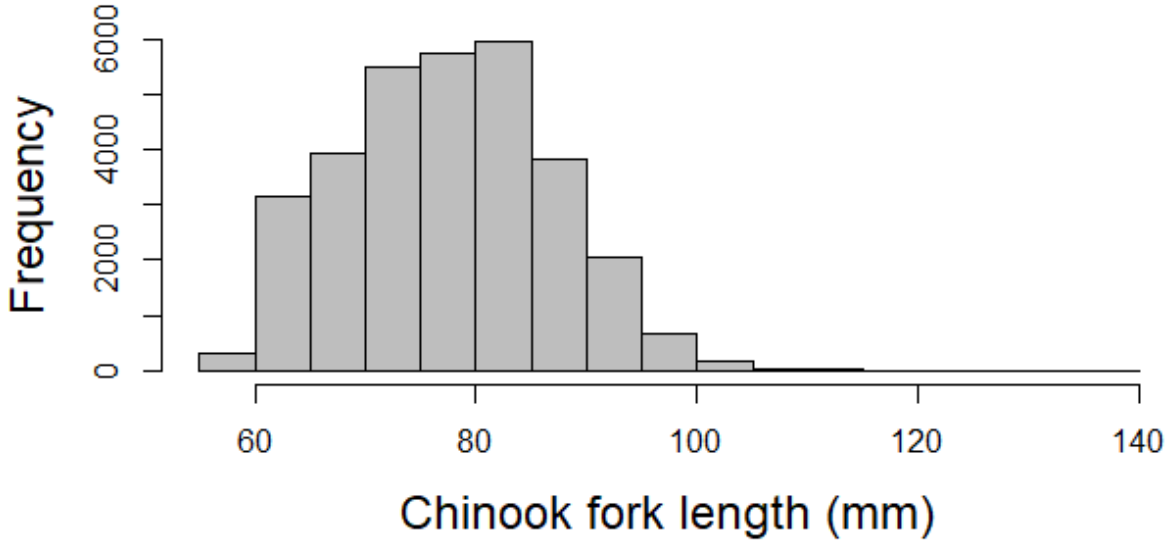


Figure 6. Total number of Chinook Salmon (n = 2,033) and steelhead (n = 197) marked (gray) and recaptured (black) by release strategy: (1) Strategy A – PIT-tagged fish were released during daylight hours at the normal release site, 0.32 km upstream from trap; (2) Strategy B - tagged fish were released at the normal release site after the end of civil twilight; and (3) Strategy C – tagged fish were released 1.5 km upstream from the trap during daylight hours. Recapture rate is provided above each bar.



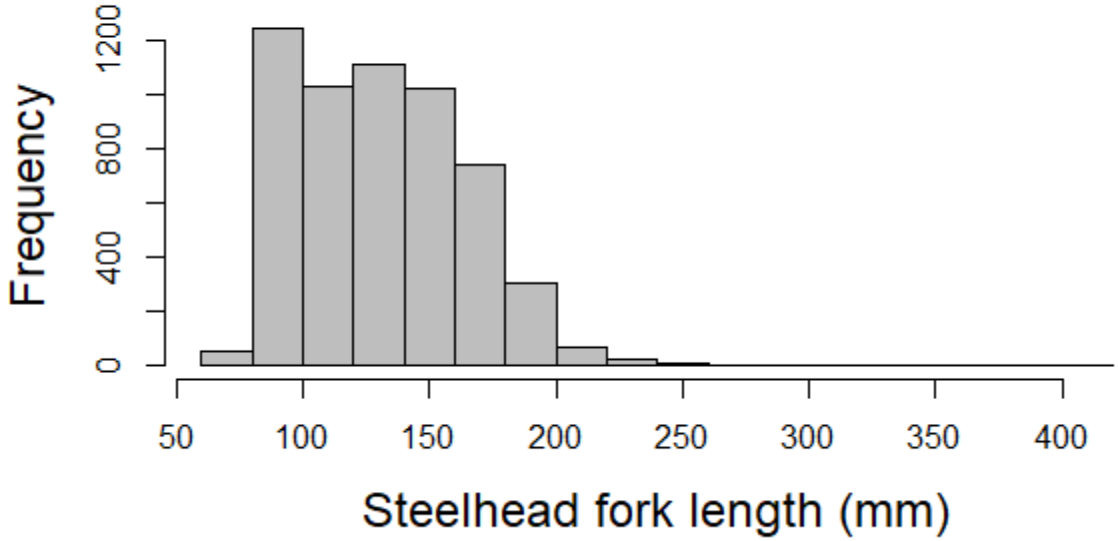
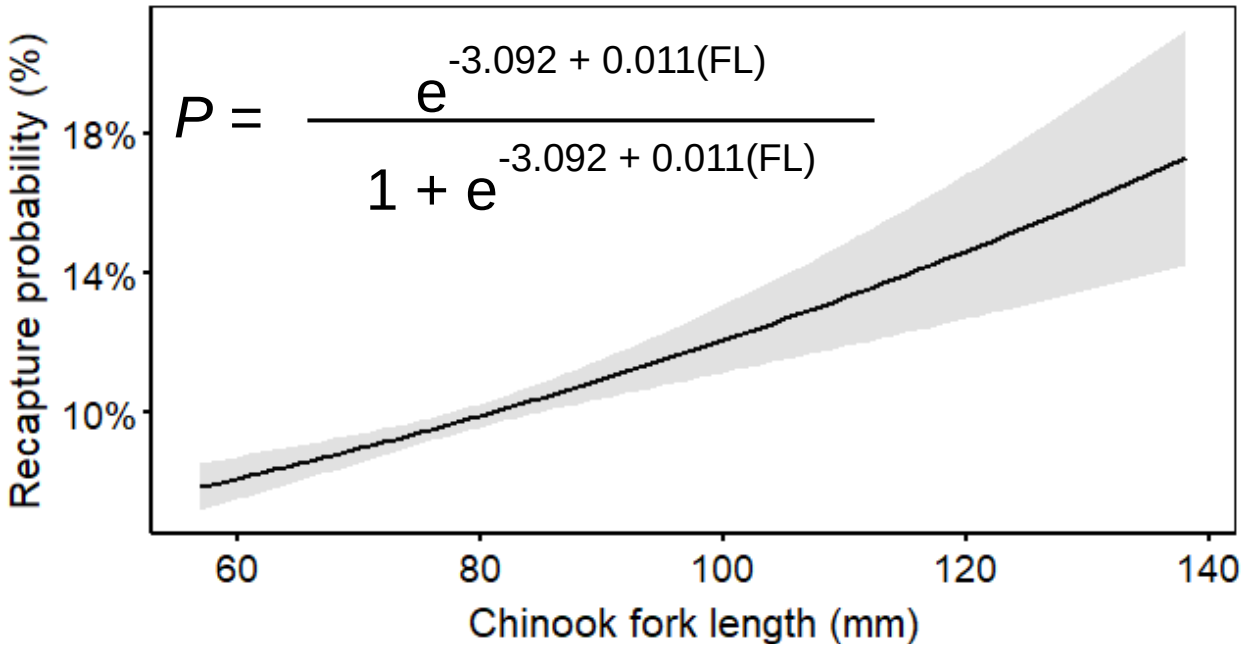


Figure 7. Histogram showing the fork lengths of all marked Chinook Salmon and steelhead at the SFSRKT from 2015–2021.



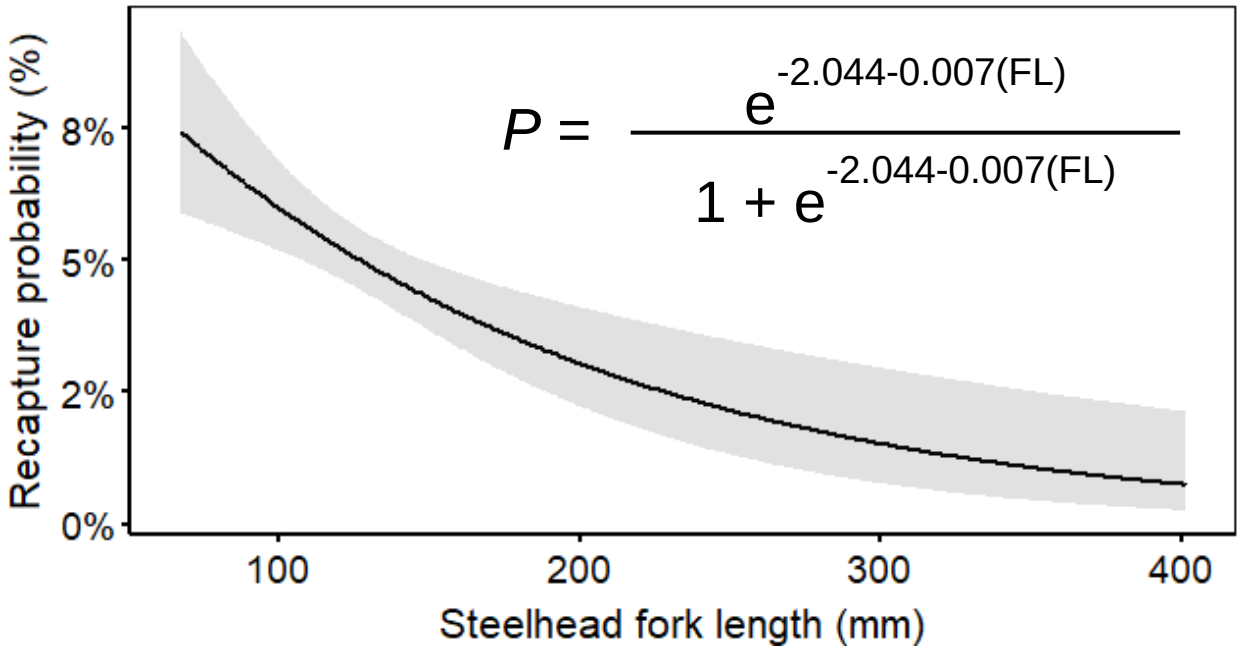


Figure 8. Logistic regression estimating the recapture probability (*P*) of Chinook Salmon and steelhead based on fork length (mm; FL). The grey colored bands represent the 95% confidence intervals.

APPENDICES

Appendix A. Rotary screw traps operated by Idaho Department of Fish and Game in 2021 to monitor Chinook Salmon and steelhead juvenile emigrants in Idaho. Major population group (MPG) and population for each species are identified. Funding projects include Idaho Salmon and Steelhead Monitoring and Evaluation Studies (ISSMES), and Intensively Monitored Watershed (IMW).

Map reference number	**Trap location (PTAGIS code)**	**Chinook Salmon MPG / *population***	**Steelhead Trout MPG / *population***	**Funding project**	**Years of operation**	**Adult escapement infrastructure**
		Salmon River Basin				
1	Rapid River (RPDTRP)	**South Fork Salmon River /** *Little Salmon River*	**Salmon River /** *Little Salmon River*	ISSMES	2007-2021	Permanent weir
2	Lower South Fork Salmon River (SFSRKT)	**South Fork Salmon River /** *South Fork Salmon River*	**Salmon River** / *South Fork Salmon River*	ISSMES	2015-2021	PIT array
3	Big Creek (BIG2CT)	**Middle Fork Salmon River /** *Big Creek*	**Salmon River** / *Lower Middle Fork Salmon River*	ISMES	2007-2021	PIT array
4	Lower Marsh Creek (MARTR2)	**Middle Fork Salmon River** / *Marsh Creek*	**Salmon River /** *Upper Middle Fork Salmon River*	ISSMESS	2009-2021	None
5	North Fork Salmon River (NFSTRP)	**Upper Salmon River /** *North Fork Salmon River*	**Salmon River /** *North Fork Salmon River*	ISMES	2015-2021	PIT array
6	Lemhi River (LEMTRP)	**Upper Salmon River /** *Lemhi River*	**Salmon River /** *Lemhi River*	IMW	1992-2021	PIT array
7	Lower Lemhi River (LLRTP)	**Upper Salmon River /** *Lemhi River*	**Salmon River /** *Lemhi River*	ISSMES	2013-2021	PIT array
8	Hayden Creek (HYDTRP)	**Upper Salmon River /** *Lemhi River*	**Salmon River /** *Lemhi River*	IMW	2006-2021	PIT array
9	Upper Salmon River (SAWTRP)	**Upper Salmon River /** *Upper Salmon River mainstem*	**Salmon River** / *Upper Salmon River mainstem*	ISSMESS	1992-2021	Permanent weir
10	Pahsimeroi River (PAHTRP)	**Upper Salmon River** / *Pahsimeroi River*	**Salmon River** / *Pahsimeroi River*	ISSMESS	1992-2021	Permanent weir
		Clearwater River Basin				
11	Big Bear Creek (BBCTRP)	**Dry Clearwater River /** *Upper South Fork Clearwater River*	**Clearwater River /** *Lower Clearwater Mainstem*	IMW	2004-2021	PIT array
12	East Fork Potlatch River (EFPTRP)	**Dry Clearwater River /** *Upper South Fork Clearwater River*	**Clearwater River /** *Lower Clearwater Mainstem*	IMW	2007-2021	Seasonal weir
13	Crooked River (CROTRP)	**Dry Clearwater River /** *Upper South Fork Clearwater River*	**Clearwater River /** *South Fork Clearwater River*	ISMES	1990-2021	Seasonal weir
14	Lower Lochsa River (LOCTRP)	**Wet Clearwater River /** *Lochsa River*	**Clearwater River** / *Lochsa River*	ISMES	2015-2021	PIT array
15	Fish Creek (FISTRP)	**Wet Clearwater River /** *Lochsa River*	**Clearwater River** / *Lochsa River*	ISMES	1995-2021	Seasonal weir

Appendix B. Rotary screw trap operations in the Salmon River and Clearwater River basins, Idaho for 2021, with a brief summary of operations and logistical issues that possibly affected estimation of juvenile Chinook Salmon and steelhead emigrants.

Trap Operation			
Location (PTAGIS site code)	**Date range (mm/dd)**	**Total days operated / total days in date range**	**Operation summary and logistical issues**
Salmon River basin			
Rapid River (RPDTRP)	4/24 – 11/3	175/192	The trap did not operate until after the hatchery smolt release in late April. It was not in operation for 14 days during spring runoff. The trap was found inoperable on 10/25 due to excessive leaves and debris.
Lower South Fork Salmon River (SFSRKT)	3/12 – 11/9	161/243	The trap did not run for one day during the spring due to a sudden spike flow. The cone was pulled for the smolt hatchery release for eight days. The trap was pulled for spring runoff on 4/30/21 and redeployed on 6/7/21. The trap was shut down for 21 days due to hot water temperatures. The trap was then kept running but no tagging occurred for 24 days due to the high water temperature. The trap was shut down on 11/9/21 due to onset of winter conditions.
Big Creek (BIG2CT)	3/18-11/7	168.5/235	The trap did not operate between 4/30/21 and 6/11/21 due to high water conditions and heavy debris load. The trap was shut down for 17 days due to fire danger in the area. The trap was pulled on 11/7/21 due to onset of winter conditions.
Lower Marsh Creek (MARTR2)	3/20 – 10/31	198/224	Freezing conditions made the trap inoperable on four occasions in early spring. The trap was pulled for 24 days during spring runoff. A fyke was built from river rock in late August to improve flow and efficiency during low water conditions.
North Fork Salmon River (NFSTRP)	06/18-11/15	148/150	The trap was launched later than normal due to the moving of the trap to a new location upstream of the old location and then high flows at the time of the move. The trap started operating in its new location on 6/8/21. Additionally, on multiple occasions the trap was found to be inoperable due to logs jams, et cetera (6/24 and 9/19).
Lemhi River Weir (LEMTRP)	03/17 – 11/15	234/244	The upper Lemhi trap was installed on 3/27/2021. The trap operated for 234 days. The trap was inoperable for 3 days and partially operated for a day in the spring due to debris and low flows causing cone to be stuck on river bottom. In the summer the trap did not operate for 4 days due to staff attending statewide trainings and installation of an array, while it was partially operated for 2 days because of debris. The trap was partially operated in the fall for 3 days all due to debris.

Appendix B. Continued

Trap Operation			
Location (PTAGIS site code)	**Date range (mm/dd)**	**Total days operated / total days in date range**	**Operation summary and logistical issues**
Hayden Creek (HYDTRP)	03/17 – 11/15	160.5/244	The Hayden Creek trap was installed 3/17/2021. The trap operated for 160.5 days. During the spring, the trap was partially operated for 16 days and it was inoperable for a total of 16 days. The trap did not operate due to low flows that limited the ability of the trap cone to spin and due to high flows that caused the trap cone to spin too fast and created an unsafe environment. During the summer, the trap was inoperable for 4 days due to staff attending statewide trainings and installation of an array. In the fall the trap was inoperable for 51 days due extremely low flows.
Lower Lemhi River (LLRTP)	03/19 – 11/15	224.5/242	The lower Lemhi River trap was installed on 03/19/2021. The trap operated for 224.5 days. The trap was inoperable for 5 days and was partially operated for 11 days in the spring due to high flows and debris. During the summer the trap did not operate for 4 days due to staff attending statewide trainings and installation of an array. In the fall the trap was partially operated for a total of 5 days due to increased debris and leaf litter.
Upper Salmon River (SAWTRP)	3/18 – 10/31	221/226	The trap was not in operation for 3 days in April due to the hatchery release of integrated brood Chinook smolts. The trap was moved out of the main current and remained fishing during spring runoff. During this time, a large tree hit and hung up on the trap preventing operation for 2 days.
Pahsimeroi River (PAHTRP)	03/09-12/5	251/271	The trap was not operated for 20 days in April due to hatchery release of juvenile Chinook Salmon from 04/08–04/28. Additionally, the cone was pulled after trap was checked on 11/24 to allow staff to take Thanksgiving day off, so the trap was not operable 11/25.
Big Bear Creek (BBCTRP)	3/8-6/3	74/88	The BBCTRP operated was installed on 3/8/2021 and operated for 74 days. The trap was inoperable for 5 days and partially operated for 9 days in the spring due to low water conditions. Trapping operations ceased on 6/3/2021 and no trapping was conducted during the summer and fall.
East Fork Potlatch River (EFPTRP)	3/8-6/3	79/88	The EFPRTRP was installed on 3/8/2021 and operated for 79 days. The trap was inoperable for 4 days and was partially operable for 5 days in the spring due to low water conditions. Trapping ceased on 6/3/2021 and no trapping was conducted during the summer and fall.

Appendix B. Continued

Trap Operation			
Location (PTAGIS site code)	**Date range (mm/dd)**	**Total days operated / total days in date range**	**Operation summary and logistical issues**
Crooked River (CROTRP)	3/23-11/8	204/231	The CROTRP was installed on 3/23/2021 and operated for 204 days. The trap was inoperable for 9 days and partially operated for 18 days due to high flows/debris loads in the spring and low water conditions in the summer. Trapping ceased on 11/8/2021.
Fish Creek (FISTRP)	03/19-11/01	223/230	Trap did not operate for seven days in July due to extremely poor air quality resulting from local wildfires.
Lower Lochsa (LOCTRP)	03/10-10/31	151/236	The trap was partially operated for 10 days after a hatchery smolt release mid-March. Trap was inoperational for repairs during two days in late May and four days in early June. It was not in operation for 79 days between July 3rd and September 19th due to high temperatures and low flows.

Appendix C. Seasonal catch of juvenile steelhead <80 mm FL from rotary screw traps operated in streams in Idaho in 2021.

Population, location and PTAGIS site code	Season	Catch
Little Salmon River		
Rapid River	Spring	4
RPDTRP	Sum/Fall	5
South Fork Salmon River		
Lower South Fork Salmon River	Spring	17
SFSRKT	Sum/Fall	2,275
Lower Middle Fork Salmon River		
Big Creek	Spring	6
BIG2CT	Sum/Fall	282
Upper Middle Fork Salmon River		
Lower Marsh Creek	Spring	8
MARTR2	Sum/Fall	102
North Fork Salmon River		
North Fork Salmon River	Spring	NA
NFSTRP	Sum/Fall	345
Lemhi River		
Lemhi River	Spring	12
LEMTRP	Sum/Fall	45
Hayden Creek	Spring	132
HYDTRP	Sum/Fall	236
Lower Lemhi River	Spring	23
LLRTP	Sum/Fall	5
Upper Salmon River mainstem		
Upper Salmon River	Spring	110
SAWTRP	Sum/Fall	556
Pahsimeroi River		
Pahsimeroi River	Spring	4
PAHTRP	Sum/Fall	272
South Fork Clearwater River		
Crooked River	Spring	3
CROTRP	Sum/Fall	147
Lower Clearwater Mainstem		
East Fork Potlatch River	Spring	2
EFPTRP	Sum/Fall	NA
Big Bear Creek	Spring	4
BBCTRP	Sum/Fall	NA
Lochsa River		
Fish Creek	Spring	0
FISTRP	Sum/Fall	119
Lower Lochsa River	Spring	3
LOCTRP	Sum/Fall	0

Appendix D. Chinook Salmon abundance and productivity estimates by cohort.

Location	Brood Year	Abundance at RST	Emigrants per Redd/Female	Abundance at LGR	Smolts at LGR per Redd/Female
			Salmon River Basin		
South Fork Salmon	2014	102,681	210	27,314	56
	2015	90,453	245	24,109	65
	2016	178,845	391	48,198	105
	2017	89,419	497	34,393	191
	2018	128,901	448	51,578	179
	2019	146,374	774	57,073	302
Big Creek	2006	63,442	1,475	7,573	176
	2007	55,885	931	24,469	408
	2008	131,740	1,387	46,867	493
	2009	183,268	1,167	58,509	373
	2010	247,912	1,271	60,485	310
	2011	211,204	943	45,161	202
	2012	129,134	615	28,287	135
	2013	127,661	1,130	33,051	292
	2014	323,649	1,904	74,589	435
	2015	205,194	1,274	59,057	367
	2016	215,345	1,455	51,981	351
	2017	56,476	2,017	24,462	874
	2018	42,461	885	18,346	382
	2019	67,327	3,544	34,817	1,832
Marsh Creek	2010	366,082	1,126	59,733	184
	2011	499,303	1,600	82,888	266
	2012	323,548	1,634	51,029	258
	2013	224,927	1,315	34,638	203
	2014	587,266	1,439	88,978	218
	2015	315,545	1,160	44,014	162
	2016	151,505	670	27,625	121
	2017	60,170	1,114	15,446	281
	2018	128,716	1,030	40,874	327
	2019	46,337	1,103	16,141	384
North Fork Salmon River	2014	16,199	228	6,002	85
	2015	17,812	262	5,565	82
	2016	27,377	1,141	7,941	331
	2017	2,086	1,043	1,202	601
	2018	15,746	787	5,391	270
	2019	8,362	597	3,026	216
Upper Lemhi River[(a)]	1991	17,479	318	5,269	96
	1992	11,132	742	3,073	205
	1993	10,428	282	3,983	108
	1994	1,789	89	814	41
	1995	1,706	190	802	89
	1996	6,790	234	4,071	140
	1997	46,950	939	20,970	419
	1998	12,755	311	5,673	138

Appendix D. Continued.

Location	Brood Year	Abundance at RST	Emigrants per Redd/Female	Abundance at LGR	Smolts at LGR per Redd/Female
	1999	13,654	284	4,573	95
	2000	14,743	159	5,384	58
	2001	46,696	138	13,082	39
	2002	19,424	159	6,667	55
	2003	8,570	121	2,566	36
	2004	10,216	341	3,859	129
	2005	7,743	155	2,730	55
	2006	4,843	127	1,706	45
Lemhi River cont.	2007	4,376	151	1,842	64
	2008	7,035	213	2,224	67
	2009	47,560	523	19,238	211
	2010	23,018	256	10,231	114
	2011	33,951	281	12,047	100
	2012	11,721	143	5,873	72
	2013	20,877	215	9,644	99
	2014	80,386	374	24,842	116
	2015	55,177	361	19,994	131
	2016	34,065	313	6,387	59
	2017	16,381	381	5,758	134
	2018	35,462	394	13,808	153
	2019	20,132	395	8,049	158
Hayden Creek	2005	3,369	241	1,037	74
	2006	9,110	701	2,650	204
	2007	55,223	1,781	7,026	227
	2008	11,777	1,309	4,617	513
	2009	18,430	1,084	2,847	167
	2010	32,961	891	5,733	155
	2011	20,013	294	5,490	81
	2012	28,039	1,078	3,703	142
	2013	7,860	231	2,172	64
	2014	77,221	1,058	3,895	53
	2015	63,389	409	12,452	80
	2016	43,792	796	6,068	110
	2017	2,315	193	661	55
	2018	8,094	99	1,661	45
	2019	9,802	350	4,057	145
Pahsimeroi River[a]	1992[b]	3,227	179	1,053	59
	1993	27,566	452	8,546	140
	1994	8,936	559	4,219	264
	1995	4,270	356	2,641	220
	1996	3,180	227	1,552	111
	1997	17,793	574	10,131	327
	1998	26,240	673	12,867	330
	1999	19,954	289	7,595	110
	2000	17,288	360	4,715	98
	2001	62,567	372	24,148	144
	2002	42,508	244	14,182	82

Appendix D. Continued.

Location	Brood Year	Abundance at RST	Emigrants per Redd/Female	Abundance at LGR	Smolts at LGR per Redd/Female
	2003	72,724	166	19,754	45
	2004	36,989	147	10,495	42
Pahsimeroi River cont.	2005	79,159	222	23,439	66
	2006	13,255	141	3,063	33
	2007	14,133	196	4,600	64
	2008	22,341	243	8,607	94
	2009	50,896	320	18,696	118
	2010	44,247	301	17,491	119
	2011	51,713	247	16,706	80
	2012	62,148	679	15,368	173
	2013	16,525	223	3,879	52
	2014	70,596	200	22,856	70
	2015	44,166	237	19,323	104
	2016	79,501	365	27,511	126
	2017	16,656	126	7,166	54
	2018	19,109	120	6,346	40
	2019	11,343	222	5,840	115
Upper Salmon River[a]	1992[b]	3,744	44	1,185	14
	1993	22,705	101	8,470	38
	1994	17,644	504	7,394	211
	1995	NE	NE	NE	NE
	1996	3,804	211	1,976	110
	1997	22,703	631	11,781	327
	1998	35,618	2,375	10,982	732
	1999	17,015	740	5,047	219
	2000	106,597	635	30,291	180
	2001	351,651	727	39,624	82
	2002	441,082	665	48,503	73
	2003	235,254	588	43,650	109
	2004	236,914	887	36,336	136
	2005	295,396	1,588	52,317	281
	2006	135,547	1,059	31,342	245
	2007	80,711	1,261	19,161	299
	2008	94,687	802	20,405	173
	2009	150,729	908	25,506	154
	2010	144,768	766	28,665	152
	2011	153,147	672	26,519	116
	2012	135,031	475	33,463	118
	2013	30,354	416	6,361	87
	2014	57,039	213	9,546	36
	2015	80,286	664	10,441	86
	2016	99,055	461	16,582	77
	2017	52,301	297	13,809	78
	2018	22,829	387	5,028	85
	2019	12,757	395	2,358	98

Appendix D. Continued.

Location	Brood Year	Abundance at RST	Emigrants per Redd/Female	Abundance at LGR	Smolts at LGR per Redd/Female
	1992	9,922	220	3,382	75
Crooked River[(a)]	1993	33,448	697	8,648	180
	1994	836	209	262	66
	1995	NE	NE	NE	NE
	1996	6,422	1,284	3,730	746
	1997	12,132	221	4,203	76
	1998	10,887	1,089	2,141	214
	1999	611	611	271	271
	2000	6,470	70	2,503	27
	2001	5,819	67	1,228	14
	2002	6,640	226	1,481	82
	2003	19,955	499	4,886	122
	2004	10,149	597	3,419	201
	2005	2,008	502	703	176
	2006	698	698	218	218
	2007	455	114	255	64
	2008	4,388	169	1,631	63
	2009	3,608	241	2,021	135
	2010	1,944	194	810	81
	2011	2,318	166	816	58
	2012	7,868	NE	1,705	NE
	2013	622	207	NE	NE
	2014	1,857	98	421	22
	2015	11,911	851	2,793	200
	2016	1,704	170	263	26
	2017	305	305	184	184
	2018	2,221	NE	590	NE
	2019	NE	NE	NE	NE

[a] From 1991 to 1996 smolt traps were not operated during summer periods (June, July, August). Estimates for these years are on the conservative side.

[b] Smolts only.

Appendix E. Estimated productivity for juvenile steelhead emigrants by cohort, expressed as emigrants at rotary screw trap (RST) per female spawner, for populations with estimates of female spawner abundance in the Salmon River and Clearwater River basins, Idaho. Accounting is incomplete for cohorts with dashes in any age column.

Population and RST location	Cohort	Number of emigrants by age (years)						Sum	Female parents	Productivity
		Age-0	Age-1	Age-2	Age-3	Age-4	Age-5			
					Salmon River MPG					
Little	2007	112	716	1,864	1,628	260	0	4,580	21	218
Salmon	2008	72	478	885	958	216	65	2,675	46	58
River	2009	17	286	1,327	768	725	19	3,142	63	50
	2010	0	448	1,783	1,699	261	0	4,189	116	36
[b]Rapid River	2011	0	774	1,378	955	94	0	3,200	101	32
RPDTRP	2012	23	405	1,561	1,084	60	0	3,134	57	55
	2013	0	579	1,530	478	28	0	2,615	15	174
	2014	9	1,175	1,155	565	132	0	3,036	16	190
	2015	71	1,039	677	1,338	127	0	3,252	54	60
	2016	8	416	800	453	63	6	1,746	13	134
	2017	0	162	265	396	180	--	1,003	8	122
	2018	0	100	362	756	--	--	--	5	--
	2019	0	111	646	--	--	--	--	8	--
	2020	0	341	--	--	--	--	--	8	--
	2021	0	--	--	--	--	--	--	9	--
South Fork	2012	--	--	--	0	0	0	0	369	--
Salmon River	2013	--	--	277	437	0	0	759	301	--
	2014	--	5,188	1,179	1,221	0	0	7,796	275	--
[a]Lower South	2015	5,049	28,262	10,954	429	170	0	44,864	550	82
Fork Salmon	2016	3,919	22,455	6,785	511	175	0	33,845	239	142
River	2017	711	15,202	6,133	2,260	148	--	24,454	163	150
SFSRKT	2018	859	3,918	4,124	488	--	--	--	55	--
	2019	454	11,761	3,341	--	--	--	--	45	--
	2020	502	7,457	--	--	--	--	--	39	--
	2021	464	--	--	--	--	--	--		--
Lower	2010	0	7,604	18,632	6,950	603	0	33,791	688	49
Middle Fork	2011	0	3,316	10,142	5,980	558	0	19,994	443	45
Salmon River	2012	84	14,552	19,328	6,754	244	0	40,962	263	156
	2013	85	13,263	20,761	1,097	211	0	35,418	302	117
[a]Big Creek	2014	0	13,432	9,812	1,603	0	0	24,847	180	138
BIGC2T	2015	0	12,824	6,777	666	98	0	20,365	532	38
	2016	443	4,772	14,701	2,557	0	0	22,473	216	104
	2017	0	4,098	8,179	2,450	120	--	14,847	42	354

Appendix E Continued

Population and RST Location	Cohort	Number of emigrants by age (years)						Sum	Female parents	Productivity
		Age-0	Age-1	Age-2	Age-3	Age-4	Age-5			
	2018	154	7,841	24,258	1,698	--	--	--	85	--
Big Creek	2019	195	4,737	5,117	--	--	--	--	56	--
Cont.	2020	0	2,754	--	--	--	--	--	62	--
	2021	260	--	--	--	--	--	--	85	--
Upper Salmon River Mainstem	2001	264	9,916	4,316	581	57	0	15,211	24	634
	2002	32	1,780	2,798	563	0	0	5,173	39	133
	2003	17	3,158	1,548	205	13	NE	4,941	16	309
	2004	22	989	955	1,842	NE	0	3,808	7	544
	2005	62	1,000	4,734	NE	0	0	5,796	15	386
[b]Upper Salmon River	2006	0	4,172	NE	48	0	0	4,220	9	469
	2007	128	NE	2,553	344	0	0	3,025	17	178
	2008	NE	1,923	2,817	80	8	0	4,828	7	690
SAWTRP	2009	12	5,054	4,133	304	14	0	9,517	14	680
	2010	13	7,607	3,907	175	0	0	11,703	56	209
	2011	15	4,978	4,092	27	0	0	9,112	64	142
	2012	39	6,278	3,901	333	0	0	10,551	42	251
	2013	0	4,107	3,701	328	0	0	8,137	18	452
	2014	0	8,069	3,997	72	0	0	12,138	17	714
	2015	526	19,544	2,187	377	0	0	22,634	39	580
	2016	1,374	6,540	2,776	1,245	26	0	11,961	44	272
	2017	436	856	2,579	180	23	--	4,074	18	226
	2018	51	3,587	3,167	261	--	--	--	9	--
	2019	111	4,598	2,269	--	--	--	--	8	--
	2020	1,148	9,658	--	--	--	--	--	21	--
	2021	4,789	--	--	--	--	--	--	59	--
[b]Pahsimeroi	2001		23,396	5,188	148	0	0	28,732	77	
River	2002	12,194	17,705	2,429	281	0	0	32,609	225	145
PAHTRP	2003	8,447	8,993	3,448	124	0	0	21,012	124	169
	2004	7,786	10,702	1,584	0	0	0	20,072	33	608
	2005	3,282	5,897	189	151	0	0	9,518	27	353
	2006	3,658	8,044	1,445	77	0	0	13,223	23	575
	2007	5,766	11,467	903	550	0	0	18,686	7	2,669
	2008	5,040	8,139	5,371	453	0	0	19,004	23	826
	2009	2,227	9,879	1,305	0	0	0	13,412	24	559
	2010	1,580	3,410	2,050	666	0	0	7,707	68	113
	2011	202	4,897	6,418	64	0	0	11,581	153	76
	2012	1,224	8,369	2,104	22	0	0	11,719	168	70
	2013	12,085	11,431	1,399	159	0	60	25,135	107	235
	2014	2,533	4,941	1,566	0	0	0	9,040	121	75

Appendix E Continued.

Population and RST Location	Cohort	Number of emigrants by age (years)						Sum	Female parents	Productivity
		Age-0	Age-1	Age-2	Age-3	Age-4	Age-5			
	2015	5,524	10,340	680	132	0	0	16,676	76	219
	2016	3,330	6,140	2,114	127	0	0	11,711	57	205
PAHTRP	2017	1,436	6,339	679	73	0	--	8,527	18	474
	2018	1,142	2,614	934	25	--	--	--	20	--
	2019	2,281	3,725	676	--	--	--	--	21	--
	2020	1,798	6,306	--	--	--	--	--	26	--
	2021	5,321	--	--	--	--	--	--	14	--
[a]Lower	2010	0	6,023	NE	218	0	0	6,241	278	22
Lemhi River	2011	0	NE	682	314	0	0	996	228	4
LLRTP	2012	NE	682	2,666	1,176	7	1	4,531	249	18
	2013	0	610	4,819	93	15	22	5,558	226	25
	2014	0	11,181	4,904	209	33	0	16,327	181	90
	2015	1,884	7,600	1,798	929	141	0	12,352	249	50
	2016	260	4,219	3,705	2,407	73	0	10,664	190	56
	2017	246	3,799	4,925	202	168	--	9,341	123	76
	2018	99	5,898	1,785	2,176	--	--	--	74	--
	2019	309	4,960	6,468	--	--	--	--	48	--
	2020	0	4,384	--	--	--	--	--	86	--
	2021	0	--	--	--	--	--	--	77	--
[a]Upper	2010	388	8,600	1,732	125	47	0	10,892	9	1,155
Lemhi River	2011	89	9,202	1,270	198	21	0	10,780	56	192
LEMTRP	2012	782	8,689	2,200	213	41	0	11,925	26	453
	2013	683	7,199	2,401	807	0	0	11,090	52	215
	2014	522	17,677	5,407	51	0	0	23,657	12	1,916
	2015	1,284	13,390	1,138	204	0	0	16,015	26	607
	2016	0	11,119	882	142	12	0	12,155	31	388
	2017	725	6,852	1,204	76	0	--	8,857	16	554
	2018	611	5,091	717	186	--	--	--	12	--
	2019	388	6,675	1,420	--	--	--	--	6	--
	2020	0	21,102	--	--	--	--	--	6	--
	2021	305	--	--	--	--	--	--	7	--
				Clearwater River MPG						
Lower	2006	1	2,450	3,286	903	0	0	6,640	20	332
Clearwater	2007	0	2,109	4,383	205	0	0	6,697	69	97
River	2008	23	1,266	6,621	175	0	0	8,085	44	182
Mainstem	2009	3	3,264	3,452	279	0	0	6,998	61	114
[b]Big Bear	2010	5	209	6,548	1,049	0	0	7,811	150	52
Creek	2011	0	4,224	11,109	338	0	0	15,671	66	238

Appendix E Continued.

Population and RST Location	Cohort	Number of emigrants by age (years)							Female	
		Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Sum	parents	Productivity
	2012	4	10,526	4,530	932	0	0	15,992	217	74
BBCTRP	2013	1	608	4,880	213	0	0	5,702	73	78
Cont.	2014	0	2,742	3,388	73	0	0	6,203	163	38
	2015	0	4,224	3,242	139	0	0	7,605	61	124
	2016	61	7,613	6,788	533	42	0	15,037	64	237
	2017	0	3,256	4,890	625	23	--	8,794	16	538
	2018[cc]	0	726	3,377	45	--	--	--	15	--
	2019[cc]	0	4,544	2,325	--	--	--	--	5	--
	2020[cc]	0	1,512	--	--	--	--	--	8	--
	2021[cc]	0	--	--	--	--	--	--	8	--
[b]East Fork	2008	140	9,525	7,230	0	0	0	16,895	46	368
Potlatch	2009	0	22,018	4,366	666	0	0	27,050	46	588
River	2010	550	9,959	2,785	694	0	0	13,987	55	257
EFPTRP	2011[(a)]	0	9,138	6,242	393	0	0	15,773	21	765
	2012	258	33,289	4,515	1,020	0	0	39,082	53	732
	2013	0	5,628	5,006	379	0	0	11,013	48	231
	2014	0	9,456	3,296	0	0	0	12,752	45	282
	2015	0	5,538	2,937	107	0	0	8,583	59	145
	2016	206	12,273	3,547	326	0	0	16,353	54	301
	2017	0	6,127	1,468	62	17	--	7,674	8	959
	2018	0	1,305	570	428	--	--	--	10	--
	2019	0	1,552	1,625	--	--	--	--	2	--
	2020	0	684	--	--	--	--	--	10	--
	2021	0	--	--	--	--	--	--	13	--
South Fork	2007	0	131	827	376	144	0	1,479	8	193
Clearwater	2008	0	54	115	291	30	0	490	1	454
River	2009	0	0	93	125	9	0	226	0	--
[b]Crooked	2010	0	1,024	1,751	1,026	9	0	3,810	4	906
River	2011	0	82	1,283	387	0	0	1,753	0	--
CROTRP	2012	5	993	832	0	0	0	1,829	3	610
	2013	0	0	0	7	0	0	7	1	6
	2014	0	0	87	26	0	0	112	0	--
	2015	0	1,455	343	0	8	0	1,806	4	452
	2016	0	290	0	48	0	0	338	1	372
	2017	0	0	144	30	2	--	176	0	--
	2018	0	82	427	13	--	--	522	0	--
	2019	0	213	27	--	--	--	--	0	--
	2020[(d)]	0	1	--	--	--	--	--	0	--
	2021	0	--	--	--	--	--	--	0	--

Appendix E Continued.

Population and RST Location	Cohort	Number of emigrants by age (years)						Sum	Female Parents	Productivity
		Age-0	Age-1	Age-2	Age-3	Age-4	Age-5			
Lochsa	1996	0	5,286	6,869	843	20	0	13,019	24	534
River	1997	57	4,974	8,928	624	88	0	14,672	18	819
	1998	0	10,713	10,962	2,932	0	0	24,607	52	474
[b]Fish Creek	1999	99	8,582	15,847	600	0	0	25,128	60	418
FISTRP	2000	137	8,466	4,484	1,189	0	0	14,275	20	711
	2001	239	7,661	15,114	1,050	0	0	24,064	56	428
	2002	0	13,501	15,288	4,265	0	0	33,054	153	217
	2003	340	14,030	23,945	2,449	116	0	40,879	242	169
	2004	241	23,094	14,091	2,080	70	0	39,576	125	317
	2005	492	9,022	12,148	1,295	0	0	22,957	82	280
	2006	65	9,236	9,227	853	156	0	19,539	69	283
	2007	57	4,553	8,107	1,418	0	0	14,135	49	287
	2008	0	4,883	11,808	288	0	0	16,979	55	308
	2009	47	16,006	29,647	1,739	104	0	47,544	141	336
	2010	0	16,982	16,280	2,426	0	0	35,688	132	269
	2011	0	7,723	23,653	1,147	43	0	32,565	357	91
	2012	70	7,624	10,895	962	435	0	19,986	124	162
	2013	0	3,441	9,765	597	0	0	13,803	65	211
	2014	0	8,735	5,661	487	0	0	14,884	38	387
	2015	93	70,461	25,307	260	33	0	96,155	349	276
	2016	0	12,654	9,259	802	39	0	22,753	142	161
	2017	122	2,380	5,060	401	0	--	7,962	58	138
	2018	37	868	1,893	217	--	--	--	8	--
	2019	100	2,414	3,042	--	--	--	--	40	--
	2020	0	1,969	--	--	--	--	--	10	--
	2021	27	--	--	--	--	--	--	74	--

[a] Adult estimate from PIT array using DABOM model.
[b] Estimate from weir escapement.
[c] Low abundance so DABOM was not used. Minimum expanded estimate based on detections at Lower Granite.
[d] Weir was not in for most of the season

Appendix F. Plan for operation of rotary screw traps by Idaho Department of Fish and Game in 2021.

FINAL 2-25-21

2021 Plan for IDFG Screw Traps and Biosampling Adult Steelhead and Chinook Salmon Released at Weirs

Bill Schrader, Brett Bowersox, Jeff Diluccia, Greg Schoby, Dale Allen, and Tim Copeland, IDFG

The following plan was initially drafted in 2014 to facilitate the ISS project closeout, transfer equipment to other projects, prepare 2015 budgets for Bonneville Power Administration, and complete NOAA 4(d) Research Permit applications. Here it is updated for 2021. The plan describes IDFG screw trapping and biosampling of adult steelhead and Chinook Salmon released at hatchery and research weirs. Operation of screw traps and weirs forms the basis for "Fish-in and Fish-out" population monitoring designed to track population level abundance and productivity and fish response to habitat improvement projects. Starting in 2018, all hatchery weirs have been permitted under Hatchery and Genetic Management Plans (HGMPs). Sampling at IDFG research weirs and screw traps (outside the SMP/CSS traps and those covered in the HGMPs) in tributaries of the Clearwater and Salmon basins will be conducted under separate 4(d) permits. The Sawtooth screw trap (SAWTRP) and Lemhi River weir will operate under separate Section 10 permits. General contracting and permitting deadlines are as follows: BPA contracting due 9/30/20 and NOAA Section 4(d) permitting applications due 10/6/20.

The contracts and operations plan for IDFG screw traps is part of the closeout of ISS and transfer of most traps to other BPA projects that started in 2015 (Table 1; Figures 1 and 2 in report). Additional screw traps are operated by the Potlatch and Lemhi IMW projects. IDFG trap operators include Brian Knoth (Potlatch IMW), Stacey Meyer (Lemhi IMW), and Scott Putnam (Idaho SMP/CSS) as well as Idaho Salmon and Steelhead Monitoring and Evaluation Studies (ISSMES) staff from Nampa Research and Regions 2, 3M, and 7 as indicated. Outside the SMP/CSS traps, sampling at screw traps will include collecting scales for ageing wild steelhead; tissue samples for genetics will not be collected from any species. Outside the SMP/CSS traps, trap operators will be responsible to provide estimates of abundance and survival to Lower Granite Dam for each species at each screw trap.

The IDFG weir biosampling plan refers to sampling wild or integrated hatchery steelhead and Chinook Salmon adults trapped and released at hatchery or research weirs (Table 2; Figures 1 and 2). Sampling adults released at weirs will include collecting scales from wild steelhead for aging but not from Chinook Salmon. Tissue samples for genetics will be collected from all anadromous fish released at the weir. A comprehensive sampling checklist is provided for all Chinook Salmon trapped at IDFG hatchery weirs (Table 3).

Table 1. IDFG plan for rotary screw trap operations during 2021.

Map #	Trap and PTAGIS Site Code	Subbasin	NOAA Juvenile Permit	Migratory Year 2021 Status	Calendar Year 2021 Contract and Operator	Screw Trap Comments
IDFG Wild Salmon & Steelhead Projects (ISSMES)						
9	Sawtooth (SAWTRP)	Upper Salmon	10-2022-#1124-6R	OPERATE	ISSMES-Jake Ruthven	
10	Pahsimeroi River (PAHTRP)	Upper Salmon	4d-2021-#24294	OPERATE	ISSMES-Megan Heller	
5	North Fork Salmon River (NFSTRP)	Upper Salmon	4d-2021-#24294	OPERATE	ISSMES- Megan Heller	
4	Marsh Creek Lower (MARTR2)	MF Salmon	4d-2021-#24294	OPERATE	ISSMES-Eli Felts	
3	Big Creek (BIG2CT)	MF Salmon	4d-2021-#24294	OPERATE	ISSMES-Josh Poole	
2	Krassel (SFSRKT)	SF Salmon	4d-2021-#24294	OPERATE	ISSMES-Josh Poole	
1	Rapid River (RPDTRP)	Lower Salmon	4d-2021-#24294	OPERATE	ISSMES-Alexa Ballinger	
15	Fish Creek (FISTRP)	Lochsa	4d-2021-#24258	OPERATE	ISSMES-Nolan Smith	
14	Lochsa River Lower (LOCTRP)	Lochsa	4d-2021-#24258	OPERATE	ISSMES-Nolan Smith	
13	Crooked River (CROTRP)	SF Clearwater	4d-2021-#24258	OPERATE	ISSMES-Brian Knoth	Steelhead monitoring, CSS PIT-tagging, habitat evaluation
IDFG Potlatch Project (IMW)						
11	Big Bear Creek (BBCTRP)	Lower Clearwater	4d-2021-#24258	OPERATE	Potlatch IMW-Brian Knoth	
12	East Fork Potlatch River (EFPTRP)	Lower Clearwater	4d-2021-#24258	OPERATE	Potlatch IMW-Brian Knoth	
IDFG Lemhi Projects (IMW)						
6	Lemhi River Upper (LEMTRP)	Upper Salmon	4d-2021-#24271	OPERATE	Lemhi IMW-Stacey Meyer	
8	Hayden Creek (HYDTRP)	Upper Salmon	4d-2021-#24271	OPERATE	Lemhi IMW-Stacey Meyer	
7, 22	Lemhi River Lower (LLRTP)	Upper Salmon	4d-2021-#24271	OPERATE	Lemhi IMW-Stacey Meyer	
IDFG Smolt Monitoring Project (SMP/CSS)						
17	White Bird (SALTRP) [(a)]	Lower Salmon	05-21-FPC-47	OPERATE	Idaho SMP/CSS-Scott Putnam	Permitted (LOD) through FPC
18	Lewiston (SNKTRP) [(a)]	Lower Snake	05-21-FPC-47	OPERATE	Idaho SMP/CSS-Scott Putnam	Permitted (LOD) through FPC

[(a)] White Bird and Lewiston are scoop and dipper traps, respectively, and not rotary screw traps.

Table 2. Plan for contracts and operations of IDFG adult weirs relative to sampling wild and integrated fish released at each weir in 2021. Scale and genetics sampling for steelhead and Chinook Salmon are indicated.

	Wild and Integrated Adult Sampling at Hatchery and Research Weirs							
	Steelhead				Spring-Summer Chinook Salmon			
IDFG Adult Weir (Map #)	**Collect Scale Sample ?**	**Collect Genetic Sample ?**	**NOAA Adult Permit**	**2021 Contract & Operator**	**Collect Scale Sample ?**	**Collect Genetic Sample ?**	**NOAA Adult Permit**	**2021 Contract & Operator**
Sawtooth (9)	Yes	Yes	HGMP	ISSMES-Sawtooth FH	No	Yes	HGMP	INPMEP-Sawtooth FH
EFSR (19)	Yes[a]	Yes	HGMP	ISSMES-Sawtooth FH	N/A[b]	N/A[b]	N/A[b]	N/A[b]
Pahsimeroi (10)	Yes	Yes	HGMP	ISSMES-Pahsimeroi FH	No	Yes	HGMP	INPMEP-Pahsimeroi FH
Lemhi River (22)	N/A[c]	N/A[c]	4d-2021-#24271	Lemhi IMW-Stacey Meyer	No[c]	Yes[c]	N/A	Lemhi IMW-Stacey Meyer
Hayden Creek (8)	N/A[c]	N/A[c]	N/A[c]	Lemhi IMW-Stacey Meyer	N/A[c]	N/A[c]	4d-2021-#24271	Lemhi IMW-Stacey Meyer
Bear Valley Creek (34)	N/A[c]	N/A[c]	N/A[c]	Lemhi IMW-Stacey Meyer	N/A[c]	N/A[c]	4d-2021-#24271	Lemhi IMW-Stacey Meyer
Twelve Mile Creek (25)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	N/A
Poison Creek (26)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	N/A
Carmen Creek (27)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	N/A
Tower Creek (28)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	N/A
Fourth of July Creek (29)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	N/A
Iron Creek (30)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	N/A
Cow Creek (33)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	Not operated
Challis Creek (31)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	Not operated
Morgan Creek (32)	Yes	Yes	4d-2021-#24294	Region 7-Megan Heller	N/A	N/A	N/A	Not operated
McCall SFSR (20)	Yes[d]	Yes[d]	HGMP	ISMES-Josh Poole	No	Yes	HGMP	ISSMES-McCall FH
Rapid River (1)	Yes[d]	Yes[d]	HGMP	ISSMES-Vacant	No	Yes	HGMP	ISSMES-Rapid River FH
Hells Canyon Oxbow (24)	Yes	Yes	HGMP	ISSMES-Oxbow FH	No	Yes	HGMP	ISSMES-Oxbow FH
Powell (21)	N/A[d]	N/A[d]	N/A	N/A	No	Yes	N/A[e]	ISSMES-Clearwater FH
Fish Creek (15)	Yes	Yes	4d-2021-#24258	ISSMES-Nolan Smith	No	Yes	N/A[e]	ISSMES-Marika Dobos
Red River (23)	N/A[d]	N/A[d]	N/A	N/A	No	Yes	N/A[e]	ISSMES-Clearwater FH
Crooked River (13)	Yes[d]	Yes[d]	4d-2021-#24258	ISSMES-Brian Knoth	No	Yes	N/A[e]	ISSMES-Clearwater FH
EF Potlatch River (12)	Yes	Yes	4d-2021-#24258	Potlatch IMW-Brian Knoth	No	Yes	N/A[e]	Potlatch IMW-Brian Knoth

[a] EFSR steelhead scales should be collected from all wild fish trapped; scales not needed from hatchery fish.
[b] EFSR hatchery rack not generally operated for Chinook broodstock collection; 2014 last year of biosampling for Captive Chinook project.
[c] Lemhi River weir is not a full escapement weir, anticipate capturing roughly half of the total return; Hayden and Bear Valley Creek weirs are operated for bull trout in September, anticipate Chinook incidental catch.
[d] Hatchery rack not generally operated for steelhead broodstock collection; opportunistic biosamples at McCall SFSR.
[e] Spring/summer Chinook are not listed in the Clearwater drainage and sampling them does not require a NOAA permit.

Table 3. Checklist for Chinook Salmon at IDFG hatchery weirs.

		CHINOOK SALMON AT IDFG HATCHERY WEIRS					
	To Do: (see footnotes below for why)	**TRAPPED - Record length, sex, marks and tags from all fish trapped**	**POND MORTS, GIVEAWAYS, OUTPLANTS - Record data according to weir protocols**	**SPAWNED MORTS**			
		RELEASED ABOVE WEIR Ad Intact (UNM), with or without CWT		BROOD Ad Intact (UNM), without CWT	BROOD Ad Intact (UNM), with CWT	BROOD Ad Clip, with CWT	BROOD Ad Clip, without CWT
(1)	Opercle punch (OP)	ALL	Recycled (different OP than released above weir)				
(2)	Collect tissue sample	ALL	UNM (and IBS at Sawtooth, Pahsimeroi, and SF Salmon/McCall)	ALL	ALL	ALL	ALL
(3)	Collect dorsal fin ray sample			ALL			
(4)	Collect snout		20 JACKS (CWT lab request)				
(5)	Collect snout AND dorsal fin ray sample				30 KNOWN AGE - 10 FROM EACH AGE GROUP TO BE PAIRED WITH CWT SAMPLE (based on standard length cut-offs, hatchery defined). Can also be collected from pond morts or giveaways to achieve desired sample size.		
(6)	Collect scale sample						

(1) Opercle punches are needed for any fish released above the weir to enable mark/recapture estimates of weir efficiency and total spawner abundance. Recycled fish are punched on the opposite opercle to distinguish them from newly arrived fish returning to the weir.

(2) Fin clip tissue samples are used to establish parentage based tagging (PBT) genetic baselines for hatchery fish. They are also used to age and assign returning fish to their appropriate parents and to their hatchery stock of origin or release group. Tissue samples from wild fish are used to derive genetic diversity information.

(3) Dorsal fin ray samples are used to assign age to returning fish. They should not be collected from live fish, only morts or carcasses. Both wild and hatchery Chinook can be aged using these samples. Fin rays are not commonly used to age steelhead or sockeye.

(4) Snouts are collected from a sample of fish that have a coded wire tag (CWT). These tags are used to assign hatchery stock of origin, release group, and age. These can be collected from spawned broodstock, pond morts, or giveaways.

(5) Snouts are collected from a sample of fish that have a coded wire tag (CWT). These tags are used to assign hatchery stock of origin, release group, and age. When paired with a fin ray sample, these tagged fish are used for fin ray age validation since their absolute age is known from the CWT. These can be collected from spawned broodstock, pond morts, or giveaways.

(6) Scale samples are used to assign age to returning fish. They should not be collected from Chinook at hatchery weirs or on the spawning grounds due to their degraded condition. Scale samples should be collected from wild steelhead returning to and passed above the weir. In general throughout Idaho, only wild and not hatchery steelhead can be accurately aged using scales.

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