FISHERY RESEARCH

IDAHO CHINOOK SALMON SPAWNING GROUND SURVEYS: PROTOCOL AND HISTORIC TRENDS

Photo: Bruce Barnett

Prepared by:

Timothy Copeland, Fisheries Program Coordinator
William C. Schrader, Principal Fisheries Research Biologist
Bruce Barnett, Fisheries Data Coordinator
Micah T. Davison, Fisheries Biologist
Kimberly A. Apperson, Fisheries Biologist
Matthew Belnap, Fisheries Biologist
Evan Brown, Senior Fisheries Data Coordinator
Eli A. Felts, Fisheries Biologist

IDFG Report Number 19-16
October 2019

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William C. Schrader
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Micah T. Davison
Kimberly A. Apperson
Matthew Belnap
Evan Brown
Eli A. Felts

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

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ABBREVIATIONS AND ACRONYMS

BPA	Bonneville Power Administration
BY	Brood Year
CI	Confidence Interval
CWT	Coded Wire Tag
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
HOR	Hatchery Origin
ICTRT	Interior Columbia Basin Technical Recovery Team
IDFG	Idaho Department of Fish and Game
INPMEP	Idaho Natural Production Monitoring and Evaluation Project
ISS	Idaho Supplementation Studies
LSRCP	Lower Snake River Compensation Plan
MPG	Major Population Group
NMFS	U.S. Department of Commerce, National Marine Fisheries Service
NOR	Natural Origin
PIT	Passive Integrated Transponder
RPA	Reasonable and Prudent Alternatives
USFS	U.S. Forest Service
VSP	Viable Salmonid Population

Suggested citation:

Copeland, T., W. C. Schrader, B. Barnett, M. T. Davison, K. A. Apperson, M. Belnap, E. Brown, and E. A. Felts. 2019. Idaho Chinook Salmon spawning ground surveys: protocol and historic trends. Idaho Department of Fish and Game, Annual Report 19-16, Boise.

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ABSTRACT

A key part of a fisheries management program is the proper assessment of the abundance and character of the spawning population. For anadromous salmonids, such assessments are often conducted while the fish are on the spawning grounds and most easily available for enumeration and sampling. The Idaho Department of Fish and Game (IDFG) developed a program several decades ago to index annual spawning escapement by enumerating salmon redds in selected transects. However, the information needs for fisheries management have changed greatly since the program was initially conceived and implemented. Our goals in this report were to recount program history, to describe the current status of the methodology, present trends in redd counts through 2017, and discuss how the program should move forward. We documented current methods from field planning, to survey implementation, to data quality control and archiving. We also reported the trends in redd counts from 1957 through 2017. The IDFG redd count data series now spans seven decades. Data sets of this length are extremely rare and valuable. In this report, we updated the draft guidance for spawning ground surveys that had been used for the last 25 years. The trends formerly reported have been extended and presented in the current population assessment framework. We anticipate that this protocol will be reviewed and updated in 10 years, especially if assumption testing show that changes are needed. A particular program focus should be data archiving and sharing in the evolving information world. What should not change is the value of the core data series for tracking the status of Idaho's spring/summer Chinook Salmon (*Oncorhynchus tshawytscha*) populations for conservation and fisheries management purposes.

Authors:

Timothy Copeland
Fisheries Program Coordinator

William C. Schrader
Principal Fisheries Research Biologist

Bruce Barnett
Fisheries Data Coordinator

Micah T. Davison
Fisheries Biologist

Kimberly A. Apperson
Fisheries Biologist

Matthew Belnap
Fisheries Biologist

Evan Brown
Senior Fisheries Data Coordinator

Eli A. Felts
Fisheries Biologist

INTRODUCTION

A key part of a fisheries management program is the proper assessment of the abundance and character of spawning fish in the populations of interest. For anadromous salmonids, such assessments are often conducted while the fish are on the spawning grounds and most easily available for enumeration and sampling. Biologists may enumerate the spawning population by counting the redds made by spawning females (Gallagher et al. 2007), counting live fish moving past fixed locations (e.g., Maxwell 2007; Woody 2007; Zimmerman and Zabkar 2007), or counting fish throughout a spawning reach (Crawford et al. 2007a; Jones et al. 2007). Enumeration techniques are typically supplemented with biological information from live fish collected by seining or other netting methods (e.g., Hahn et al. 2007) or by sampling the carcasses of semelparous species (Crawford et al. 2007b). In some cases, sampling techniques may be used in combination to generate mark-recapture estimates. The choice of techniques for a management program is usually driven by information requirements and logistics.

In Idaho, it is difficult to census all potential spawning tributaries due to the large geographic area available to anadromous fish and because of difficulty accessing spawning grounds in remote and rugged wilderness areas. For these reasons, several decades ago, the Idaho Department of Fish and Game (IDFG) developed a program to index annual spawning escapement by enumerating salmon redds in selected transects. However, the information needs for fisheries management have changed greatly since the program was initially conceived and implemented. Our goals in this report were to recount program history, to describe the current status of the methodology, present trends in redd counts through 2017, and to discuss how the program should move forward.

History of Spawning Ground Surveys in Idaho

Spawning ground surveys of salmon in Idaho began 70 years ago when funding support became available from a number of sources. Work was initially supported by grants from the Bureau of Reclamation, US Department of the Interior, and the US Army Corps of Engineers (COE) to conduct studies relevant to salmon and steelhead fisheries that might be impacted by dam construction projects on the Columbia and Snake rivers (Parkhurst 1950; Zimmer 1950; Hauck 1953a). Most spring Chinook Salmon (*Oncorhynchus tshawytscha*) records from this work apparently have been lost except for the final report (see Table 2 in Hauck 1953a). The COE project was continued during 1953-1955 (Pirtle 1957) to determine number, seasonal occurrence, and final distribution of adult salmon and steelhead in the Snake River and Columbia River above its confluence with the Snake River with IDFG as the lead agency.

The spawning ground survey program was supported for many years through the Dingell-Johnson (DJ) Act as part of the Salmon and Steelhead Investigations Project. This project began in 1951 to collect information for the purpose of fisheries management (see Hauck 1951). Work was conducted to estimate spawning escapement in Idaho to manage fisheries and estimate fishery potential as well as to assess spawning distribution relative to suitable habitat. For example, in Mallet's (1977) coordination report on DJ research projects conducted by IDFG, he stated, "Each year regional fishery biologists survey major Chinook Salmon spawning areas in their respective regions to count the number of redds constructed in trend count areas and to obtain age and sex composition data. The data are made available for trend analysis, management, and research use." These activities still form the core of today's spawning ground survey program. The Salmon and Steelhead Investigations Project also addressed other issues relevant to anadromous fisheries management, such as development and evaluation of survey techniques (e.g., Ortmann and Richards 1965) and investigation of population production (e.g., Bjornn 1978).

Spawning ground surveys were also supported by other sources. Surveys in the Salmon and Weiser river drainages after 1956 were continued with support from the Columbia River Fisheries Development Program (US Fish and Wildlife Service, Bureau of Commercial Fisheries) to evaluate conservation and enhancement of anadromous fisheries (Metsker 1958; Delarm and Wold 1986), although the focus of study in Idaho was switched to re-introduction of salmon into the Clearwater drainage during the 1960s (see Hoss 1970). In the 1980s, support became available as a result of the Pacific Salmon Treaty and the Lower Snake River Compensation Plan (see White and Cochnauer 1989). In the 1990s, funding began to come from the Bonneville Power Administration to do redd counts associated with salmon supplementation research (the Idaho Supplementation Studies [ISS]; Bowles and Leitzinger 1991). Today, spawning ground surveys are still conducted with support from many of the past sources. Each source had a slightly different emphasis, which expanded the scope of the spawning ground survey program, but the core mission remained the same.

The most consistent species of focus for spawning ground surveys conducted by IDFG has been spring/summer Chinook Salmon. Surveys have also been conducted on fall Chinook Salmon and Sockeye Salmon (*O. nerka*) but these have been much more limited in scope. Efforts have been made to survey spawning steelhead (anadromous *O. mykiss*), but these often have proven ineffective (Pirtle 1957; Thurow 1985). A description of selected significant events and results of the spawning ground survey program follows.

Survey implementation evolved over time. Initially, surveys were aerial counts conducted from fixed-wing aircraft with checks to verify accuracy by ground counts in selected areas (Hauck 1951). Ground counts were made by walking the bank, wading the stream, or floating in a raft (Hauck 1954). Fall Chinook Salmon surveys were a combination of aerial and ground surveys, with experimental use of aerial photographs to count large aggregations (Pirtle 1957). The initial focus of spring Chinook Salmon surveys was on the important spawning reaches of the Salmon River basin, but soon expanded to include the Weiser River drainage. Fall Chinook Salmon redds were counted in the Snake River from Swan Falls Dam to Lewiston, with the focus being the production areas upstream from the Brownlee and Oxbow dam sites. At first, surveys were conducted after most spawning was completed (mid-September for spring and summer Chinook Salmon) but it was recommended to survey soon after the peak of spawning in headwater streams because of the likelihood that grazing livestock would muddy the water or obliterate redds (Hauck 1951). It was also concluded that surveys in streams with basaltic geology should be made while redds were easily distinguishable, which was soon after the peak of spawning (Pirtle 1957). Verification that the survey was in the desired time window was assessed by presence of live fish and condition of redds (distinct or indistinct).

The number of surveys per reach per season also fluctuated through time. Multiple-pass ground counts (up to 6 passes) were instituted during the later COE study (Pirtle 1957). This tactic was particularly important for fall Chinook Salmon, which have a more extended spawning period than spring-run populations. One of the initial program goals was to describe the accumulation of redds during the season and the final count was usually made soon after peak spawning. Spring Chinook Salmon spawning had a shorter spawn period and so the peak count carried most of the information about spawning escapement.

Based on Pirtle's (1957) findings, spring Chinook Salmon surveys after 1956 were done with a single-pass, downstream aerial survey timed to follow peak spawning (Metsker 1958).

Some reaches were flown twice if the concentration of redds or weather made counting difficult or if the appearance of fish or redds indicated peak spawning hadn't occurred yet. A limited number of ground counts were done to check accuracy and adjust the aerial count if necessary. Date ranges were proposed based on the observed time of peak spawning. Data summaries were recorded by reach on maps in report appendices, beginning with Metsker (1958) and continuing in subsequent reports. This reporting structure facilitated tracking trends in salmon abundance as reaches were added or dropped (Ortmann and Richards 1965). Over time, some aerial counts were converted to ground counts for safety and efficiency reasons, typically where canyons were narrow or there was heavy tree or brush cover over the stream. As the number of ground counts grew, combined aerial and ground counts were used if the entire stream could not be counted from the ground because typically more redds would be observed from the ground than from an airplane (Bjornn 1961). The first record of helicopter use for a spawning ground survey in Idaho was in the Lemhi River in 1961 because there were too many redds to count from an airplane (Bjornn 1961).

Although IDFG relied on aerial surveys in many areas, biological data from carcasses were also important. This information included age, length, sex, gonad condition (percentage spawned), evidence of diseases, and the presence of marks or tags. Sex ratio of carcasses was found to change during the spawning season, resulting in a biased sex-ratio estimate if carcasses are collected only once (Richards 1960); therefore, it was recommended to survey all streams at least 3 times (before, during, and after peak spawning) to obtain a representative carcass sample (Bjornn and Richards 1961). Over time, carcass collections were focused on key index reaches so that biological data could be obtained most efficiently.

Data from the spawning ground surveys were used for fisheries management. Total spawning escapement was estimated from combined ground and aerial surveys as expanded for the sex ratio, assuming each spawning female makes only one redd. Aerial counts were assumed to cover all suitable spawning habitat and were adjusted for efficiency as measured by comparison to ground counts. If no aerial count was available, ground counts were expanded for un-surveyed habitat. A conservative estimate of abundance was made based on the sex ratio from trapping and sport catch (Hauck 1953b). Spawning escapement and harvest were used to estimate exploitation rate, from which fishery management decisions were made (see Hauck 1953b). Several research projects were conducted to improve the quality of this information (e.g., Ortmann and Richards 1965). Thus, spawning ground surveys have been a functional part of fisheries management in Idaho since the early 1950s.

During the 1960s and 1970s, the IDFG spawning ground survey program changed dramatically as Idaho's salmon populations declined. Surveys for fall Chinook Salmon in the Snake River by IDFG ceased after 1962. In the Weiser River drainage, spring Chinook Salmon redd counts declined from 71 in 1960 to 2 in 1963 (Bjornn et al. 1964), after which surveys ceased. The first redd surveys in the Clearwater River drainage started in 1966 to assess the success of eyed egg plants in the Selway River drainage, although a remnant endemic run in the upper Lochsa River drainage was also noted (Hoss 1970). Redd counts and carcass surveys were included in the trend analysis during 1969 for selected Clearwater River tributaries (Crooked Fork and Selway River; Welsh et al. 1970) to evaluate re-introduction efforts. In the Salmon River drainage, several survey reaches were dropped in the 1970s and 1980s as spring/summer Chinook Salmon runs declined following construction of hydroelectric dams on the Snake River in Washington State. Multiple pass surveys for carcasses were conducted in the upper Salmon River to evaluate efforts to supplement the population (Reingold 1968). Helicopters were used to cover reaches more efficiently at low escapements but consequently the number of carcasses collected declined. Eventually, spring/summer Chinook Salmon in the Salmon River basin were listed as threatened under the Endangered Species Act in 1992.

To provide a rigorous assessment of the population trends leading to ESA listing, Hassemer (1993a) reviewed and conducted quality control on redd count data for Chinook Salmon from 1957 through 1992. All historic redd count data were re-examined to verify accuracy and inadvertent errors made in previous reports were corrected. Expansions of redd counts were eliminated from the record and only the observed counts within the standardized transects were retained. Detailed appendices were provided describing transect boundaries, count method, recommended timing, and documentation of changes made through the years. This work provided the basis for consistent annual reporting of redds counted in each trend area beginning in 1957. Subsequent reports were built on this foundation (Riley and Elms-Cockrum 1995; Elms-Cockrum et al. 1995; Elms-Cockrum 1996, 1997, 1998, 1999; Brown 2002). Reporting on the series ceased after Brown (2002).

After ESA listing, a number of new projects began to assess spawning escapement and to evaluate conservation measures. Surveys by the US Forest Service of all accessible spawning habitat began in the Middle Fork Salmon River drainage during 1995, providing a complete census for this important drainage (Thurow 2000). The ISS project assumed many of the duties for spawning ground surveys beginning in the early 1990s (Walters et al. 1999). Surveyed areas were expanded from the traditionally-surveyed transects and multiple passes were employed to measure total redd production for ISS. Aerial surveys were used only where logistically necessary. Some 30 streams were surveyed as part of ISS. Multiple pass surveys were conducted in the West Fork Yankee Fork and East Fork of the Salmon River (Hassemer et al. 1999). Carcass surveys were also prioritized to assess age, sex, and spawner origin and to evaluate efforts to supplement the threatened salmon populations. Spawning ground surveys were conducted to identify spawning locations and to establish spawner fidelity to adult release location (e.g., Abrams and Hassemer 2003). In the early 2000s, ISS personnel began to routinely georeference redds using global positioning systems (GPS). The trend count series and selected carcass data begun by Hassemer (1993a) were reported separately from these conservation efforts. Collaboration and cooperation with other agencies has increased since ESA listing, especially within the multi-agency ISS project. A complete bibliography of Chinook Salmon spawning ground survey reports issued by IDFG is given in Appendix A.

Current Needs and Methodology

Standard survey methods were compiled by Hassemer (1993b) and that summarization has guided spawning ground surveys since the mid-1990s. The program goal up to that time was to provide a useful index of the spawning escapement and subsequent production of anadromous fish. The survey protocol was designed to provide a relative and comparable measure of the number of adults spawning in trend areas each year. Hassemer’s (1993b) purpose was to define a set of redd counting methods that could be followed over time to maintain the consistency and accuracy of redd count data series. However, Hassemer (1993b) was a draft document that was never finalized, even though it has been widely cited and used.

One of the major uses of spawning ground survey data since Hassemer’s (1993a, 1993b) work has been for status reviews conducted under the ESA. A population structure was formalized by Interior Columbia Basin Technical Recovery Team (ICTRT 2003, 2005; Figure 1). Status of these populations is assessed with respect to four parameters: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). There are rigorous guidelines for the collection of data to be used in ESA reviews with respect to unbiased sample designs yielding estimates of known precision and adequate population coverage (Crawford and Rumsey 2011). Abundance of natural-origin spawners (including jacks) by population should be estimated with some measure of precision. Productivity, i.e., recruits per spawner, requires age composition and proportion of hatchery fish. Spatial distribution of redds is needed with respect to population boundaries and suitable habitat. Assessment of phenotypic and genetic diversity requires collection of DNA samples, sex ratios, and lengths. Composition of the spawning population must account for origin type (natural, supplementation, hatchery general production). The historical design of the IDFG spawning ground survey program (Hassemer 1993a, 1993b) did not address all these factors.

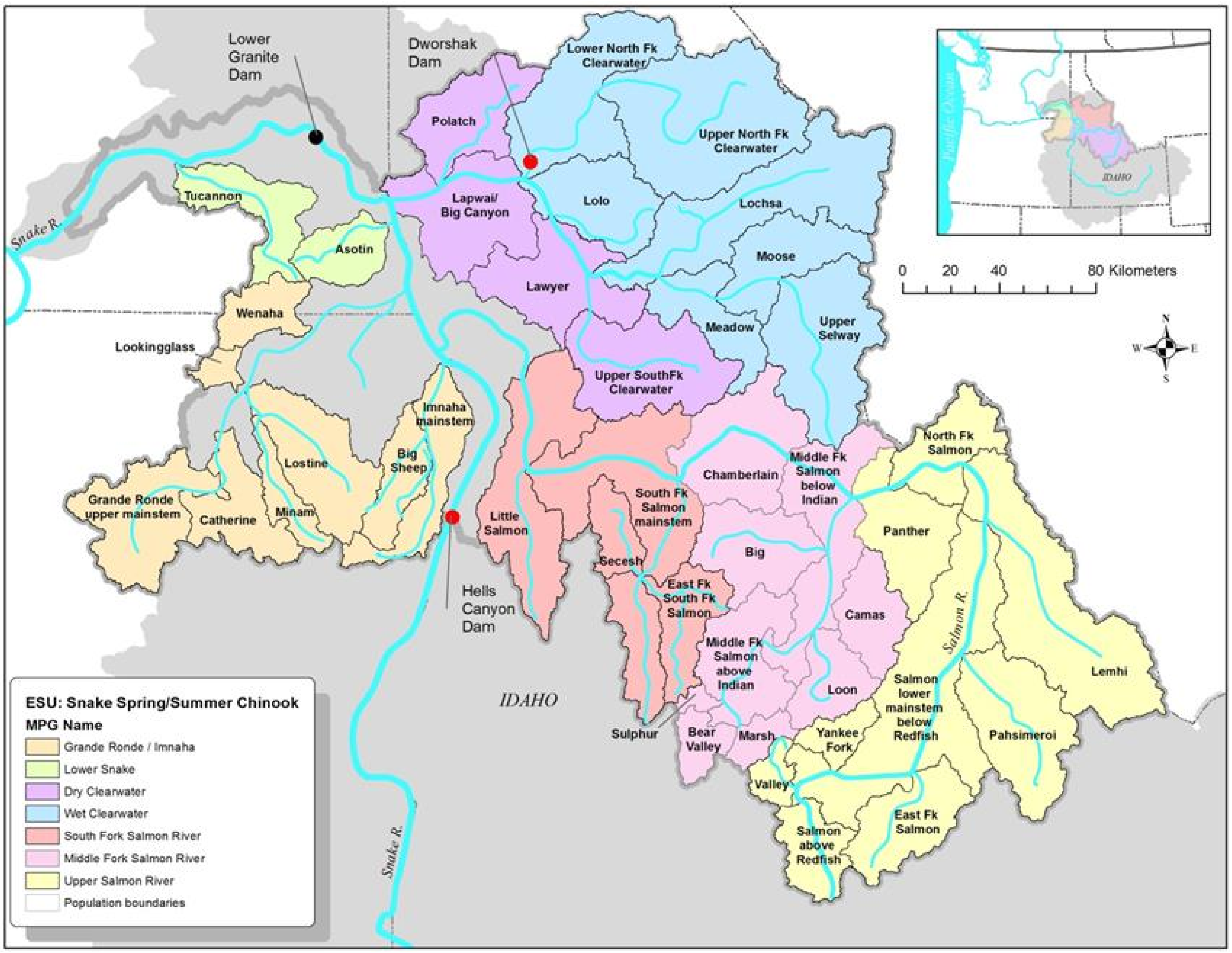


Figure 1. Spring-summer Chinook Salmon populations and major population groups (MPGs) in the Snake River evolutionary significant unit (ESU). Red dots represent impassable dams.

With the increasing amount of data generated by spawning ground surveys came the need to archive the results. Three databases have been built to house different types of data from the surveys. The Spawning Ground Survey database contains the redd count and carcass information. This database also provides the metadata to track changes to timing and length of the historic transects. The BioSamples database contains individual carcass information that is linked to the Spawning Ground Survey database. The Genetic database contains information from tissue samples that have been processed and analyzed. These data are organized and accessible to internal and external biologists for a multitude of purposes.

Much has changed since Hassemer's (1993a, 1993b) summaries and the protocol documentation needs to be updated. Next, we document current methods including survey planning, implementation, and data quality control and archiving. Formal reporting on trend series by IDFG ceased after Brown (2002). Therefore, we update the trends reported historically through the 2017 spawn year in the current population structure rather than the historical groupings. We conclude with a discussion of program direction for the near future. Our intent is to build on the past methodologies in order to better address current and future needs.

METHODS

In this section, we detail the methods used to collect the data for assessment of status and trends of spring/summer Chinook Salmon in Idaho. Much of the material presented has been abridged from Hassemer (1993a, 1993b), as modified and supplemented to reflect current practice. Analysis of data for ESA status review is covered by Felts et al. (2019) and will not be addressed here. Methodology includes redd identification, survey types, field procedures, and data management.

Redd Construction and Identification

In Idaho, spring/summer Chinook Salmon spawn beginning in late July at high elevations and finishing by October in larger rivers and at lower elevations. During this time, the fish leave holding habitat and seek suitable spawning gravels. Surveyors will encounter test digging and redds in various stages of completion. Understanding how redds are located and constructed will help surveyors make accurate identifications.

Redds are located to maximize survival of the eggs. Developing salmon eggs need a continuous supply of flowing water to deliver oxygen and remove metabolic wastes. Females will often select a redd site that has a hydraulic difference or "head" over it, which forces water through the substrate (Figure 2). These sites usually occur where the gravel aggrades at the tail of a pool or run. Chinook Salmon may be more likely to spawn in cleaned or disturbed areas than in undisturbed areas, thus increasing clustering of redds, even in underseeded spawning areas. Hyporheic flow may induce some salmon to spawn in other habitats but most redds are located in predictable areas.

Female salmon begin constructing a redd by digging a small pit in the gravel, which is often referred to as a test redd or test dig. In loose substrates, test redds resemble a circular punch or scoop in the stream bed with the disturbed material deposited immediately downstream. If testing reveals unacceptable conditions, such as bedrock or buried debris, the site likely will be abandoned. If substrate conditions are suitable, redd construction continues and spawning ensues. The initial pit is excavated about 0.3 m to 0.5 m deep. Following egg release and fertilization, the female moves upstream and continues digging, which covers the eggs with gravel. (Figure 2). This process is continued until spawning by the female is complete.

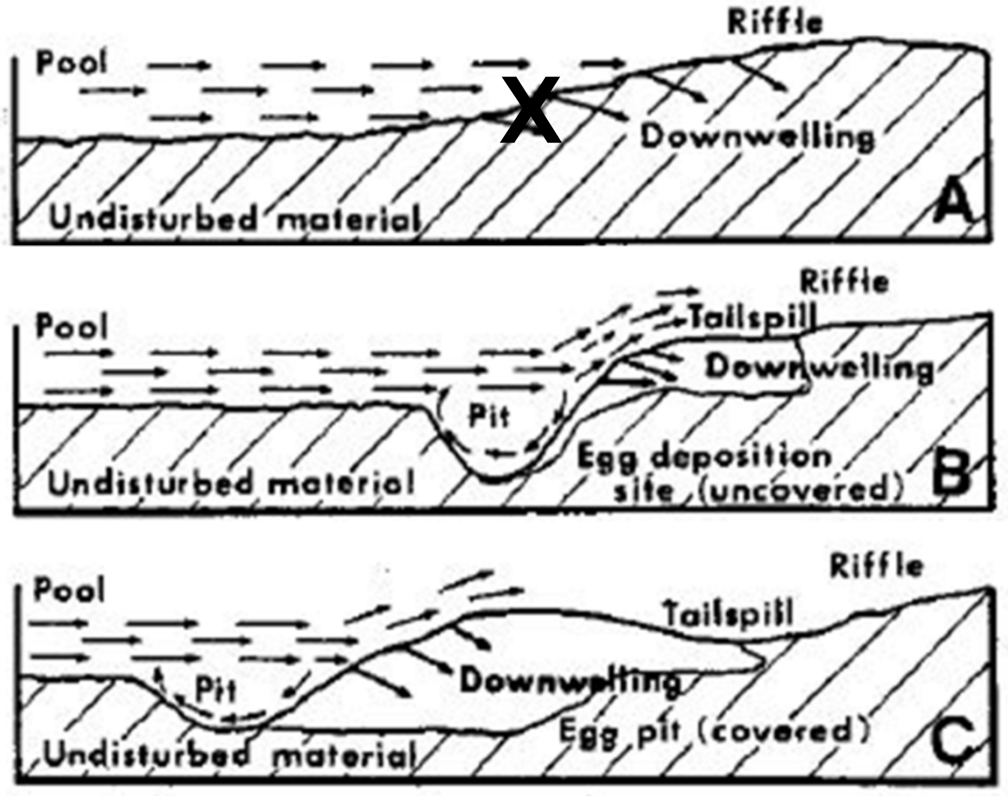


Figure 2. Longitudinal sections of a spawning area (from Bjornn and Reiser 1991). Panel A shows a riffle with downwelling water and a likely redd location marked by X. Panel B shows construction of the first pit prior to egg deposition. Panel C shows covering of the first egg pocket by excavation of another pit, which may be used for the next egg pocket.

The longitudinal profile of a redd from upstream to downstream goes from concave to convex. Redd construction produces a "pillow" or slightly raised area of substrate at the downstream end of the redd, which often raises the water surface over the redd (Figure 3). This pillow acts as a hydraulic control, forcing water down through the redd and past the eggs. The raised water surface over the redd can often be seen from a distance. Sorting of substrate particles results from the water current flushing the particles as the fish disturbs the substrate, such that larger gravels remain closer to the pit and particle size decreases downstream. This action produces a substrate pattern different from nearby undisturbed gravel. After spawning completion, the female frequently dresses up the redd site with weak, low intensity digging upstream and laterally from the redd, resulting in trenches that focus more flow into the redd.

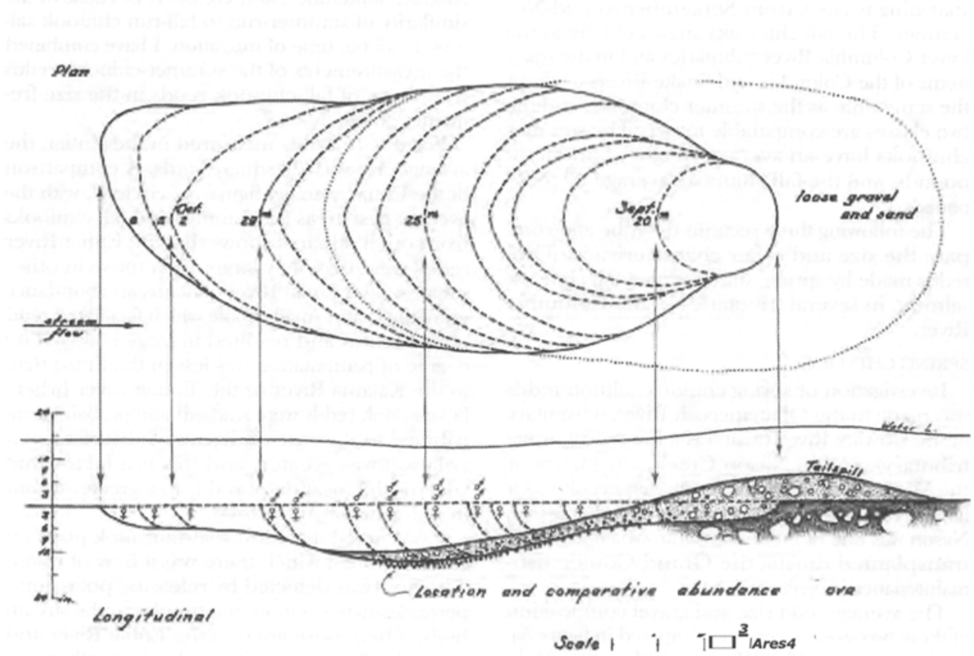


Figure 3. Diagrammatic views of a fall Chinook Salmon redd measured daily (from Burner 1951). Dashed lines mark the daily upstream growth of the redd.

Redds in the advanced stages of construction often assume a characteristic shape and size. The overall shape and size of a redd usually varies as a function of size of the fish constructing the redd, stream width, substrate composition, water velocity, and flow pattern. The classic Chinook Salmon redd is elliptical (Figure 3), but redds can appear circular, ovoid, or elongate (similar to an ironing board). Often, surveyors may see a horseshoe with the arms pointed upstream as the female digs trenches along the sides of the redd to focus flow more effectively. Redd lengths for spring/summer Chinook Salmon in Idaho may be 1.8 m to 5.3 m with an average area of 4.7 m^2 (Thurow 2010). In Washington State, Burner (1951) found average redd area of spring Chinook was 3.3 m^2 and that of summer Chinook was 5.1 m^2. Redd dimensions tend to be a function of female size. However, in systems with patchily-distributed spawning gravels, salmon often spawn in pockets of suitable gravel, which will limit the size of the redd. Conversely, where good gravel is plentiful and loose, a redd may span the entire width of the stream.

Redds can be identified by a process that parallels redd construction. Four features must be present for a streambed feature to qualify as a redd: disturbance, digging, definition, and deposition (the 4 D's, a mnemonic originated by Jason Vogel, Nez Perce Tribe Department of Fisheries Resources Management). Disturbance of the substrate, such as overturned gravel or a pit, indicate a feature for further examination. From a distance, a redd often appears as an area of streambed lighter in color than the surrounding substrate as a result of cleaning of periphyton and silt from the area during construction. Surveyors should be aware that rain may deposit silt or algae may begin to re-grow if survey time lags redd construction, but these processes don't alter other redd features. Digging is defined as an intentional disturbance, i.e., disturbance by a spawning salmon. Definition means the characteristic profile, size, and shape of a redd described above with other associated indicators. Redds have a different particle size distribution than surrounding areas. Rocks and cobble are often found in the center of the pit. The pillow has sorting of substrate with larger particles clean of fine sediments on the upstream side of the pillow and there may be a fringe of sand or fine debris along the lateral and downstream periphery. All these factors must be followed by a judgement of whether eggs have been deposited, the last step in the 4 Ds. If there is a raised pillow with a large tailspill, then most likely it has eggs in it. Test digs can be identified by their small size, the presence of fine sediment and periphyton in the immediate vicinity, and embedded gravel around the test pit. Test digs do not have a pillow of sorted gravel downstream of the pit, characteristic of true redds, and should not be counted as redds.

Redds are enumerated individually. When surveyors encounter potential redds superimposed on each other, they should first try to determine the likely chronology of spawning activities and decide if more than one female deposited eggs in the area, either adjacent to or on top of another redd. In general, digging upstream of an egg pocket is used as the next egg pocket (Figures 2 and 3); therefore, we consider each redd to have its own pit-and-pillow structure. The 4-D's process should be repeated for each potential redd. Careful attention to size of the area, number of pits, overlap of pillows, and orientation of the redds or margins of the redds will help in determining the number of redds present. Be careful not to confuse trenching on the side of one redd for the pit of another. When the pits and pillows are sufficiently distinct to indicate they were constructed by different fish, they should be counted as individual redds.

Survey Types

Spawning ground surveys may support different information needs; hence, there are different survey types. These differences have not been fully elucidated before because conservation projects (e.g., ISS) operated somewhat independently of the trend counts conducted by the fisheries managers. Differences arose because trend surveys provided consistency over time but did not meet all needs. In recent ESA evaluations (NWFSC 2015; Felts et al. 2019), data from trend surveys required additional information and assumptions to meet NOAA Fisheries' desire for estimates of total spawner abundance (Crawford and Rumsey 2011). Census surveys provide an estimate of total redd abundance in a survey reach while assuming no error, and have been expanded to estimates of total spawner abundance based on estimates of fish per redd. Additional surveys may be done to address more short-term information needs.

A brief review of past terminology used by Hassemer (1993a, 1993b) is necessary to avoid confusion for more recent applications. In the past, redd counts were summarized by trend areas, which could consist of a number of separate transects. Trend areas were important production areas containing a large portion of available spawning habitat and thus were often similar in scale to the populations delineated by the ICTRT (2003, 2005). Trend areas were classified based on three criteria. The first criterion was survey history: traditional trend areas were areas that had been continuously surveyed since the 1950s in the Salmon River basin or the 1960s in the Clearwater River, whereas nontraditional areas were added to the program during the 1980s. The second criterion was Chinook Salmon stock: spring, summer, or unclassified. The third criterion was hatchery stocking history: wild (no history of hatchery releases), hatchery influenced (ongoing releases to supplement natural spawning), and natural (past hatchery releases but current spawners are naturally produced). This terminology is no longer used for population status assessments and now all transects are grouped into the current population framework (Figure 1) for analysis with hatchery influence indexed by the presence of hatchery fish as carcasses found during surveys. Several populations contain several trend areas lumped across Hassemer's (1993a, 1993b) classes. Hereafter, we use the word 'trend' to denote a single-pass survey conducted annually at a specified time for the purpose of providing an index of abundance. For example, currently we survey Marsh Creek several times annually but only the August 21 survey is the trend survey.

Trend Surveys

Most spring/summer Chinook Salmon populations in Idaho have established trend transects (Appendix B). Maps of all trend transects are provided in Appendix C. Survey methods are detailed below. There are several recent additions to this list in the following populations (stream and transect abbreviation in parentheses): Lower Salmon River (Boulder Creek, NS-34), Upper Middle Fork Salmon (mainstem MFSR, WS-15a, 15b; Rapid River, WS-21; Pistol Creek, WS-22a, Little Pistol Creek, WS-22b; Indian Creek, WS-23, Marble Creek, WS-24), Lower Middle Fork Salmon (mainstem MFSR, WS-15c,d,e), Lemhi River (Hayden Creek, NS-35a,b), and Pahsimeroi River (Patterson Creek NS-33b) populations. Transect boundaries should be constant from year to year but have changed in the past and are under review now. For example, boundaries of some transects in the Selway River drainage are being revised after they were converted from aerial to ground surveys. Currently no redd count trend transects are identified for the following populations in the Clearwater MPG: Lapwai Creek, Potlatch River, Lawyer Creek, or Meadow Creek.

Proper timing of trend surveys is important so that information gathered is comparable among years. Each trend transect was assigned a target date for the survey, selected when the ratio of redds to live fish should be greater than one to one (Hassemer 1993a), subject to logistical constraints (e.g., if a surveyor has multiple streams to survey within a time period). A schedule was first proposed by Metsker (1958) but the criteria for choosing survey dates were not well documented. Timing of some surveys was changed in the early 1960s as survey techniques were evaluated but these changes were not well documented either. The current schedule was taken from Hassemer’s (1993a) Appendix B and is given in Appendix B of this report. Actual survey dates may vary from the target date due to weather conditions but should be completed the week of the target date. We assume that spawn timing has not changed significantly since the target dates were established. Ideally, at the designated survey time, all redds are completed or under construction, fish are in the immediate vicinity, and redds are easily visible. Because the redd count is an index of escapement rather than an absolute measure, surveys should be made close to the target date, just after the peak of spawning activity, and thus data should be comparable from year to year. The ratio of live fish to redds is important to confirm that the survey was conducted near the peak. If extenuating circumstances require the survey to be made outside the seven-day window prescribed, an explanation should be provided in the database and in the annual report.

Methods for counting redds during trend surveys are given in the Field Survey Procedures section. Biological data on spawning salmon are also collected during trend surveys conducted from the ground. Live fish observed are enumerated and data are collected from carcasses. Care must be taken in interpreting sex ratio and length-frequency data collected during trend surveys because carcass information from single-pass surveys is biased (Bjornn and Richards 1961). Additional carcass surveys should be completed to gather sufficient information in trend transects where necessary. Methods for carcass collections are also detailed below.

Census Surveys

Census surveys are designed to be intensive and generally include all probable spawning habitat in the survey area. Streams in intensively monitored populations are typically surveyed three or more times to provide a census of all redds, although census surveys in the Middle Fork Salmon are usually a single pass after spawning is complete. Multi-pass surveys were instituted in many Idaho streams, because total redd production was needed for the ISS project (Bowles and Leitzinger 1991). The need for this type of information continues in some areas. Census surveys are designed to begin and end with spawning activity, thus no live fish or new redds should be observed during the last pass. The number of passes needed may increase during large spawning runs. Multi-pass surveys allow for description of spawn timing, which will be important if peak spawn timing has changed since the 1950s. Multi-pass surveys also allow for recovery of more carcasses than possible in a single-pass design.

Additional Surveys

Additional surveys are conducted in various streams for a variety of reasons such as to collect additional carcasses, to assess prespawn mortality, or to document spawning outside of core spawning reaches. Typically such surveys are intended to supplement information obtained by the other survey types. In general, all additional surveys follow standardized survey protocols described in this document.

Field Survey Procedures

Training

The training session is a vital part of the annual survey season. New personnel learn the procedures. Experienced personnel get an opportunity to re-familiarize themselves with the characteristics of redds and carcasses. Training helps provide continuity of methods and data quality.

Training begins with a group session among the cooperating agencies. Currently, IDFG is hosting the session in alternate years. There are two parts to the session. The first part is an explanation of the purpose, history, and general methods of spawning ground surveys. Personnel are familiarized with gear decontamination procedures. Carcass sampling methods are taught, preferably using deceased hatchery fish. The second part is composed of small groups surveying short reaches under the tutelage of experienced survey leaders. Early spawning populations are selected for this part of the training so that training groups can see spawning fish and redds in various stages of progress. Group leaders point out key features of redds using the 4 Ds mnemonic and indicate natural hydrological features that may be misidentified as redds.

Training should continue through the survey season. It is impossible to teach everything of value during the time limits of a training session. Rather, the purpose of the training session is to show new personnel how to conduct ground surveys and analyze the features that they will see. Surveyors of all levels should know program objectives and keep good field notes. After the training session, new surveyors should be accompanied by an experienced observer for several outings. During this time, it is worthwhile to observe spawning fish and learn their behaviors. In particular, differences in redd characteristics between the training reaches and other streams should be pointed out by personnel familiar with those streams. Increased understanding is valuable for making accurate identifications.

Ground-based Redd Surveys

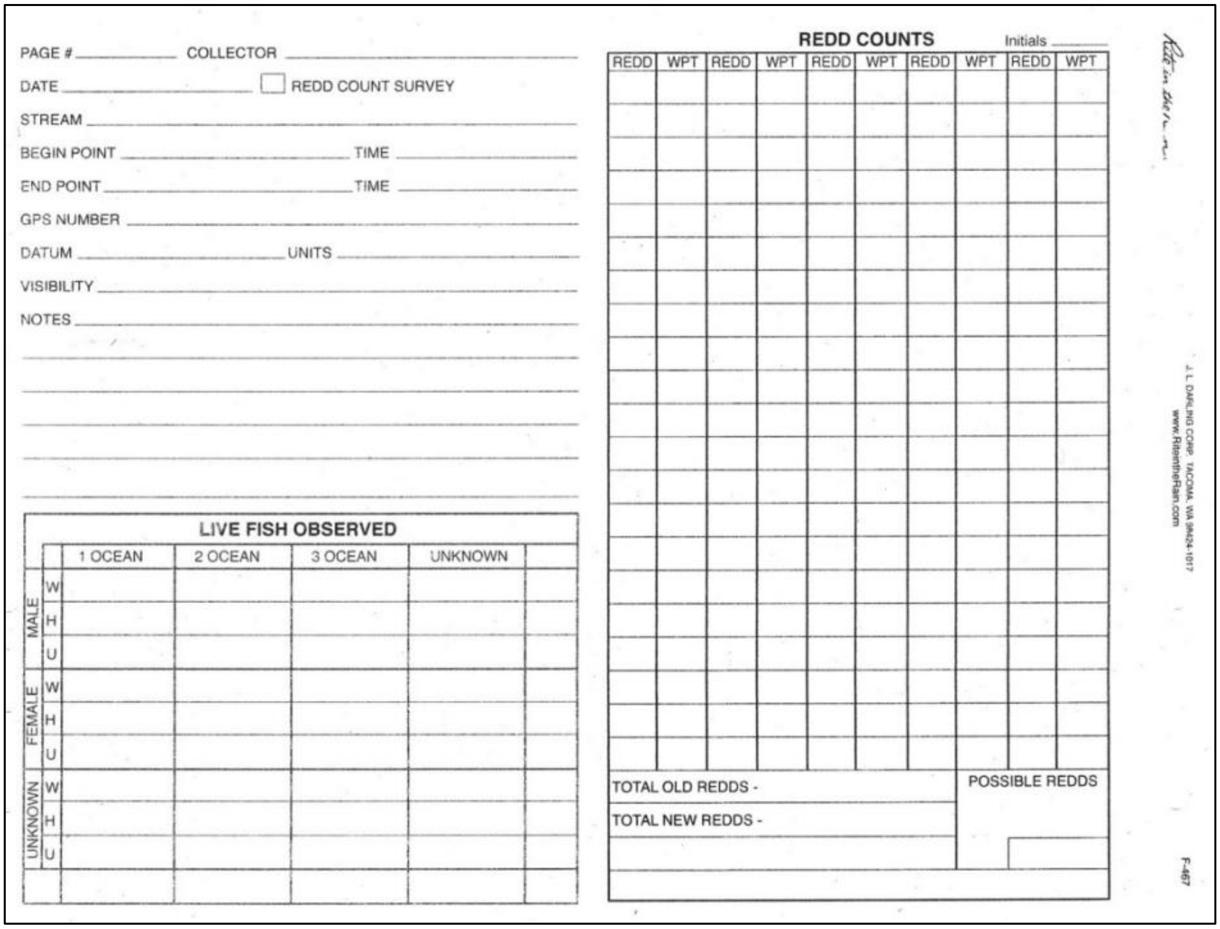
Ground surveys have long been thought to be the most accurate redd count method used in Idaho (Bjornn et al. 1963). Nonetheless, opportunities exist that can cause errors and significant variability unless standard procedures are followed (Thurow and McGrath 2010; Murdoch et al. 2018). Ground counts should be more accurate in streams with abundant vegetative cover that shades and conceals redds from aerial observers. Redds constructed in small streams tend to be near the banks and are difficult to see from the air. In some streams, periphyton is scarce and the contrast between disturbed and undisturbed substrate is indistinct; hence, redds may be undetectable by an aerial survey. However, ground surveys demand considerable time and occur within a limited field season. Surveys on stream reaches longer than 10 kilometers usually require more than one day; therefore, longer transects are often surveyed from the air.

Each survey starts with proper preparation. Prior to going into the field, the survey supervisor determines the transects to be counted by the ground crew. All transect boundaries should be known by the crew members. Current trend transect descriptions and maps for each population are included in Appendices B and C. We recommend the equipment in Table 1 when making ground counts. Polarized sunglasses should be worn to reduce glare from the water so that redds are more easily detected. Crew members should carry a wading staff when walking in streams and wear appropriate footwear (wading boots with ankle support, a firm foot bed, and soles with good traction); these items will help crew members to maintain stable footing throughout a long field day. Global positioning system (GPS) units help find survey boundaries and record locations of redds or other features of interest. Precautionary safety measures such as bear spray may also be appropriate depending on the survey location.

Table 1. Supplies recommended for spawning ground surveys conducted on the ground.

Polarized sunglasses	Sunscreen	Rain jacket
First aid kit	Drinking water	Food for the day
Coded wire tag wand	GPS unit set to WGS84	Extra batteries
Data sheets/tablet computer	Pencils and lead	Sharpie marker
Surveyors flagging	Forceps	Scissors
Serrated knife	Measuring tape (metric)	Carcass sample packets
Snout bags	Wading boots	Wading staff
Handheld PIT tag reader		

Relevant data are recorded during the survey using standard datasheets printed on water-resistant paper (Figure 4) or using a tablet computer. General survey information recorded should include surveyor's name, survey coordinator, date, stream name, beginning and ending points, and GPS metadata such as datum and units. The current IDFG standard GPS settings are WGS84 for datum with latitude and longitude in decimal degrees. A reasonable attempt should be made to enumerate live fish by sex, size category, and whether or not an adipose fin clip is present. The assigned redd number and associated locations are recorded for all surveys. Locations are important for many kinds of survey data and captured with GPS units as waypoints. Multiple pass ground counts will require recording redds already counted and flagged on previous passes, along with the new redds encountered that day.


PAGE # ________ COLLECTOR ________________
DATE ________________ ☐ REDD COUNT SURVEY
STREAM ________________
BEGIN POINT ________________ TIME ________
END POINT ________________ TIME ________
GPS NUMBER ________________
DATUM ________________ UNITS ________
VISIBILITY ________________
NOTES ________________

LIVE FISH OBSERVED

		1 OCEAN	2 OCEAN	3 OCEAN	UNKNOWN	
MALE	W					
	H					
	U					
FEMALE	W					
	H					
	U					
UNKNOWN	W					
	H					
	U					

REDD COUNTS Initials ______

REDD	WPT	REDD	WPT	REDD	WPT	REDD	WPT	REDD	WPT

TOTAL OLD REDDS -
TOTAL NEW REDDS -
POSSIBLE REDDS

J. L. DARLING CORP. TACOMA, WA 98424-1017
www.RiteintheRain.com
F-467

Figure 4. Example of a spawning ground survey data sheet.

Timing during the day of the survey is important. In the field, survey conditions must be conducive to seeing the stream substrate well. Depending on stream orientation, canyon steepness, arid vegetative cover, the appropriate start time is from 0900 to 1030 hours. Counts should be completed by 1800 hours. Unless logistically infeasible, the survey should be done while the sun is in a position to provide for good visibility and contrast. Surveys should not be done on extremely overcast, rainy, or windy days because visibility is significantly reduced under these conditions.

The direction of the survey (upstream or downstream) must be known before starting. Trend surveys are almost always downstream, which survey supervisors should verify from past surveys of each specific transect. In other cases, several factors should be considered to decide survey direction. Travel in steeper and larger streams is easier downstream, facilitating a more logistically efficient survey. However, redds and fish are more easily seen while moving upstream. Moving upstream also minimizes disturbance to spawning fish, eliminating the effects of sediment disturbance on visibility for the surveyors. For logistical efficiency, crews may divide the transect based on length, timing, access points and survey in the direction(s) necessary for timely survey completion. Previous knowledge of the survey transect will help determine survey direction.

Conducting a spawning ground survey from the ground is not complicated in concept. The observer moves in or near the stream in a manner that allows good visibility of the streambed and both banks. Usually surveys are done by foot but in a few cases, watercraft may be used. Each stream presents its own set of difficulties, such as being too steep and turbulent to wade for extended distances, dense vegetation preventing good visual coverage from the bank, or the stream is so wide that the entire width is not visible from one position. Surveyors should take advantage of the area between the vegetation and waterline and use high banks for better visibility. As necessary, follow game trails through dense cover, frequently accessing the stream or traverse the stream in a zig-zag fashion to obtain complete visual coverage. Wading in streams with large amounts of fine sediment is not advised. Where possible, the sun should be at the surveyor's back or overhead to reduce glare.

Safety is first. Surveyors must work safely as a team. Surveys should be done in pairs for safety, especially in remote and rugged terrain, and for better visual coverage of the stream. Partners should monitor each other's progress. Radios or other communication devices should be used to maintain contact if surveyors must split up. Field packs should have an adequate first aid kit. Proper protective footwear is required at all times, and good wading boots must be worn in and around the water. Wading boots with felt, sticky rubber, and/or cleated bottoms work well; however, cleats tend to slip on dry granite boulders and wet logs. A walking staff is helpful for finding and maintaining stable footing in the stream and on the bank. Crews must be particularly cautious about getting feet entrapped between rocks or debris or getting caught on debris when travelling downstream. Beaver holes in banks are often invisible in brush and high grass. ***A successful survey day is when everyone returns to the trailhead or camp safely.***

There are several techniques that can increase the efficiency of a survey. Two or more observers can divide a transect into smaller segments and complete the survey by leap-frogging one another. A vehicle can be used to reduce travel time to the next segment to be surveyed. Females on redds are often easily visible because of the white color of their caudal fin, which becomes bleached and worn from digging in the gravel. Redds near riffles often exhibit a hydraulic jump that can be seen from a short distance. When a potential redd is found, surveyors should approach and apply the 4 Ds criteria. Move around to obtain more than one viewpoint while evaluating with the 4 Ds but avoid disturbing brooding females as much as possible. When a redd is identified and confirmed, the redd is assigned a unique number and location is recorded using a GPS unit.

Census surveys are completed during 3-5 passes using the procedures outlined above. Passes are usually completed a week apart but may be made at shorter intervals. Redds are recorded as new or previously observed redds. Redds observed during census surveys are flagged; flags are removed during the last pass. Test digs are not counted but may be flagged because they may become redds later. Multiple-pass ground surveys allow observations throughout redd construction and this experience aids in redd identification. For streams that are surveyed multiple times on the ground, the final redd count is the sum of all new redds observed during each pass.

Ground surveys also allow enumeration of live fish and processing of carcasses. Live fish are classified into one of several categories (see bottom left panel in Figure 4). If possible, determine the sex of the fish and if it is wild (adipose fin intact) or hatchery-origin (adipose fin missing). Any fish less than 61 cm (24 in) is considered a jack. Fish greater than 81 cm (32 in) are recorded as a 3-ocean fish; others are recorded as 2-ocean. If surveyors are not positive of the appropriate category, use the Unknown category as necessary. Basic physical data are taken from carcasses found during the survey. Additionally, surveyors can recover information from tags, and determine the presence of fin clips, brands, and coded-wire tags. More detail is given in the Carcass Data Collection section below.

Aerial Redd Surveys

Aerial surveys are done when ground surveys cannot be done in a timely, efficient, and economical manner. Aerial redd identifications are easily and accurately made in streams or rivers that show high color contrast between disturbed and undisturbed substrate. Survey time requirements are greatly reduced through the use of aerial technologies. The cost of an aerial survey in remote areas can be expensive; therefore, several transects should be surveyed together to justify the use of aircraft. Experience is required to count redds in a consistent manner from aircraft. Prior to serving as the primary observer for aerial redd counts, observers should have several years' experience with ground surveys.

The scope and nature of aerial surveys by IDFG has changed through the years. Until the 1980s, the bulk of spawning ground surveys were done from the air using small fixed-wing aircraft. Now, fixed-wing aircraft are rarely used for reasons of safety and efficiency. Over the years, some transects surveyed from the air have been converted to ground surveys. Most recently, aerial transects have been surveyed by helicopter, and those methods are detailed below. However, helicopter surveys are in the process of being reduced because of safety and funding concerns. Survey methods using Unmanned Aircraft Systems (UASs) are now in development. Our initial recommendations for UAS methods follow.

UAS Methods

There are legal requirements that must be met for IDFG personnel to survey using a UAS. A Remote Pilot in Command (RPIC) certificate from the Federal Aviation Administration (FAA) is currently required for public agency personnel supervising a UAS flight or survey. Unlicensed personnel may operate a UAS only while in the presence of a licensed RPIC, who is responsible for mission operations. A standardized exam is required to obtain RPIC certification. Additional information regarding the exam and certification can be found on the FAA web site (https://www.faa.gov/uas/getting_started/part_107/remote_pilot_cert/).

Currently, UAS pilots must adhere to seven FAA guidelines:

1. Register the UAS with the FAA before flights.
2. Obtain a Remote Pilot in Command certification from the FAA.
3. Fly a UAS under 55 lbs.
4. Fly within visual line-of-sight.
5. Don't fly near aircraft or over people.
6. Don't fly in controlled airspace near airports without FAA permission.
7. Fly only during daylight or civil twilight at or below 400 feet.

A waiver for guidelines number four through seven can be applied for and granted by the FAA. The FAA recommends the use of standard checklists for all aspects of manned and unmanned flight; the importance of these cannot be overstated. We recommend several steps for safe operations and necessary equipment for spawning ground surveys by UAS conducted by IDFG personnel (Table 2).

Table 2. Checklist for safe operations and equipment needed during UAS spawning ground surveys.

Safe operations	Equipment
Determine airport proximity	UAS with visible registration number
Contact airport if flying within 5 miles	RPIC certification card
Check for temporary flight restrictions	Battery charger(s) for UAS
Contact Fire Incident Command posts	Remote controller
Review emergency contacts list	Charger for remote controller
Notify landowners (if necessary)	Tablet computer
Review operator/observer travel plans	Tablet-controller cable
Road use during flight (dirt/paved/highway)	Power inverter
Review flight path	SD cards (2 per UAS)
Length of survey transect(s)	Extra UAS batteries
Length of flights	Polarized filter for UAS camera
Anticipated number of battery changes	Laptop computer
Overhead obstacles identified	External hard drive
Determine availability of cell phone service	Aerial imagery cached to tablet
Review crash notification protocol	Updated firmware
Check power supplies	Tablet, UAS, batteries, controller
UAS batteries, tablet, remote controller	Extra propellers
Conduct operations briefing	Flight log
Takeoff/landing zones	
Identify risks such as trees, power lines, air traffic, bird strikes	
Flight over people not associated with the project	
Inspect airframe, motor, propeller	

Preflight planning is vital. This step defines the operations and expected outcomes for the survey. All surveys should consist of at least one team (i.e., an operator and one or more observers, including the RPIC). Larger operations may necessitate multiple UAS teams depending on the stream distance and characteristics; each team must have at least one qualified RPIC. For planning purposes, a useful on-line tool is B4UFly (https://www.faa.gov/uas/where_to_fly/b4ufly/). This application uses cell phone location data to determine proximity to controlled airspace. The RPIC should coordinate with airport controllers if surveys are expected to overlap with any airport airspace, even if the airports are small or regional. Temporary flight restrictions may be in place near wildfires. The distance that can be surveyed by a single UAS varies with canopy cover, redd density, sinuosity, and road proximity. Battery capacity and length of flight are key considerations when planning a flight to complete a survey. Battery life for most consumer-level UASs is currently 20-30 minutes and typical survey distances are 2.5 miles to 8.0 miles. Restrictive factors may include locations of airports, power lines, tall structures, wildfires, and proximity to population centers or popular recreation areas. Road proximity is a key consideration during planning. It is lawful to operate a UAS from a moving vehicle in sparsely populated areas. Obviously, the UAS operator should not drive the vehicle. This technique substantially increases the linear distance that each team can survey over the course of a day. Transect planning should be completed before leaving for a survey.

There are important technological considerations during the pre-flight planning as well. A link between a tablet computer and the remote controller enables the UAS operator to see images from the UAS camera; therefore, the RPIC should ensure that firmware for the flight control application, the remote controller, and the UAS are all updated before leaving the office. Out-of-date firmware can ground an operation or cause erratic UAS behavior during flight. Map software can be cached in the tablet prior to flights so that surveyors have access to aerial imagery during the flight to assess survey progress. Data generated from UAS flights (i.e., photos, videos, and telemetry information) are high resolution and high definition; therefore, data storage is important. Surveyors must decide before the flight how to save the imagery; the options include individual pictures, images taken systematically every 1-5 seconds during the flight, or continuous video. These options are listed in order of increasing storage space requirements. Note that currently there is no way to georeference video images. High-capacity micro SD cards are necessary to capture and archive survey data. We recommend 64 GB minimum but 128 GB capacity is preferred. The RPIC is responsible for ensuring all equipment is gathered prior to departing for flight operations.

As in any field survey, a safety briefing with all operators and observers is the first step of the actual aerial survey. The safety briefing should include a discussion of wind speeds and effects on UAS performance. Next, the survey team should move through the preflight checklist. Depending on survey location, the operator will fly the UAS and the observer will either drive the pilot in a vehicle or watch the UAS during flight to note obstacles like tall trees or power lines. Generally, the flight will proceed in a manner that keeps the sunlight behind the UAS and at an elevation between 15 m to 50 m, which is usually above tree level. In general, it is best to fly as low as possible to avoid obstacles while keeping a full-width view of the stream to obtain the best image quality. Counts should be done between 0930 and 1800 hours to increase the likelihood of direct overhead sunlight (Thurow 2010). Speed of the flight is often determined by obstacles and their proximity to the stream. For example, if an overhanging tree or power line is encountered, the UAS operator will need to adjust speed, direction, elevation, or all three to avoid the obstacle. Batteries will need to be changed during the flight. When the battery level gets low, the observer should find a pullout or other area with stable ground for the UAS to land. The UAS should have an open space of at least three feet in all directions for landing. Imagery should be backed up between flights in case something happens to the UAS during the next flight.

Observations may be recorded during or after flights. For surveys recorded with individual photos or video, the UAS operator can make observations of redds, live fish, and carcasses during the flight. However, if the survey is conducted with systematic pictures, observations are done post-flight. This option may reduce flight time but has significant post-processing time costs. As we describe below, post-flight identification offers the chance for multiple reviewers, possibly reducing the number of missed redds.

After the final flight of the day is complete, the surveyors should archive the imagery three times using external hard drives. The imagery is initially saved only to the UAS during a flight. A back-up system to save the imagery during flight would be beneficial for redundancy. The survey team should charge the UAS, remote controller, and tablet batteries for the next survey, either in the vehicle or upon return to grid power. Observations of live fish and carcasses from the survey log can be used to direct subsequent carcass surveys more efficiently.

To obtain redd counts and waypoints from archived survey imagery, surveyors should use a laptop or desktop computer with a large screen. Photos from each transect should be saved to a folder with the transect name and survey date. Independent viewers should check the images. Surveyors view each photo in sequence of capture. Apply the 4 Ds to determine which structures are actual redds. The photo that best represents an identified redd and its location should be saved (usually this is the photo taken most directly above the redd), and all others removed to a different folder. Software is available to automatically export the geotags from imagery to a file. Use this software to extract geotags from all confirmed redds in the transect folder. The output file contains the waypoints for entry in the Spawning Ground Survey database.

Helicopter Methods

The remainder of this section is concerned with surveys from helicopters. Idaho Department of Fish and Game policy A-13 is the Low Altitude Flying and Flight Safety Policy, to which all IDFG personnel conducting spawning ground surveys from aircraft must adhere. This policy covers the basic aspects required in the procurement of aircraft/pilot services, mandatory safety precautions, and the use of safety apparel and equipment. Helicopter surveyors are required to take in-person flight safety training and have a current certification. Preflight approval for all surveys is mandatory. Certain equipment must be taken on all redd count flights, such as flight suits, helmets, first aid kits, survival kits, etc. The current version of policy should be consulted each year prior to making preparations for helicopter surveys.

Selection of the pilot and ship is a key decision. Helicopter pilots should have a minimum of 100 hours of backcountry flying prior to flying spawning ground surveys. Pilots need to be familiar with the area and proficient at landing at backcountry airstrips. Communication of surveyors with the pilot is mandatory; therefore, the aircraft must be equipped with an intercom system for the pilot and surveyors. The two most important criteria when choosing helicopter type are flying capability and visibility. A helicopter must have enough power and lift to climb out of canyons and over ridges to minimize travel time and to fly the most direct routes to survey transects, fuel supplies, or back to base. Larger ships cost more but have an extended range, such that a greater distance can be travelled and surveyed on a single flight and at a faster cruising speed. These factors can offset the increased hourly cost. Performance and range is directly related to the onboard weight. Better performance is achieved with one versus two passengers. This factor should be taken into consideration for the type of flying to be done but most flights done recently have had a primary and secondary observer. If flying tight canyons at high elevations, the difference in weight can provide a performance safety margin. Never carry more weight than necessary to complete the mission.

Logistic planning must be completed before surveys begin. A flight plan should be made and flight time estimated. Landing strips on or near survey transects can be used for fuel stops. In cases where backcountry flying is being conducted, fuel barrels must be cached en route before the flights. This responsibility is assumed by IDFG personnel renting the craft, who contract with a fuel company for purchase and delivery to the selected locations. Route distance and flying time will dictate the number of fuel caches. Flying time (fuel capacity) is usually between 2 and 3 hours, depending on the individual machine. For safety, always allow at least 15 to 20 minutes more flying time than necessary to reach the refueling site. Always check with the pilot to determine proper fuel type and octane. Fuel transfer devices should be obtained as necessary. Some helicopters carry a fuel pump, hose, and filter system; others require this equipment at the fuel site.

The preflight pilot-observer briefing must include survey objectives and needs. Survey flights are strenuous for the pilot; a short communication break on the ground prior to the flight can be beneficial. Surveys should be postponed or canceled if flying conditions are unsafe or visibility is poor. We emphasize that either the pilot or the observers have the authority to abort the mission whenever weather or other circumstances warrant. ***Safety is first.***

Basic equipment needed for helicopter surveys is similar to ground-based surveys. The list includes a hand-held GPS unit, a small notepad, extra pencils, and two or more mechanical tally counters. All loose equipment must be tethered to an observer or the ship. The notepad (strapped to the thigh) should have sections for each transect to be surveyed during the flight. Even if there is a ship-mounted GPS unit linked to a hand-held computer to record observations, the basic equipment should be brought as a back-up. Polarized sunglasses are an absolute necessity. Surveyors should prepare a daypack containing lunch, emergency food items, and typical survival items for the backcountry. Surveyors must be equipped to survive a high-country overnight stay if an emergency landing occurs.

Several factors can increase the efficiency of aerial survey flights. The primary observer rides in the front seat next to the pilot for best visibility. This observer generally has the most experience and is responsible for making the “redd” or “not a redd” decision. The secondary observer verifies redds and notifies the primary observer about redds in complex habitats, shaded areas, or high density reaches. Communication between observers is a necessity. Maximum visibility occurs when the sun is behind the observers. It may not always be possible to survey in this manner, but this angle is always preferred. Often, helicopter doors are removed to increase visibility for the observers; observers should use a harness in these situations (see current flight safety policy). Counts should be done between 0930 and 1800 hours to increase the likelihood of direct overhead sunlight (Thurow 2010). The direction of the flight in a given area should be consistent from year to year. Prior to the survey, it is essential for the pilot to look over any transects not flown previously. If possible, prior to the survey, it is a good idea to fly over the transect at moderate elevation on the way to the starting point. Tight areas of canyons, cables, and other problem areas can be noted in this manner. Surveys should be done at 20 knots to 40 knots. Altitude above the stream varies depending on stream size, riparian vegetation, and light conditions. Thurow (2010) usually conducted surveys from 15 m to 50 m above the streambed.

Redds are identified and counted during the survey flight. Some of the features discussed under Redd Construction and Identification can be discerned from the air (Figure 5); however, flight speeds mean that redds must be identified and confirmed quickly. A helicopter can re-fly a short reach for a better view as needed, but hovering is dangerous and should be avoided during a survey. For this reason, observers need previous experience, which may be supplemented with a review of photos and videos from aerial surveys. Experience and training helps observers develop the gestalt search image necessary for quick decisions during flights. Identifying redds from a helicopter is not the same as from the ground; hence, the primary observer should have previous helicopter experience, whereas the secondary observer may be a trainee. When a redd is identified and confirmed, it is tallied and its location recorded with a GPS. The secondary observer often records redd locations with a handheld GPS, while the primary observer tallies and makes written notes. Sometimes a single waypoint represents multiple redds, which should be noted by the primary observer for reference after the flight. Optionally, voice recorders could be used during flight to audibly enumerate redds and landmarks as they are encountered, as a check on the written records. This option is valuable for surveys with a single observer. Once the flight is done, surveyors should check the notes, the tally, and the number of waypoints for consistency.

Figure 5. View of a stream channel and a Chinook Salmon redd from a helicopter. Note the elongated light spot in the substrate against the left bank. Photo by Matt Belnap.

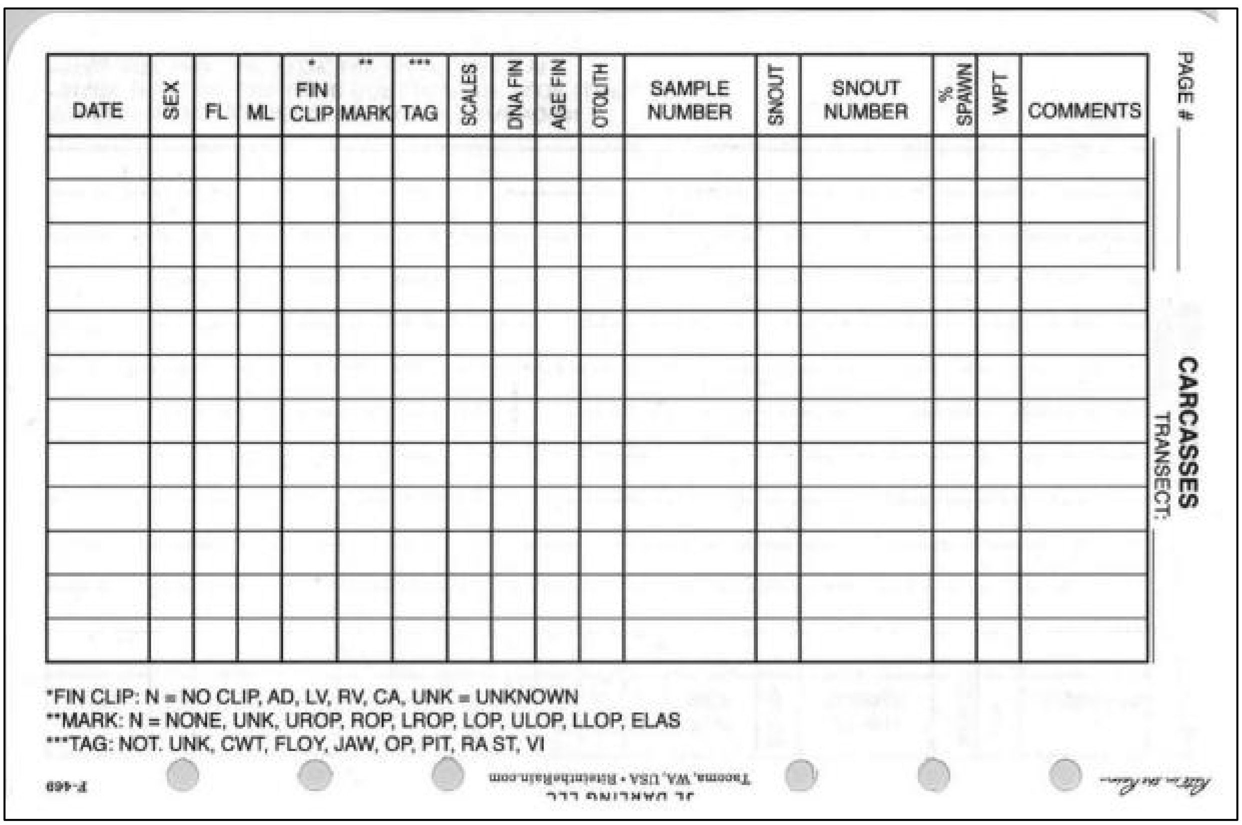
Carcass Data Collection

Biological information on spawning salmon is typically obtained by collecting data and samples from deceased fish. Unobtrusive methods are desirable for ESA-listed fish and can be done effectively in wadeable streams. Carcass data informs important metrics such as hatchery/wild fraction on the spawning grounds, length-at-age, age composition, sex ratios, and prespawn mortality.

Chinook Salmon carcasses are collected annually from spawning areas throughout Idaho. Basic data should be collected in the course of any spawning ground survey in which carcasses are encountered (Table 3; Figure 6). Additional carcass samples are often required and these may be collected by directed surveys. Sample packets for carcass samples are assembled by the IDFG Nampa Fisheries Research Anadromous Ageing Laboratory before the season and delivered to the responsible biologists at the preseason training session. Survey crews should have numbered sample packets specific to their survey transects.

Table 3. Sequential steps for processing a Chinook Salmon carcass including basic data and sample collection for wild and hatchery-origin fish.

1-Record stream location, section beginning and ending points, collector full name, supervisor, and date on survey datasheet.
2-Measure and record fork length in centimeters.
3-Check carcass for tags and external marks. Remove radio tags and save.
4-Scan for PIT and CWT tags.
   4a. PIT tag present-record full PIT tag code.
   4b. CWT present-remove snout, bag, record number on enclosed card, skip to Step 10.
   4c. Wild fish to Step 5; untagged adipose-clipped fish to Step 10.
5-Remove data card from sample packet and record previous information. Record location with sample number as GPS waypoint name.
6-Record carcass condition. See Table 4 for condition categories.
7-Remove a tissue sample from a lateral or caudal fin; check the DNA box on the envelope.
8-Remove dorsal fin ray section and place in fin-ray envelope. Place envelope in separate bag.
9-Collect otoliths if requested. Clean and place otoliths in data envelope and mark collection.
10-Cut fish from anal vent to gills to determine sex from gonad examination. For females, estimate percent spawned (0%, 50%, 100%). Not determinable for males.
11- Cut off tail to signify the carcass has been processed.
12- Return the carcass to stream where found.



CARCASSES
TRANSECT:
PAGE # ____

DATE	SEX	FL	ML	* FIN CLIP	** MARK	*** TAG	SCALES	DNA FIN	AGE FIN	OTOLITH	SAMPLE NUMBER	SNOUT	SNOUT NUMBER	% SPAWN	WPT	COMMENTS

*FIN CLIP: N = NO CLIP, AD, LV, RV, CA, UNK = UNKNOWN
**MARK: N = NONE, UNK, UROP, ROP, LROP, LOP, ULOP, LLOP, ELAS
***TAG: NOT. UNK, CWT, FLOY, JAW, OP, PIT, RA ST, VI

Figure 6. Example of a carcass data sheet.

Surveyors should search for carcasses diligently. Females tend to die in the stream channel near their redd. Males often die under banks or in woody debris. Smaller fish are harder to find than larger fish (Zhou 2002). Carcasses may settle in pools or wash up against woody debris or large rocks. Often the pale belly and sides of a carcass may be visible but some carcasses may become obscured by silt or covered in fungus, making them difficult to see. In some cases, only the edge of the caudal fin or white side of the belly will be visible between rocks or logs. Animals may carry carcasses up on gravel bars or onto banks. The presence of the latter may be indicated by a distinctive smell.

When a carcass is found, surveyors should move the carcass to a stable location for processing. The general steps for processing a salmon carcass are given in Table 3. Carcass data should always include a water body name, a date, and a waypoint location (WPT column in Figure 6). All carcasses are measured for fork length in centimeters unless the head or spinal column is not intact. The presence of marks and tags are used to identify origin. For each carcass, the head should be scanned with a CWT wand and the entire body should be scanned with a PIT tag detector. If a coded wire tag is detected the collector should cut off the snout, place it in the pre-labeled snout bag, and return it to the Nampa Fisheries Research Office for identification. The number from the snout bag label is recorded on the data sheet. Presence of other tags should be noted with as much detail as possible (e.g., color and location of VI tags and any codes printed on a Floy tag). If a telemetry tag is found, it should be noted and removed for return to the tagging project (usually noted on the tag). Visceral cavities are inspected to determine sex, which is used to calculate females per redd and associated productivity metrics. During examination, female carcasses are given a percent spawned value to indicate a prespawn mortality (0%, skeins intact), partially spawned (50%, skeins not intact but many eggs remaining), or fully spawned (100%, few or no eggs remaining). Males are not evaluated this way because the testes remain intact through spawning until the fish dies.

Biological samples are collected from carcasses to inform age composition and genetic/population structure. The IDFG Nampa Fisheries Research Anadromous Ageing Laboratory distributes sample packets for collecting fin rays, tissue samples, and otoliths to coordinators and cooperating agencies each year based on a predetermined sample size. The sample packets are pre-numbered and contain a data card (a large coin envelope), an envelope for a fin ray, and a vial for other samples. Fin rays are used to estimate the ocean age of Chinook Salmon, which allow biologists to reconstruct the cohort and estimate their productivity. Fin rays should not be taken from fish that are adipose-clipped or have a CWT in most surveys unless requested. Dorsal fin rays are the preferred method of ageing Chinook Salmon collected from spawning grounds in Idaho (Copeland et al. 2007). For genetic analysis, a tissue sample is collected from the least decayed fin and stored on Whatman sheets or in alcohol, depending on the method preferred by coordinators. Fin ray and tissue samples are delivered to the Anadromous Ageing Laboratory in Nampa, Idaho. Otoliths may be collected for special studies. Biological samples taken from carcasses are recorded on the data sheet along with the sample number.

Fin Ray Collection

There are four basic steps for removing dorsal fin rays (Figure 7). Note that dorsal rays with eroded distal ends can still be aged and should be collected. Place a hand on fish’s head to steady it in an upright position. First, using a sharp serrated knife, cut behind the first short fin ray (Figure 7, top left panel). Cut to where a crease forms with the body right along the back of the fish, not down by the spine, which is deeper. Next, cut again behind the sixth or seventh fin ray (Figure 7, top right panel). Lift the dorsal fin and cut parallel to the back of the fish where the crease forms with the body (Figure 7, bottom left panel). Be careful not to cut off the base of the fin rays (paired knobby bones). The dorsal fin rays can be separated from the spinal rays somewhat by pulling up on the fin rays. Cut level with the back, just above the spine. The cut should feel easy if it is done right. After the sampled fin rays have been removed, the cut should be even and level with the line of the back of the fish (Figure 7, bottom right panel).

Figure 7. Technique for removing dorsal fin rays from a fresh Chinook Salmon carcass.

Only the base of the fin rays are cross-sectioned and aged. The preferred cut (Figure 8, green line in the top panel) is just below the base of the fin rays. The base of the fin rays, resembling knuckles, should be visible (Figure 8, bottom panel). An acceptable cut (Figure 8, yellow line in the top panel) is slightly deeper and part of the back bone is removed as well. This is an acceptable cut because it is usable but requires extra material to be cut off before laboratory processing. A cut above the base of the fin ray (Figure 8, red line in the top panel) makes the sample unusable; please dispose of these samples rather than sending them to the laboratory.

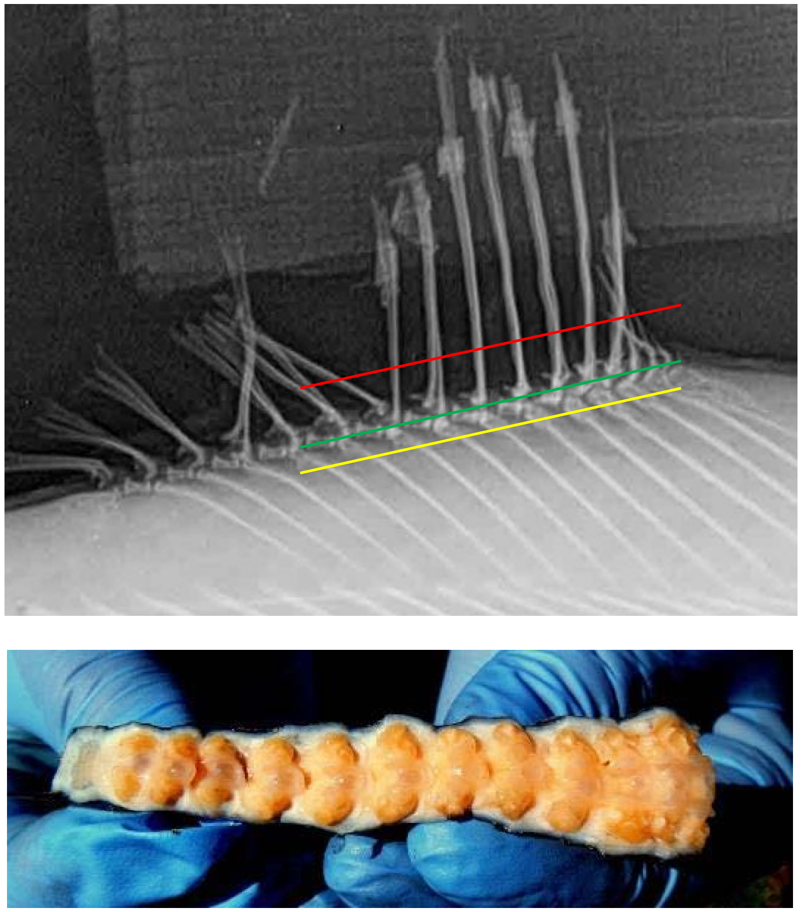


Figure 8. Examples of good and poor cuts made when removing dorsal fin rays. In the upper panel, the red line denotes an unacceptable cut, the yellow line denotes an acceptable cut, and the green line shows a preferred cut. The bottom panel shows the base of a preferred cut.

After collecting a fin-ray sample, prepare it for storage in the sample packet. Trim off excess flesh along the fin base. Do not take parts of the spinal rays; make a V-cut in the sample inside the fin rays and remove the backbone, if necessary. Fill out the information on the fin-ray envelope before placing the fin in it. Make sure the fin rays are parallel to each other and the cut end is parallel to the envelope opening (Figure 9). Put the fin ray envelope into its bag and seal it. Then place the fin-ray bag back into the bag with the tissue sample and data envelope. This step helps keep the data card unstained and readable. Record survey information on the data card. Certain information on the fin-ray envelope also should be on the carcass data sheet (sex, length, stream, sample number, etc.). Before stowing the fin-ray sample, double-check that all lines on the carcass data card and the fin-ray sample packet are filled out. Write NA or draw a line through entries that do not apply to ensure all relevant information is present. Place the entire sample bag on ice or in a freezer as soon as possible.

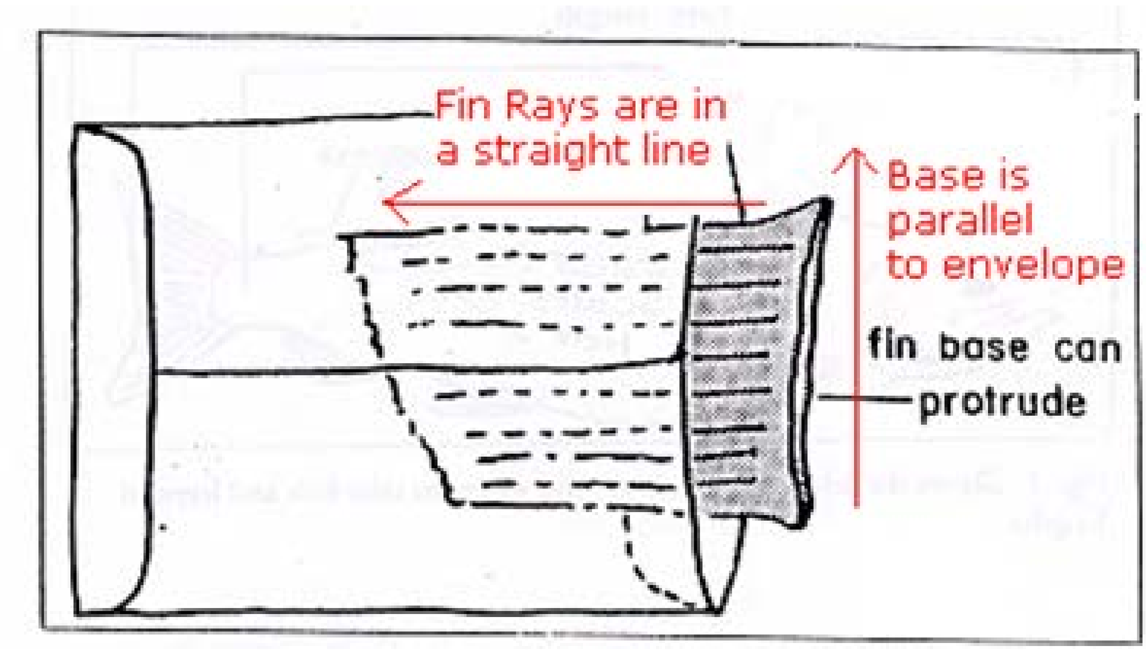


Figure 9. Proper position for storing a fin ray sample in a coin envelope.

Otolith Samples

Otoliths are collected primarily for microchemistry analysis. To collect otoliths, cut out a wedge from the skull with the first cut straight down approximately one eye width above the eye and the second cut two eye widths behind the eye to open the brain cavity (Figure 10, left panel). Remove the brain and use forceps to remove two leaf-like hard bony structures in pockets on each side of the brain cavity (Figure 10, right panel). There will be two and they can be found and retrieved with forceps. Once they are located, remove the membrane around them, place them in the data card of the sample packet, and check the Yes box (otolith collected).

Figure 10. Technique for removal of otoliths from a salmon carcass. The left panel shows location of otolith pockets in the skull of the fish. The right panel shows a pair of otoliths after removal.

Tissue Samples

Tissue samples are taken to provide genetic information from the carcass. If the carcass is in excellent-to-fair condition (Table 4), take a tissue sample. Choose a non-degraded fin with good color to take the sample. Typically, a lateral fin is used (pectoral or pelvic), although the caudal fin may be suitable in some cases. Do not use the adipose fin. From the chosen fin, use scissors to snip out a 5mm X 5mm sample, less than the area of a fingernail. Store the sample on a Whatman sheet or in a vial with alcohol. Record that a tissue sample was taken by checking the DNA box on the envelope. The success of analyzing genetic samples largely depends on the level of degradation of the sample when it is taken (Copeland et al. 2009). Record the carcass condition using criteria in Table 4.

Table 4. Categories for tissue sample quality. Based on Copeland et al. (2009).

Category	**Description**
Excellent	Freshly dead, gills have blood. Flesh is firm, skin and eye colors bright.
Good	Dead for 2-5 days, gills are white. External color not as bright as freshly dead. Flesh is still moderately firm.
Fair	Dead for 6-7 days, flesh is slightly firm, colors fading, and there may be spots of fungus.
Poor	Dead for greater than 7 days. Flesh is very soft. Cannot determine sex from internal organs, fish elongates when picked up, and might be mostly covered by fungus.
Dry	Fin is dried out because it has been exposed to the air.

Survey and Biological Data Management

Data management is an important part of any survey program. After field work is done, data must be checked to ensure it is correct and complete. Then it may be entered into electronic form, compared to quality standards, and archived into a database for long-term storage. By tradition, the responsibility to supervise this transfer belongs to the regional fisheries biologists (see quote from Mallet 1977 above). After transfer, data coordinators ensure that the data meet quality control standards. The last step is the finalization of the spawning ground survey data by the data coordinators. The following section describes these procedures.

In general, the flow of data is as follows. Spawning ground survey data, including redd count and carcass survey data, are recorded in the field on standardized paper data sheets or with electronic tablets and GPS units. Waypoints are captured for new redds, carcasses, and boundaries using standardized naming conventions with a standard geographic coordinate system and units. The survey data are entered into the local Spawning Ground Survey database application and the GPS data are imported into their respective surveys. The data are quality checked by the compilers against the paper survey forms. The waypoint data are visually inspected by the compilers to ensure accuracy. Upon verification of complete and correct surveys by the responsible biologist, the data are uploaded to the centralized Spawning Ground Survey database on the Idaho Fish and Wildlife Information System (IFWIS) server. The data are again checked for completeness and accuracy by data coordinators. Corrections must be authorized by the responsible biologist; corrections are uploaded from their respective database copy to the centralized database, if necessary. Once the data are correct and complete and on the IFWIS server, data coordinators then assign surveys to index numbers/names and populations. The data coordinators and programmers also link supplementary data from sample analysis (age, genetics) held on other databases to the records in the Spawning Ground Survey database via web services. The data management process starts with complete and correct data collection and entry.

Data Entry

The Spawning Ground Survey database is intended to handle the entry, editing, transfer, and manipulation of survey data including redd counts, carcass counts, and observations of live fish. Data entry modules encourage the use of waypoints for observations of fish, redd, and transect boundaries. The program also makes use of user-defined protocols that configure data entry for any session. The database program can be downloaded from: https://idfg.idaho.gov/ifwis/sgs/sgsinstall/publish.htm. It can also be downloaded from the Spawning Ground Survey page on the IFWIS website, https://idfg.idaho.gov/data/fisheries/sgs, along with the Spawning Ground Survey 2 Database User Manual. The User Manual is intended to inform new users about basic database functions and to provide a reference document for experienced users. The User Manual describes protocol configurations, waypoint files, surveys, redds, and fish data entry in detail but a brief overview is provided in this document.

Protocols are configurations that should be used to ensure correct and complete data entry vis-à-vis marks, tags, sample numbers, length constraints, etc. They should be set up by project leaders in charge of survey planning and distributed to personnel entering data. Protocols are logged with the individual surveys such that the limits and constraints imposed by the protocol are maintained as an integral part of the record, reflecting the survey methods. They are an excellent source of metadata.

Data flow depends on the level of the database application being used: field or coordinator versions. Data can be entered into both but only a coordinator's version can upload to the IFWIS server. Typically field technicians use a field version, which is created by clicking *Make Field Version* in the *File* menu. Field personnel double-check their data and transfer it via xml to the regional biologist who imports them into a coordinator's version and checks them again by exporting to a spreadsheet file. The biologist can make edits to the data in the field version, or notify the technician of any changes that need to be made and the process begins again. The data are uploaded from the coordinator's version to the IFWIS server where the data coordinators double check again and notify the regional biologists of any errors. When the data are judged free of errors, the data coordinators finalize the data by assigning index transect codes, populations, and major population groups (MPGs) to them.

To begin data entry, open the database program by double clicking on the icon. To enter a new survey, click on the *Spawning Ground Survey* tab on the top toolbar then click the *Add* button located to the right of the survey grid (Figure 11). This step will transition the program to a form that will allow the entry of a survey with redds, fish, and waypoints (Figure 12). All the general survey information on the database survey form should be on the field data sheet, such as location and date. Database fields that were set as mandatory in the protocols will be in red letters. Click the *Choose Transect* button and select a waterbody and transect boundaries. All index surveys will have the transect number in the upper right corner of that form. Selecting the transect number will automatically select the boundaries. For other surveys, select the boundaries from the list at the bottom (not pictured).

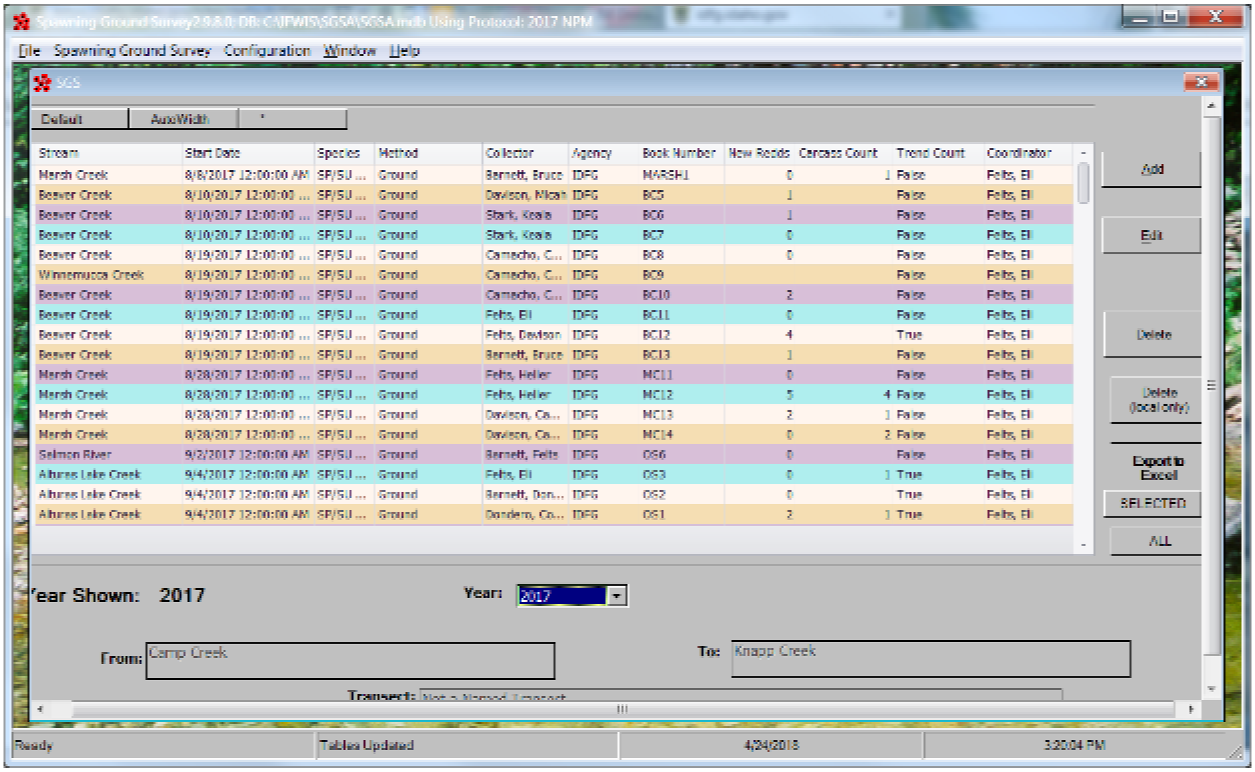


Figure 11. Screen shot of the survey grid. From this screen, data from current surveys may be accessed or entry of new survey records initiated.

An annual index survey that could not be completed is entered as a Null Survey. When entering a Null Survey, one should enter all the information for the survey that would normally be entered if the survey had occurred (stream, boundaries, method, coordinator, etc.). Because the survey was not done, there will not be a specific date to enter, but the record will document why this survey was not done for the year. Therefore, enter 1/1/YYYY and 12/31/YYYY as the StartDate and EndDate where YYYY is the year for which the survey was not done. Enter a *Survey Note* explaining why the survey did not occur, e.g., “No count due to wildfires” or “No count due to unavailable aircraft.” Select the *ReddCount*, *TrendCount*, and **The Survey Was Not Taken** flags, and then *Commit* the record because there were no redds or carcasses. A Null Survey is not the same as a count of zero in a completed survey. Null Surveys maintain the continuity of annual records for long-term trends and explain why a survey was not done.

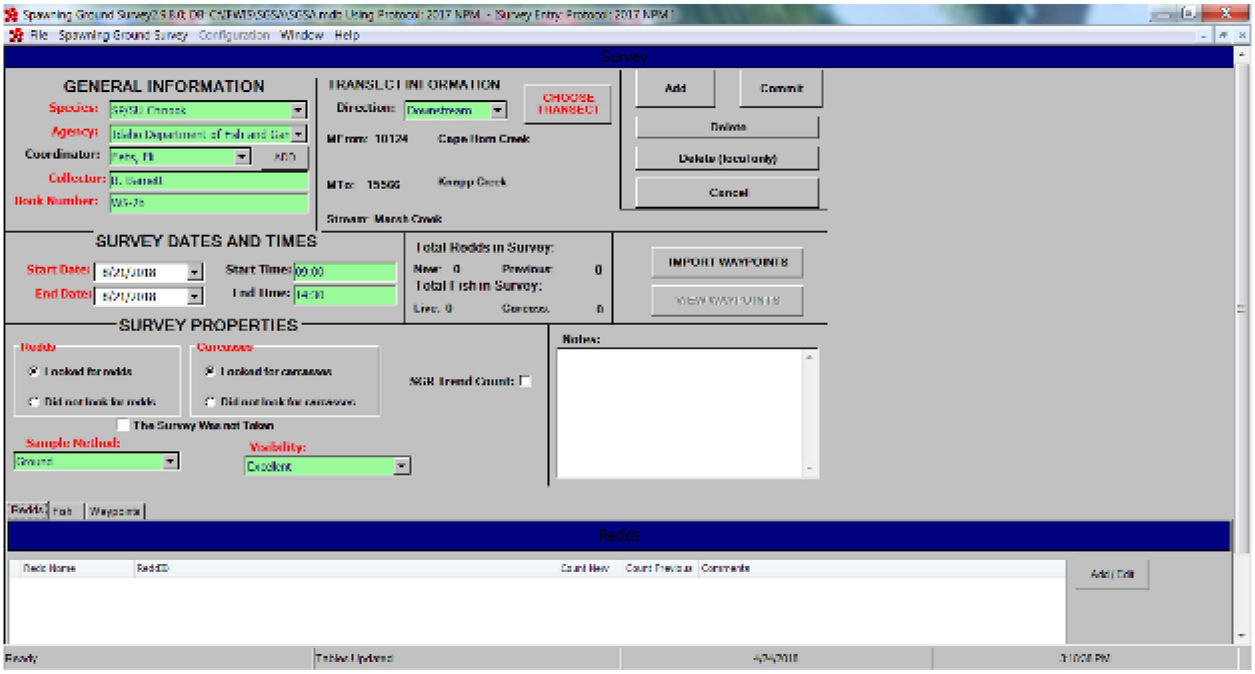


Figure 12. Screen shot of the survey entry form. General survey information, redd data, fish data, and waypoints may be entered from this screen.

Redds are entered by selecting the *Redd* tab at the bottom of the Survey Entry form and clicking *Add/Edit*. The Redd form is intended primarily for two types of entry: selecting waypoints from a list or entering a series of consecutive redd names when waypoints are not available (Figure 13). Once entry is complete, select *Finished with Form*.

Locations are important for many kinds of survey data and are denoted in the Spawning Ground Survey database as waypoints. Waypoints may be imported en masse from a text file (csv), copied and pasted one at a time, or hand entered individually. We encourage the use of the first option. For tips on collecting, downloading, and managing waypoint data, refer to section Managing Waypoint Data in the user manual. Although the database will record whatever datum the waypoints are in, IDFG uses WGS84 as a standard. Waypoints are imported by selecting the *Import Waypoints* button and directing it to the waypoint file.

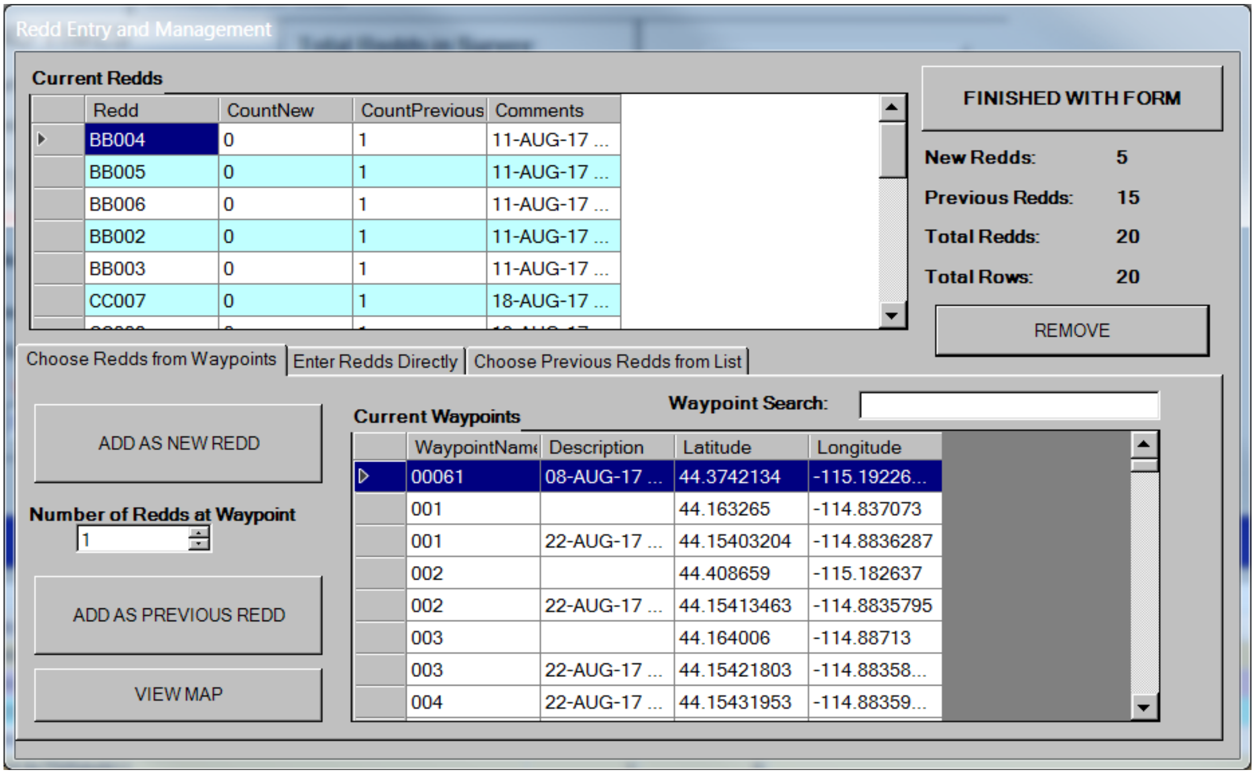


Figure 13. Screen shot of the redd data entry form. Note the three tabs representing different options for mode of data entry.

Fish records are entered by selecting the *Fish* tab at the bottom of the Survey Entry form and clicking *Add/Edit* at the right. The Fish form can be used to enter either live fish observations or carcass information (Figure 14). They can be entered in any order, or interspersed between each other. There are several fields that apply to only one type; carcass-specific fields can be enabled by checking the *Carcass* toggle. Note that this form is highly influenced by user-defined protocol settings. Under the default setting, the only field that is mandatory is number of fish but other fields can be made mandatory. If a field is mandatory, the label for that field will be written in red. Click on the *Waypoints* tab to select the waypoint associated with each fish. Select the *Samples Taken* tab to enter the sample types and numbers associated with each fish. The *Manage* tab opens a fish diagram with the different marks possible for selection. To enter another fish record select *Next* or select *OK* to leave the Fish form and go back to the Survey form.

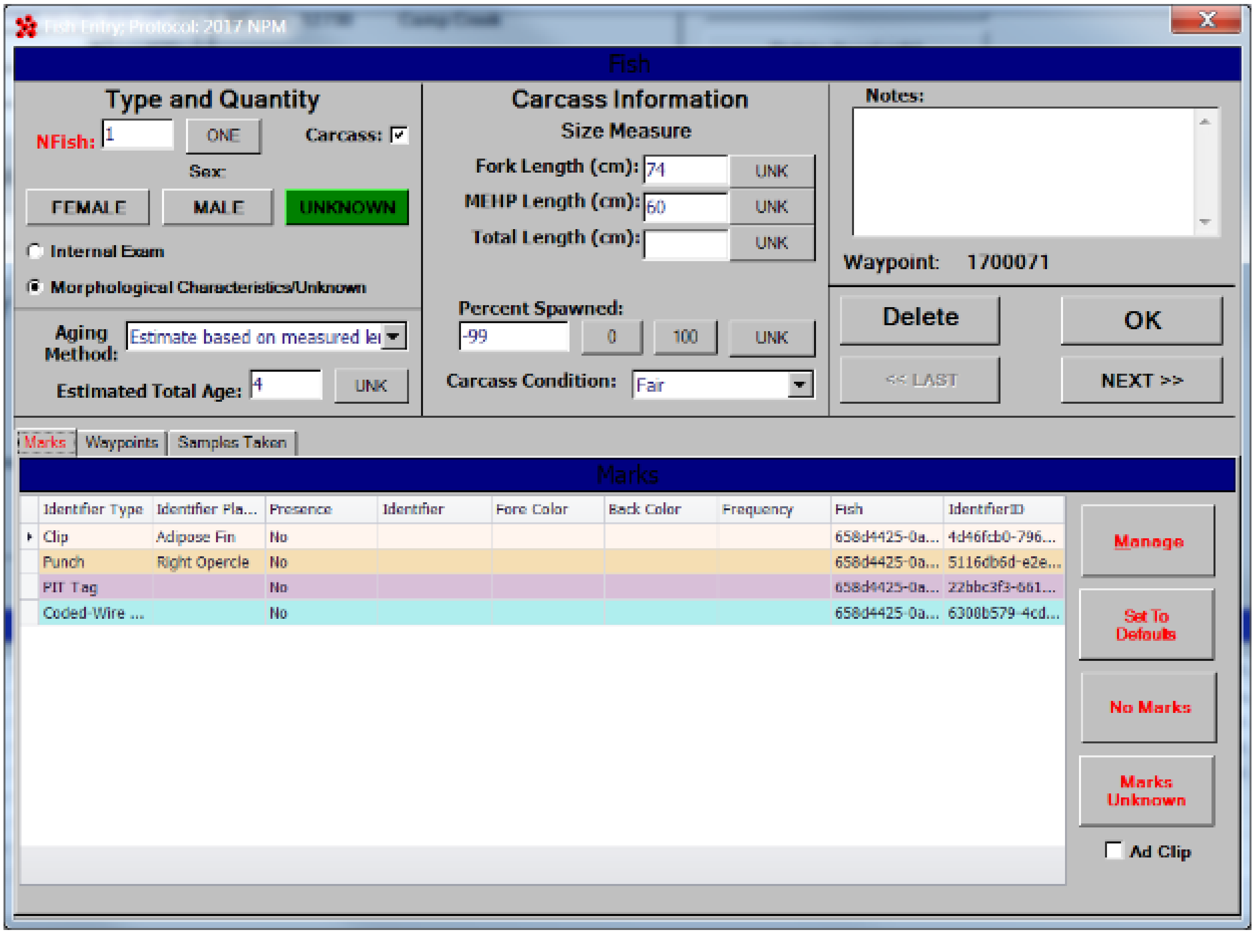


Figure 14. Screen shot of the Fish Data entry form. Note the *Carcass* field is toggled on.

After all redd, fish, and waypoint data have been entered click the *Commit* button on the Survey form to save survey data to the database. The survey can now be seen on the survey grid page (Figure 11). For quality control, selected surveys or all surveys can be exported to a spreadsheet file by clicking the *Export* button on the right. The data can then be checked against the raw data sheets and corrections made. Another valuable quality control measure is to view the waypoints on aerial imagery or a map. This step can be done by clicking *View Waypoints* on the Survey page (Figure 12). Locations in error are often not on the stream. Click on the waypoint icon and drag it to the appropriate position to correct the location.

The previous description is for data entry from field data sheets into a computer at an office. Data entry in the field during a survey may also be accomplished using a tablet computer. Entry on the tablet is similar to entry at the office, except it is done using a touch-screen rather than a keyboard. Choosing sites is easier and waypoints are automatic because the tablet has a built-in GPS. The current tablet routine is being updated to incorporate map-driven entry. After the survey and upon return to the office, data are transferred from the field tablet to the office computer for proofing.

Once all the data have been entered, all or some of the surveys may be selected from the Survey page and exported to a spreadsheet file for proofing or other purposes. Use the spreadsheet to double check the data against the raw data sheets. Common errors include incorrect sample number formats, marks, lengths, and waypoints. However, all fields should be double-checked. If errors are found, then open the specific surveys and make the corrections, remembering to click Commit when finished. If the survey had been sent to the IFWIS server, the corrected data will need to be uploaded again, which will overwrite the previous file.

After entry and quality control are completed, survey data can be transferred between databases as read-only copies and to the centralized database on the IFWIS server. Data can be exported to an xml file by going to the *File* menu in the top left corner (Figure 15). The xml file can be imported into another database by selecting *Import Data* in the same *File* menu. Data is uploaded to the IFWIS server by selecting *Upload Data* and following the instructions. The *Make Field Version* option will make a field version that cannot upload data to the IFWIS server but is used for data entry in the field. Data can only be uploaded to the server from a coordinator's version, which is the default setting. Data cannot be transferred from a coordinator's version to a field version, only vice versa. Versions that will be transferring data from the field to the office should be field versions.

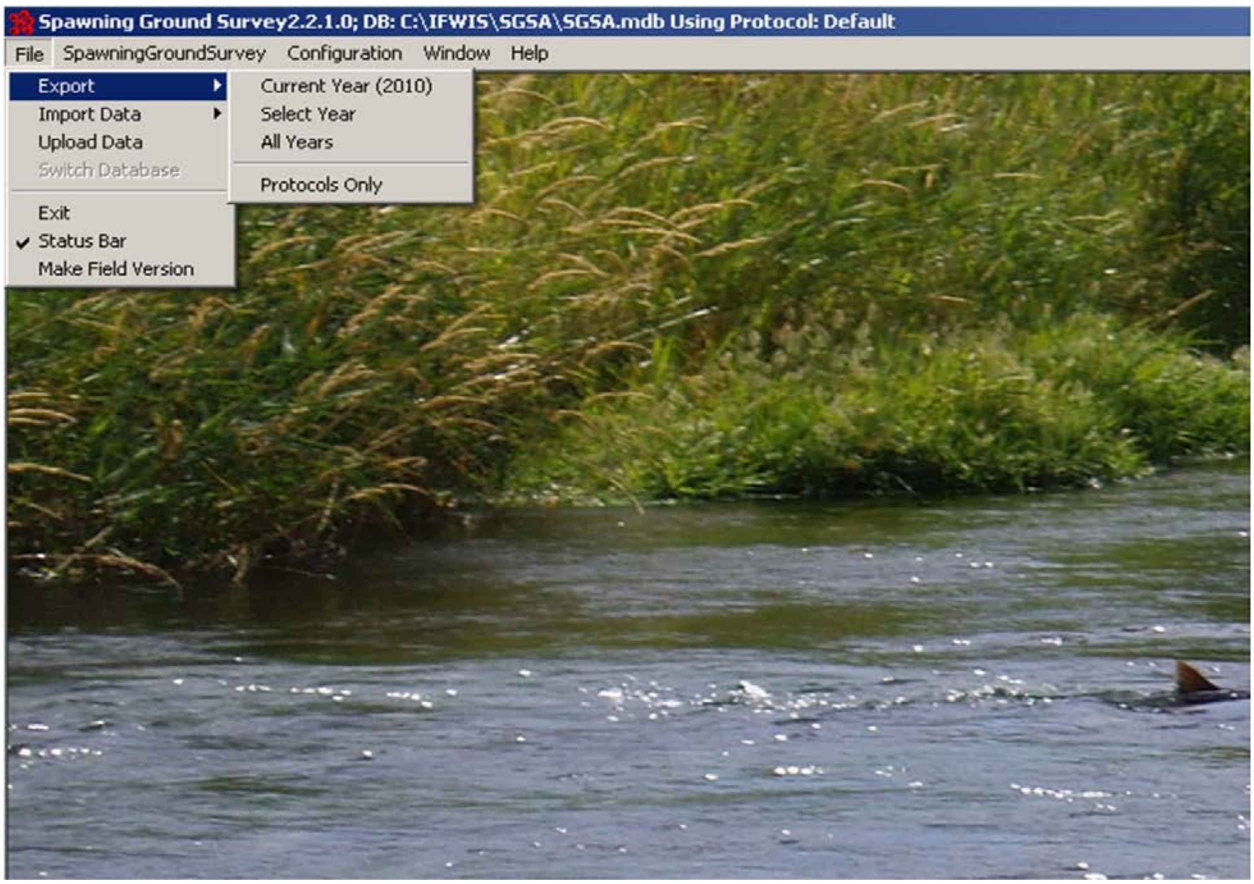


Figure 15. Screen shot of the *File* menu. Data sets may be transferred using this menu.

Data Finalization

Before the year's data are permanently archived in the IFWIS server, the data coordinators take two final steps. Trend count transects are assigned their transect code names (e.g. WS-1, NS-1, etc.) by designated data coordinators based upon the criteria described in Appendix B. A software program called SGSTransectManager is used to perform this function. Once the transect codes have been assigned, they are reviewed by the biologists that compiled the survey data. Once the transect codes are assigned, data coordinators then use Access or Sequel Server Management Studio to assign transects to a salmon population.

There is another step that biologists must make to complete data entry responsibilities after the field season. Recoveries of any PIT tags need to be posted in the PIT Tag Information System (PTAGIS, www.ptagis.org). If a PIT tag is detected, the PIT-tag code is recorded as a recapture event in a P4 interrogation file and uploaded to the PTAGIS database as a recovered adult mortality.

Carcasses in the centralized Spawning Ground Survey database with fin ray samples are joined via web service to the ageing data in the BioSamples database on a unique fish identification code and the sample number. This step is completed by the Ageing Laboratory Supervisor once the data are final in both databases. When the fin rays are analyzed, the estimated age from the BioSamples database populates the Estimated Total Age field in the Spawning Ground Survey database along with the ageing method (fin ray). This process is further described in the following section.

BioSamples Database

The BioSamples database was established to house the anadromous ageing information, including fin ray data (see Wright et al. [2015], Appendix B, for metadata). Data are uploaded using a standardized spreadsheet template. Sample information is ready for upload after formatting and quality control are complete. Uploads are posted on the BioSamples Extranet website https://collaboration.idfg.idaho.gov/biosamples/default.aspx, where the database coordinator retrieves the spreadsheet and appends data. For access, contact the current Nampa Fisheries Research Database Coordinator.

Data entry into the BioSamples database takes place after the field season is complete and samples are being cataloged and processed. Fin ray samples collected in the field have unique sample numbers that are added to the Spawning Ground Survey database via the data entry routine. Sample numbers and their associated data are queried from the Spawning Ground Survey database by the Nampa Fisheries Research Anadromous Ageing Laboratory. After fin ray samples are processed and assigned an age by the Ageing Laboratory, age data can be associated to each unique sample number in the query and appended to the BioSamples database. A unique Spawning Ground Survey database identification code is also uploaded to the BioSamples database in parallel with the age data, allowing age data to be automatically populated into the Spawning Ground Survey database.

RESULTS

The IDFG trend redd count series spans multiple decades. We present the standardized trend series by MPGs. This is the first time the full trend count series has been presented in the current population delineation framework developed by the ICTRT (2003, 2005). We summarize information by Salmon River and Clearwater River MPGs separately (Figure 16).

Trend redd counts in the three Salmon River MPGs have varied over several orders of magnitude over the entire record (Figure 16, top panel). Counts trended downward in tandem from the late 1950s to the late 1970s. At their highest, the 1957 counts in the trend transects were 3,379 redds, 3,136 redds, and 6,617 redds within South Fork Salmon River, Middle Fork Salmon River, and Upper Salmon River MPGs, respectively. The decline reached a nadir in 1980 at ≤160 redds in each. Redd counts increased slightly in the 1980s, although the increase was not as great in the Upper Salmon River MPG. The South Fork Salmon River and Middle Fork Salmon River MPGs also showed a minor peak in 1993; this did not happen in the Upper Salmon River MPG. The years 1994-1996 showed another nadir in all three MPGs with the lowest counts ever observed occurring in 1995: 133 redds, 20 redds, and 33 redds in the trend transects within South Fork Salmon River, Middle Fork Salmon River, and Upper Salmon River MPGs, respectively. However, trend redd counts greatly increased in the early 2000s and exceeded 1,000 redds in all three MPGs during 2001-2003. Since then, trend counts have exceeded 1,000 redds in all three Salmon River MPGs in 2011, 2012 and 2014. Counts declined after 2014, sharply from 2016 to 2017.

The temporal patterns in the two Clearwater River MPGs were different from the Salmon River MPGs (Figure 16, bottom panel). These series were begun as the Salmon River counts were declining in the late 1960s and early 1970s. The peak count during the 1980s occurred in 1985 for the Dry Clearwater at 264 redds, which was the highest to that point, and in 1988 for the Wet Clearwater at 144 redds, although that was less than the higher counts in the 1970s. Like in the Salmon River MPGs, counts in the Clearwater River MPGs were very low during 1994-1996 with extreme low counts in 1995: 6 redds and 12 redds in the Dry and Wet Clearwater MPGs, respectively. However, 6 redds were also counted in the Dry Clearwater MPG in 1991 and 1999. The 2001 count was the highest ever in the Clearwater MPGs: 503 redds and 355 redds for the Dry and Wet Clearwater MPGs, respectively. Since then, counts in the Dry Clearwater have fluctuated around the values observed in the 1980s and counts in the Wet Clearwater have fluctuated around the values observed in the 1970s. However, the 2017 count was the lowest since 1999 in both Clearwater MPGs.

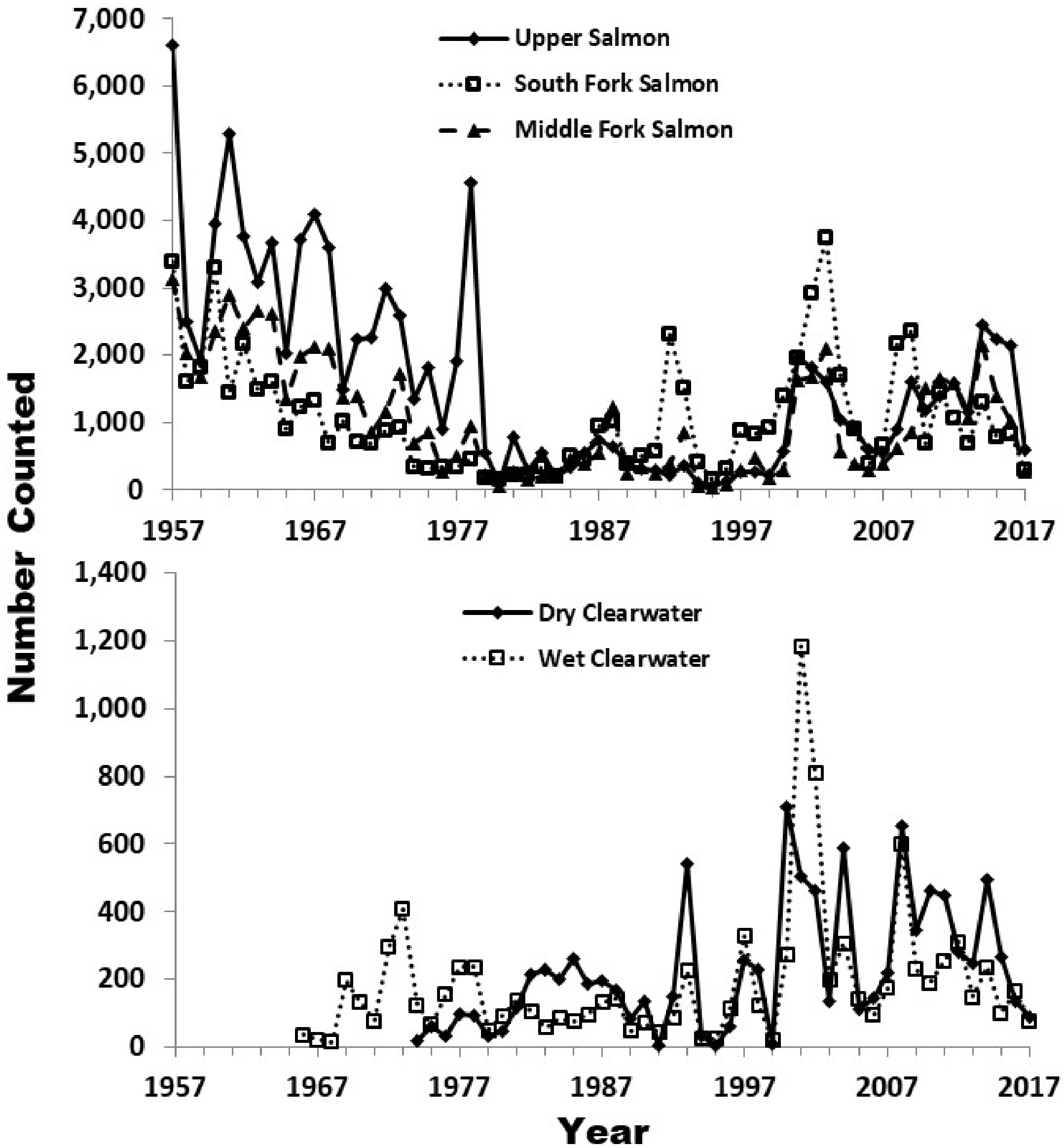


Figure 16. Spring-summer Chinook Salmon index redd count trends in Idaho, by major population group. Top panel shows counts from the Salmon River drainage (1957-2017) and bottom panel shows counts from the Clearwater River drainage (1966-2017).

DISCUSSION

The IDFG redd count data series now spans seven decades. Data sets of this length are extremely rare and valuable. In the past, these data have been used to assess status with respect to harvest and to manage fisheries on Idaho's salmon populations. That use has faded as Idaho's wild Chinook Salmon populations dropped to low levels and now harvest is directed at salmon produced by mitigation hatchery programs. As populations declined, the redd count series was used to assess status with respect to historical levels, now in the conservation and ESA arena. The value of the data series has been maintained despite various methodological changes (e.g., shifts from fixed-wing to helicopter for aerial counts). The data series presented above provides a means to compare spawning abundance among periods of very different management regimes. Standardized redd counts, paired with biological data such as age composition, provide measures of abundance, productivity, and spatial structure which are necessary to assess status of Idaho's spring/summer Chinook Salmon populations regardless of management focus. Thus, redd count data form the framework upon which current and future assessment techniques will be built.

Data Flow and Access

One of the major changes made since Hassemer's (1993a, 1993b) summaries has been the creation of databases to hold the burgeoning amount of information generated by spawning ground surveys. Step-wise quality assurance and quality control procedures have also necessarily been developed. Together, consistent data collection, archiving structure, and careful data checking result in a powerful source of information for salmon managers and biologists. Here we discuss how interested readers can access data summaries or the raw data themselves.

There are multiple ways to access spawning ground survey data. Data can be viewed in the database, exported to a spreadsheet, viewed in web reports, or viewed in spreadsheet live links. Biologists and technicians can view their current data in their local database copy. All or part of those data may be output into a spreadsheet file. All data that have been uploaded to the IFWIS server can be viewed through read-only Web Reports on the IFWIS Spawning Ground Survey webpage: https://idfg.idaho.gov/data/fisheries/sgs.

The Redd Count Summary web report provides views of data from redds, carcasses, and live fish observed. One can query for redd count data by Survey Year, Species, and/or Stream Name. Once a report is generated, there are many options for exporting the data. The Redd Detail Viewer provides redds that have waypoints associated. The Carcass and Live Fish Summary will provide the user with fish records. These web reports are available to cooperators who apply for and receive access through IFWIS (https://idfg.idaho.gov/accounts/user/register). The web queries mentioned here can then be accessed at https://idfg.idaho.gov/data/fisheries/sgs.

For IDFG staff, there are several live links available at K:\Fishery\ReddCounts. The live links are embedded in spreadsheets and are designed around the same data types as the web reports. Currently there are live links for viewing redd count summary data such as index and multiple ground counts, for accessing redd waypoints, and for accessing carcass and live fish data, including waypoints and sample numbers. Live links can be saved to computers or on other drives for individual custom applications without breaking the link. Users can create pivot tables on their versions and view the data as they choose.

Summaries of spawning ground survey data are also published externally in several formats. Annual summaries of redd counts by populations are available via Follow Idaho Salmon Home (F.I.S.H.; https://idfg.idaho.gov/science). Technical reports on spawning ground surveys issued by IDFG can be found in the on-line report library (https://idfg.idaho.gov/reports), including all reports referenced in this document. Population abundance estimates based on expansions of redd counts are published on the Stream Net web site (https://www.streamnet.org/data/coordinated-assessments/) and the NOAA Fisheries Salmonid Population Summary database (https://www.webapps.nwfsc.noaa.gov/apex/f?p=261:HOME). It has been a program goal to make information more easily available to IDFG managers and biologists, cooperators and collaborators, and the interested public. Although significant progress has been made, we continue to strive for improvements to information delivery.

Future of Spawning Ground Surveys

Currently and in the foreseeable future, use of spawning ground data in Idaho is and will be dominated by ESA concerns. The standards for data used in ESA status assessments (Crawford and Rumsey 2011) are more stringent than for data formerly used in fisheries management; therefore, additional considerations are warranted for the protocol used to guide data collection during spawning ground surveys that we have described here. For example, total spawning abundance estimates with a measure of precision are desired, whereas the current protocol aims for a peak count with no measure of precision. The IDFG policy guidance is to build onto the past record rather than to develop a completely new protocol. Therefore, additional metrics need to be measured to provide the necessary estimates using model-based inference (e.g., Liermann et al. 2015). Several analytical steps need to be taken. Peak counts should be expanded to complete counts using information from multi-pass data sets. Estimates from trend transects need to be expanded to all available suitable habitat. Redd counts need to be converted to spawning abundance in terms of adults and adults with jacks using weir data or carcass sex ratio. Observational errors can also be incorporated to obtain precision (e.g., Thurow and McGrath 2010; Murdoch et al. 2018). These elements can be encompassed within an analytical model, the description of which is beyond the scope of this report. Another growing concern is prespawn mortality (Bowerman et al. 2016, 2018). These considerations highlight the importance of carcass data and multi-pass surveys to this protocol.

The analytical structure used to make inferences about spawning salmon populations rests on several key assumptions made early in the program and these need to be verified again, given the changing environment. Our experiences conducting intensive surveys in the past 25 years suggests that a static survey date could miss peak spawning. Results from transects where multiple-pass surveys have been conducted annually should be used to evaluate the assumption that peak spawn timing has remained constant. Passes should be timed to capture peak and verify end of spawning. Where multiple-pass surveys are not available, the ratio of live fish to redds may be used to assess trends in spawn timing. Over time, trend counts are assumed to be proportional to total redd abundance. Intensive sampling, including multiple pass redd counts and mark-recapture, has been conducted alongside trend counts in a subset of populations for many years and provides an opportunity to test the assumption that trend counts are proportional to total abundance.

Small numbers of carcass samples during low returns and from remote areas surveyed aerially has necessitated assumptions regarding age composition in many populations. Currently, when less than 20 carcass samples are obtained from a population the overall age composition from that population’s MPG is applied (Felts et al. 2019). The ramifications of this assumption are not well understood. Age data from fin rays have been collected since the late 1990s and provide the opportunity to quantify age structure variability among brood years. Such analysis can be used to evaluate the sensitivity of productivity estimates to variability in age structure. Additionally, this type of prior baseline may be used to estimate age composition and an appropriate level of uncertainty when carcass sample size is insufficient for empirical estimation.

We are sure that other concerns will affect the spawning ground survey program in the future. IDFG is in the process of reducing or eliminating helicopter time for safety reasons. Therefore, guidance for surveys with UASs should be developed beyond the initial efforts described in this report. Greater efficiency of redd surveys and carcass collections will be required in order to stay within budgets. Appropriate use of UAS technology may also lead to greater survey efficiency. IDFG biologists are also modifying Clearwater basin transect boundaries to better encompass the suitable spawning habitat for Chinook Salmon. We recommend investigation of optimal effort allocation. The program must balance logistical factors with increased informational requirements.

The hallmark of any trend data series is consistency. Although there have always been changes to the spawning ground survey protocol, there have been key elements that have maintained the necessary consistency in data quality. The annual training session helps maintain consistency as personnel have turned over. Common training with other agencies makes data sets others now collect compatible and comparable to IDFG standards. Rigorous quality control measures have always been necessary. More recently, databases have provided ways to check data quality more easily as well as functioning as secure archives. It is important to explicitly acknowledge the significance of these elements to provide for appropriate uses into the future.

In this report, we have updated the draft guidance for spawning ground surveys that has been used for the last 25 years. The trends formerly reported have been extended and presented in the current population assessment framework. We anticipate that this protocol will be reviewed and updated in 10 years, especially if assumption testing show that changes are needed. A particular program focus should be data archiving and sharing in the evolving information world. What should not change is the value of the core data series for tracking the status of Idaho’s spring/summer Chinook Salmon populations for conservation and fisheries management purposes.

ACKNOWLEDGEMENTS

We would be remiss if we did not acknowledge the work of our predecessors in providing a solid foundation on which to build. It was very instructive to read reports from the founding years of the program and we encourage interested readers to peruse them (see Appendix A). Pete Hassemer encouraged us to update the summaries he wrote in the 1990s. This document was improved after review and commentary by Lance Hebdon, Josh Poole, and Curtis Roth. Data collection for this report was supported with funds from the sale of fishing licenses, tags, and permits; from federal excise taxes on fishing equipment and boat fuel through the Sport Fish Restoration Program (Dingell-Johnson Act); and from grants by the Pacific Salmon Commission, the US Fish and Wildlife Service (Lower Snake River Compensation Program), Idaho Power Company, and the Bonneville Power Administration.

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APPENDICES

Appendix A. Annotated bibliography of spawning ground survey reports completed by Idaho Department of Fish and Game personnel. Note that these citations reflect information in the report and might not correspond to the title in the IDFG electronic report library.

Years	Citation	Comments
1951	Hauck, F.R. 1951. An aerial survey of Chinook Salmon spawning utilization of the major streams of the Salmon River drainage, Idaho. Job Completion report, project 1-R-1.	First surveys conducted with DJ funding.
1952	Hauck, F.R. 1953. The size and timing of runs of anadromous species of fish in the Idaho tributaries of the Columbia River. Report to the US Army Corps of Engineers.	Includes steelhead; spring Chinook Salmon, fall Chinook Salmon and Sockeye Salmon. Data include tag recovery, dam counts, and harvest.
1952	Hauck, F.R. 1953. The 1952 spring Chinook escapement to Idaho waters: management recommendations. Completion report, project F-1-R-2.	Recommended fishery closures in some streams due to high harvest versus spawning escapement.
1953-1956	Pirtle, R.B. 1957. Field studies to estimate the size and timing of runs of anadromous species of fish in the Columbia and Snake rivers and their tributaries above the confluence of the Snake River. Final report to US Army Corps of Engineers.	Includes steelhead; spring Chinook Salmon, fall Chinook Salmon, Coho Salmon, and Sockeye Salmon.
1953	Hauck, F.R. 1954. Spring Chinook in Idaho waters. Completion report, project F-1-R-3.	Includes fishery analysis.
1953	Hauck, F.R. 1953. The size and timing of runs of anadromous species of fish in the Idaho tributaries of the Columbia River. Report to the US Army Corps of Engineers.	Includes steelhead trout; spring Chinook, fall Chinook and Sockeye Salmon.
1954-1956	Pirtle, R.B. 1957. Additional redd count information, 1954-1956.	Annotated maps with survey information. Introductory memo by Director Simpson.
1954	Anonymous. 1954. The size and timing of runs of anadromous species of fish in the Columbia and Snake rivers and their tributaries above the confluence of the Snake River. Report to the US Army Corps of Engineers.	
1955	Metsker, H. 1955. Aerial survey of Chinook Salmon spawning for 1955 in major tributaries of the Snake River.	
1955	Pirtle, R.B. 1956. The size and timing of runs of adult spring Chinook Salmon in the Columbia and Snake rivers and their tributaries above the confluence of the Snake River. Report to the US Army Corps of Engineers.	

1956	Pirtle, R.B. 1958. Chinook Salmon spawning survey summaries- 1956.	Tables and histogram.
1956	Pirtle, R.B. 1957. Field studies to estimate the size and timing of runs of anadromous species of fish in the Columbia and Snake rivers and their tributaries above the confluence of the Snake River.	Includes steelhead; spring Chinook, fall Chinook, Coho, and Sockeye Salmon. Final report of COE study.
1957	Metsker, H.E. 1958. Aerial survey of spring Chinook Salmon redds in the Salmon and Weiser river drainages, Idaho, 1957.	Includes annotated maps with survey information. Later reports continue these. Funding from Col. R. Fishery Dev.
1957	Richards, M. 1957. Snake River fall Chinook spawning ground survey, 1957.	
1958	Richards, M., and S. Gebhards. 1959. Aerial survey of spring Chinook Salmon redds in the Salmon and Weiser river drainages, Idaho. Report to Columbia River Fishery Development Program.	
1958	Richards, M. 1958. Snake River fall Chinook spawning ground survey, 1958.	
1959	Richards, M., and T.C. Bjornn. 1960. Aerial survey of Chinook Salmon redds in the Salmon and Weiser river drainages, Idaho, 1959. Report to Columbia River Fishery Development Program.	
1959	Richards, M. 1959. Snake River fall Chinook spawning ground survey, 1959.	
1960	Richards, M. Lower Salmon River drainage Chinook spawning ground survey, 1960.	Surveys in South Fork and Middle Fork. Includes forecast of 1961 run.
1960	Bjornn, T.C., and M. Richards. 1961. Aerial survey of Chinook Salmon redds in the Salmon and Weiser river drainages – 1960.	Includes data from Richards' smaller 1960 report.
1960	Richards, M. 1960. Snake River fall Chinook spawning ground survey, 1960.	
1960	Richards, M. 1961. Summary of Area 3, spring and summer Chinook aerial redd counts – 1960.	Two-page summary.
1961	Richards, M. 1961. Snake River fall Chinook spawning ground survey, 1961.	
1961	Ortmann, D., and M. Richards. 1964. Lower Salmon River drainage Chinook spawning ground survey, 1961.	Included carcass length frequency, ages from scales and comparison to dam counts.
1961	Bjornn, T.C. 1961. Survey of Chinook Salmon spawning grounds in the upper Salmon River drainage – 1961.	Included carcass length frequency, ages from scales and comparison to dam counts.

1962	Bjornn, T., D. Corley, and J. Mallet. 1963. Survey of Chinook Salmon spawning grounds in the upper Salmon River drainage – 1962. Annual progress report, project F-49-R-1.	Includes evaluation of aerial redd counts.
1962	Ortmann, D., and M. Richards. 1965. Salmon and steelhead investigations. Annual progress report, project F-49-R-1.	Includes data from Bjornn et al 1963; tests to evaluate harvest, escapement, and survey techniques.
1962	Richards, M. 1962. Snake River fall Chinook spawning ground survey, 1962.	
1963	Bjornn, T.C., D.W. Ortmann, D. Corley, and W. Platts. 1964. The gathering and compilation of relevant data for Idaho salmon and steelhead runs (salmon spawning ground surveys – 1963). Pages 40-92 in Ortmann et al. Salmon and steelhead investigations (1963). Annual progress report, project F-49-R-2.	One of 5 jobs within Salmon & Steelhead Investigations. One job assessed carcass survey techniques. Other jobs begin work in South Fork Salmon and Lemhi drainages.
1964	Platts, W., D. Corley, and D. Ortmann. 1966. Salmon spawning ground surveys, Salmon River drainage. Pages 19-67 in Salmon and steelhead investigations (1964). Annual progress report, project F-49-R-3.	Full report also includes Lemhi production studies and South Fork Salmon harvest and escapement studies.
1965	Welsh, T.L., D. Corley, D. Ortmann, and T. Holubetz. 1966. Salmon spawning ground surveys, Salmon River drainage. Pages 11-57 in Salmon and steelhead investigations (1965), Jobs 1 and 2. Annual progress report, project F-49-R-4.	
1966	Welsh, T.L., and D. Corley. 1968. Salmon spawning ground surveys, Salmon River drainage, August 1, 1966 to September 30, 1966. Annual progress report, project F-49-R-5, Salmon and steelhead investigations, Job 2.	
1967	Corley, D., and T.L., Welsh. 1968. Salmon spawning ground surveys, Salmon River drainage, August 1, 1967 to September 30, 1967. Annual progress report, project F-49-R-6, Salmon and steelhead investigations, Job 1.	
1968	Welsh, T.L., and D. Corley. 1969. Salmon spawning ground surveys, Salmon River drainage, March 1, 1968 to February 28, 1969. Job completion report, project F-49-R-7, Salmon and steelhead investigations, Job 1.	Report format now rote; abstract here used in subsequent reports, as quoted by Mallet (1977).
1969	Welsh, T.L., D.L. Corley, and T. Holubetz. 1970. Salmon spawning ground surveys, Salmon River drainage, March 1, 1969 to February 28, 1970. Job completion report, project F-49-R-8, Salmon and steelhead investigations, Job 1.	

1969	Hoss, S.A. 1970. Evaluation of salmon and steelhead reintroductions into the Clearwater River drainage, Idaho. Columbia River Fisheries Development Program, Annual Project Closing Report, July 1, 1968 to June 30, 1969.	Surveys in Lochsa and Selway drainages. Documentation of remnant run into Lochsa?
1970	Corley, D.L., T. Holubetz, and T.L. Welsh. 1971. Salmon spawning ground surveys, Salmon River drainage, March 1, 1970 to February 28, 1971. Job completion report, project F-49-R-9, Salmon and steelhead investigations, Job 1-a.	
1970	Hoss, S.A. 1972. Evaluation of salmon and steelhead reintroductions into the Clearwater River drainage, Idaho. Columbia River Fisheries Development Program, Annual Project Closing Report, July 1, 1969 to June 30, 1970.	Aerial surveys of upper Selway drainage.
1971	Holubetz, T., S.A. Hoss, T.L. Welsh, and D. Corley. 1972. Salmon spawning ground surveys, March 1, 1971 to February 29, 1972. Job progress report, project F-49-R-10, Salmon and steelhead investigations, Job 1-a.	Trend counts now include surveys in Selway and Lochsa rivers.
1971	Hoss, S.A. 1972. Evaluation of salmon and steelhead reintroductions into the Clearwater River drainage, Idaho. Columbia River Fisheries Development Program, Annual Project Closing Report, July 1, 1970 to June 30, 1971.	Aerial surveys of upper Selway drainage.
1972	Welsh, T.L., S.A. Hoss, T.L. Welsh, and D. Corley. 1973. Salmon spawning ground surveys, March 1, 1972 to February 28, 1973. Job progress report, project F-49-R-11, Salmon and steelhead investigations, Job 1-a.	
1972	Reingold, M. 1973. Evaluation of pond rearing fish culture methods, evaluation of survival of pond reared Chinook Salmon, March 1, 1973 to February 28, 1974. Job progress report, project F-49-R-12, Salmon and steelhead investigations, Job IIIa and IIIb.	Carcass surveys in upper Salmon River.
1972	Hoss, S.A. 1973. Evaluation of salmon and steelhead reintroduction into the Clearwater River drainage, Idaho. Columbia River Fisheries Development Program, Annual Project Closing Report, July 1, 1971 to June 30, 1972.	Aerial surveys of upper Selway drainage.
1973	Corley, D., S.A. Hoss, and T.L. Welsh. 1974. Salmon spawning ground surveys, March 1, 1973 to February 28, 1974. Job performance report, project F-49-R-12, Salmon and steelhead investigations, Job 1-a.	

1973	Reingold, M. 1974. Evaluation of pond rearing fish culture methods, evaluation of survival of pond reared Chinook Salmon, March 1, 1973 to February 28, 1974. Job progress report, project F-49-R-12, Salmon and steelhead investigations, Job IIIa and IIIb.	Carcass surveys and mark-recapture study in upper Salmon River.
1973	Hoss, S.A. 1974. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, July 1, 1973 to June 30, 1974.	Clearwater River redd surveys to support reintroduction.
1974	Hoss, S.A., M. Reingold, and T.L. Welsh. 1975. Salmon spawning ground surveys, 1 March 1974 to 28 February 1975. Job performance report, project F-49-R-13, Salmon and steelhead investigations, Job 1-a.	Includes first surveys in the South Fork Clearwater drainage.
1974	Reingold, M. 1974. Evaluation of pond rearing fish culture methods, evaluation of survival of pond reared Chinook Salmon, March 1, 1974 to February 28, 1975. Job progress report, project F-49-R-13, Salmon and steelhead investigations, Job IIIa and IIIb.	Carcass surveys in upper Salmon River.
1974	Hoss, S.A. 1975. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, July 1, 1974 to June 30, 1975.	Clearwater River redd surveys to support reintroduction.
1975	Hoss, S.A., K. Ball, and T.L. Welsh. 1976. Salmon spawning ground surveys, 1 March 1975 to 29 February 1976. Job performance report, project F-49-R-14, Salmon and steelhead investigations, Job 1-a.	
1975	Reingold, M. 1976. Evaluation of pond rearing fish culture methods, evaluation of survival of pond reared Chinook Salmon, March 1, 1975 to February 28, 1976. Job progress report, project F-49-R-14, Salmon and steelhead investigations, Job IIIa and IIIb.	Carcass surveys and mark-recapture study in upper Salmon River.
1975	Lindland, R.L. 1976 Evaluation of survival of hatchery reared salmonids, 1 March 1975 to 29 February 1976. Job performance report, project F-49-R-14, Salmon and steelhead investigations, Job V-a.	Helicopter surveys in the Clearwater drainage.
1976	Hoss, S.A., K. Ball, and T.L. Welsh. 1977. Salmon spawning ground surveys, 1 March 1976 to 28 February 1977. Job performance report, project F-49-R-15, Salmon and steelhead investigations, Job 1-a.	
1976	Reingold, M. 1977. Evaluation of pond rearing fish culture methods, evaluation of survival of pond reared Chinook Salmon, March 1, 1976 to February 28, 1977. Job progress report, project F-49-R-15, Salmon and steelhead investigations, Job IIIa and IIIb.	Carcass surveys in upper Salmon River.

1977	Welsh, T.L., S.A. Hoss, and K.W. Ball. 1978. Salmon spawning ground surveys, 1 March 1977 to 28 February 1978. Job performance report, project F-49-R-16, Salmon and steelhead investigations, Job 1-a.	
1977	Hoss, S.A. 1977. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1976 to September 30, 1977.	Clearwater River redd surveys to support reintroduction.
1978	Ball, K.W., W.W. Reid, and S.A. Hoss. 1979. Salmon spawning ground surveys, 1 March 1978 to 28 February 1979. Job performance report, project F-73-R-1, Fishery Research, Subproject II: Salmon and steelhead investigations.	
1978	Hoss, S.A. 1978. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1977 to September 30, 1978.	Clearwater River redd surveys to support reintroduction.
1979	Lindland, R.L., K.W. Ball, and W.W. Reid. 1980. Salmon spawning ground surveys, 1 March 1979 to 29 February 1980. Job performance report, project F-73-R-2, Fishery Research, Subproject II: Salmon and steelhead investigations.	
1979	Lindland, R.L. 1979. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1978 to September 30, 1979.	Clearwater River redd surveys to support reintroduction.
1980	Ortmann, D.W., R.L. Lindland, K.W. Ball, and W.W. Reid. 1981. Salmon spawning ground surveys, 1 March 1980 to 28 February 1981. Job performance report, project F-73-R-3, Fishery Research, Subproject II: Salmon and steelhead investigations.	
1980	Lindland, R.L. 1980. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1979 to September 30, 1980.	Clearwater River redd surveys to support reintroduction.
1981	Pollard, H.A., R.L. Lindland, K.W. Ball, and W.W. Reid. 1982. Salmon spawning ground surveys, 1 March 1981 to 28 February 1982. Job performance report, project F-73-R-4, Fishery Research, Subproject II: Salmon and steelhead investigations.	Includes Sockeye Salmon survey, which is included in subsequent reports until after 2000.
1982	Pollard, H.A. 1983. Salmon spawning ground surveys, 1 March 1982 to 28 February 1983. Job performance report, project F-73-R-5, Subproject II: Salmon and steelhead investigations, Study II, Job 1.	

1982	Lindland, R.L. 1982. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1981 to September 30, 1982.	Clearwater River redd surveys to support reintroduction.
1983	Pollard, H.A. 1984. Salmon spawning ground surveys, 1 March 1983 to 28 February 1984. Job performance report, project F-73-R-6, Subproject II: Salmon and steelhead investigations, Study II, Job 1.	
1984	Pollard, H.A. 1985. Salmon spawning ground surveys, March 1, 1984 to February 28, 1985. Job performance report, project F-73-R-7, Subproject II: Salmon and steelhead investigations, Study I.	
1984	Lindland, R.L. 1984. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1984 to September 30, 1985.	Clearwater River redd surveys to support reintroduction.
1985	Hall-Griswold, J., and T. Cochnauer. 1986. Salmon spawning ground surveys, March 1, 1985 to February 28, 1986. Job performance report, project F-73-R-8, Subproject II: Salmon and steelhead investigations, Study I.	
1985	Lindland, R.L., and B. Bowler. 1986. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1984 to September 30, 1985.	Clearwater River redd surveys to support reintroduction with expansion factor.
1986	Hall-Griswold, J., and T. Cochnauer. 1987. Salmon spawning ground surveys, March 1, 1986 to February 28, 1987. Job performance report, project F-73-R-9, Subproject II: Salmon and steelhead investigations, Study I.	
1986	Lindland, R.L., and B. Bowler. 1986. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1985 to September 30, 1986.	Clearwater River redd surveys to support reintroduction with expansion factor.
1987	Hall-Griswold, J., and T. Cochnauer. 1988. Salmon spawning ground surveys, March 1, 1987 to February 28, 1988. Job performance report, project F-73-R-10, Subproject II: Salmon and steelhead investigations, Study I.	
1987	Lindland, R.L., and B. Bowler. 1988. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1986 to September 30, 1987.	Clearwater River redd surveys to support reintroduction with expansion factor.

1988	White, M., and T. Cochnauer. 1989. Salmon spawning ground surveys.	Report funding from Lower Snake River Compensation Plan and Pacific Salmon Treaty Program.
1988	Lindland, R.L., and B. Bowler. 1989. Clearwater River development of spring Chinook and steelhead stocks. Columbia River Fisheries Development Program, Annual Project Closing Report, October 1, 1987 to September 30, 1988.	Clearwater River redd surveys to support reintroduction with expansion factor.
1989-1992	Hassemer, P.F. 1993. Salmon spawning ground surveys, 1989-1992.	Report funding from Project F-73-R-15 and Pacific Salmon Treaty Program.
1991-1992	Leitzinger E.J., K. Plaster, and E. Bowles. 1993. Idaho Supplementation Studies, annual report 1991-1992. Annual progress report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	First report of field work by Idaho Supplementation Studies.
1992-1996	Walters, J., J. Hansen, J. Lockhart, C. Reighn, R. Keith, and J. Olson. 1999. Idaho Supplementation Studies five-year report 1992-1996. Annual progress report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
1992-1994	Sankovich, P., and P.F. Hassemer. 1999. Spawning distribution of out-planted adult summer Chinook Salmon in the South Fork Salmon River, 1992-1994, project progress report. Idaho Department of Fish and Game Report 99-04.	Lower Snake River Compensation Plan study to re-distribute spawning.
1993	Riley, S.C., and T. Elms-Cockrum. 1995. Salmon spawning ground surveys, 1993. Idaho Department of Fish and Game Report 95-6.	
1993	Leitzinger, E.J., K. Plaster, P. Hassemer, and P. Sankovich. 1996. Idaho Supplementation Studies, annual progress report, 1993. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
1994	Elms-Cockrum, T.J., E.J. Leitzinger, and C.E. Petrosky. 1995. Salmon spawning ground surveys, 1994. Idaho Department of Fish and Game Report 95-38.	Report funding from Pacific Salmon Treaty Program.
1994	Nemeth, D., K. Plaster, K. Apperson, J. Brostrom, T. Curet, and E. Brown. 1996. Idaho Supplementation Studies, Annual Report 1994, Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
1995	Elms-Cockrum, T.J. 1996. Salmon spawning ground surveys, 1995. Idaho Department of Fish and Game Report 96-13.	Report funding from Pacific Salmon Treaty Program.

1995-1997	Abrams, J., and P.F. Hassemer. 2003. Carcass distribution of out-planted and weir-released adult summer Chinook Salmon in the South Fork Salmon River, 1995-1997, project completion report. Idaho Department of Fish and Game Report 03-43.	Lower Snake River Compensation Plan study to re-distribute spawning.
1996	Elms-Cockrum, T.J. 1997. Salmon spawning ground surveys, 1996. Idaho Department of Fish and Game Report 97-25.	Report funding from Pacific Salmon Treaty Program.
1997	Elms-Cockrum, T.J. 1998. Salmon spawning ground surveys, 1997. Idaho Department of Fish and Game Report 98-46.	Report funding from Pacific Salmon Treaty Program.
1997-2001	Lutch, J., B. Leth, K. Apperson, A. Brimmer, N. Brindza. 2003. Idaho Supplementation Studies, Project Progress Report 1997-2001. Annual progress report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
1998	Elms-Cockrum, T.J. 1999. Salmon spawning ground surveys, 1998. Idaho Department of Fish and Game Report 99-32.	Report funding from Pacific Salmon Treaty Program.
1999	Elms-Cockrum, T.J. 2001. Salmon spawning ground surveys, 1999. Idaho Department of Fish and Game Report 01-10.	Report funding from Pacific Salmon Treaty Program.
2000	Brown, E.M. 2002. Salmon spawning ground surveys, 2000. Idaho Department of Fish and Game Report 02-33.	Report funding from Pacific Salmon Treaty Program.
2002	Venditti, D.A., K.A. Apperson, A. Brimmer, N. Brindza, C. Gass, A. Kohler, and J. Lockhart. 2005. Idaho Supplementation Studies brood year 2002 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	First cooperative report with tribal agencies.
2003	Venditti, D.A., A. Kohler, C. Bretz, N. Brindza, J. Lockhart, A. Brimmer, and K.A. Apperson. 2006. Idaho Supplementation Studies brood year 2003 Cooperative Report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2004	Venditti, D.A., J. Lockhart, A. Kohler, A. Brimmer, K.A. Apperson, B. Bowersox, and C. Bretz. 2007. Idaho Supplementation Studies, brood year 2004 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2005	Venditti, D.A., A. Kohler, K.A. Apperson, A. Brimmer, B. Bowersox, C. Bretz, and J. Lockhart. 2008. Idaho Supplementation Studies brood year 2005 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	

2006	Venditti, D.A., J. Lockhart, A. Brimmer, A. Kohler, B. Bowersox, C. Bretz, and K.A. Apperson. 2009. Idaho Supplementation Studies brood year 2006 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2007	Venditti, D.A., K.A. Apperson, R. Kinzer, J. Flinders, A. Teton, C. Bretz, B. Bowersox, and B. Barnett. 2010. Idaho Supplementation Studies brood year 2007 Cooperative Report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2008	Venditti, D.A., J. Flinders, R. Kinzer, B. Bowersox, A. Teton, B. Barnett, C. Bretz, and K.A. Apperson. 2011. Idaho Supplementation Studies brood year 2008 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2009	Venditti, D.A., J. Flinders, R. Kinzer, C. Bretz, M. Corsi, B. Barnett, K.A. Apperson, and A. Teton. 2012. Idaho Supplementation Studies brood year 2009 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2009	Stark, E.J., and D.P. Richardson. 2011. Captive rearing program for Salmon River Chinook Salmon, 2010 annual report. Idaho Department of Fish and Game Report 11-03.	Surveys of West Fork Yankee Fork and East Fork Salmon River, see Appendix C in this report.
2009-2010	Kennedy, P., T. Copeland, J. Johnson, K.A. Apperson, J. Flinders, and R. Hand. 2011. Idaho natural production monitoring and evaluation, 2009 and 2010 combined annual report. Idaho Department of Fish and Game Report 11-23.	Renewed reporting of trend transects.
2010	Venditti, D.A., R. Kinzer, K.A. Apperson, J. Flinders, M. Corsi, C. Bretz, K. Tardy, and B. Barnett. 2013. Idaho Supplementation Studies brood year 2010 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2010	Stark, E.J., and J. Gable. 2010. Captive rearing program for Salmon River Chinook Salmon, 2009 annual report. Idaho Department of Fish and Game Report 10-01.	Surveys of West Fork Yankee Fork and East Fork Salmon River, see Appendix C in this report.
2011	Kennedy, P., T. Copeland, J. Johnson, K.A. Apperson, J. Flinders, R. Hand, and M. Corsi. 2012. Idaho natural production monitoring and evaluation, 2011 annual report. Idaho Department of Fish and Game Report 12-18.	

2011	Venditti, D.A., C. Bretz, B. Barnett, M.P. Corsi, K.A. Apperson, K. Tardy, R. Kinzer, and J. Messner. 2014. Idaho Supplementation Studies brood year 2011 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2011	Stark, E.J., M.R. Campbell, C.C. Kozfkay, and K.J. Freischmidt. 2012. Captive rearing program for Salmon River Chinook Salmon, 2011 annual report. Idaho Department of Fish and Game Report 12-07.	East Fork Salmon River surveys
2012	Kennedy, P., K.A. Apperson, J. Flinders, M. Corsi, J. Johnson, R. Hand, and J. Messner. 2013. Idaho natural production monitoring and evaluation, 2012 annual report. Idaho Department of Fish and Game Report 13-12.	
2012	Venditti, D.A., R. Kinzer, B. Barnett, K.A. Apperson, K. Tardy, M.P. Corsi, M. Belnap, and C. Bretz. 2015. Idaho Supplementation Studies brood year 2012 cooperative report. Report to Bonneville Power Administration, Project 198909800, Portland, Oregon.	
2012	Stark, E.J., B.S. Ayers, and C.C. Kozfkay. 2013. Captive rearing program for Salmon River Chinook Salmon, 2012 annual report. Idaho Department of Fish and Game Report 13-01.	East Fork Salmon River surveys
2013	Stiefel, C.., K.A. Apperson, M. Belnap, T. Copeland, M.P. Corsi , R. Hand, P. Kennedy, J. Messner, S. Putnam, and K.K. Wright. 2014. Idaho natural production monitoring and evaluation, 2013 annual report. Idaho Department of Fish and Game Report 14-18.	
2013	Stark, E.J., B.S. Ayers, and C.C. Kozfkay. 2014. Captive rearing program for Salmon River Chinook Salmon, 2013 annual report. Idaho Department of Fish and Game Report 14-03.	East Fork Salmon River surveys
2014	Stiefel, C.., M. Amick, K.A. Apperson, M. Belnap, T. Copeland, M.P. Corsi, R. Hand, M. Pumfery, S. Putnam, R. Roberts, and K.K. Wright. 2015. Idaho natural production monitoring and evaluation, 2014 annual report. Idaho Department of Fish and Game Report 15-14.	
2014	Stark, E.J., B.S. Ayers, and C.C. Kozfkay. 2014. Captive rearing program for Salmon River Chinook Salmon, 2014 annual report. Idaho Department of Fish and Game Report 14-17.	East Fork Salmon River surveys
2015	Stiefel, C.., B. Barnett, K.K. Wright, K.A. Apperson, M. Belnap, R. Hand, M. Peterson, E. Ziolkowski, E. Brown, L. Hebdon and W.C. Schrader. 2016. Idaho adult Chinook Salmon monitoring, 2015 annual report. Idaho Department of Fish and Game Report 16-12.	

2016	Belnap, M.J., B. Barnett, K.A. Apperson, M. Amick, C. Camacho, R. Hand, M. Peterson, and E. Brown. 2017. Idaho adult Chinook Salmon monitoring, 2016 annual report. Idaho Department of Fish and Game Report 17-07.
2017	Felts, E.A., B. Barnett, M. Davison, M.J. Belnap, K.A. Apperson, R. Hand, M. Peterson, and E. Brown. 2018. Idaho adult Chinook Salmon monitoring, 2017 annual report. Idaho Department of Fish and Game Report 18-08.

Appendix B. Current trend transect methods, boundaries, and timing by population for IDFG spring-summer Chinook Salmon redd count index surveys – update of Hassemer (1993a), Appendix B.

Appendix Table B1. Single pass redd count index surveys that are conducted for IDFG spring-summer Chinook Salmon in Idaho. Surveys are organized by major population group (MPG). Transects are listed by ascending transect code within each population.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		South Fork Salmon River MPG				
Little Salmon River	Boulder Creek	Mouth	Squirrel Creek	NS-34	9/5	Ground
SF Salmon River Mainstem	SF Salmon River	SFSR Weir	Rice Creek	NS-26	9/5	Ground
		Poverty Flat	SFSR Weir	NS-27	9/5	Ground
		Miner's Peak Bridge	Poverty Flat	NS-28	9/5	Ground
		East Fork SFSR	Miner's Peak Bridge	NS-29	9/5	Ground
Secesh River	Secesh River	Long Gulch Bridge	USFS Boundary	WS-16	8/28	Ground
		Loon Creek	Long Gulch Bridge	WS-17	8/28	Ground
	Lake Creek	Three-mile Creek	Willow Creek	WS-18	8/25	Ground
		Mouth	Three-mile Creek	WS-19	8/25	Ground
		Willow Creek	Lake Creek Bridge	WS-20	8/25	Ground
East Fork South Fork Salmon River	Johnson Creek	Deadhorse Rapids/Ice Hole Campground	Moose Creek/Clements Ranch	NS-30	9/7	Ground
		Top of canyon between Sheep and Lunch creeks	Boulder Creek	NS-31	9/7	Ground
		Middle Fork Salmon River MPG				
Chamberlain Creek	Chamberlain Creek	WF Chamberlain Creek	Flossie Creek	WS-1a	8/25	Ground
	WF Chamberlain Creek	Mouth	Game Creek	WS-1	8/25	Ground
MFSR Mainstem Above Indian Creek	Rapid River	Mouth	Duffield Creek	WS-21	9/5 – 9/12	Aerial

Appendix Table B1. Continued.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		Middle Fork Salmon River MPG continued				
MFSR Mainstem Above Indian Creek	Pistol Creek	Mouth	Luger Creek	WS-22a	9/5 – 9/12	Aerial
	Little Pistol Creek	Mouth	Browning Creek	WS-22b	9/5 – 9/12	Aerial
	Indian Creek	Mouth	Big Chief	WS-23	9/5 – 9/12	Aerial
	Marble Creek	Mouth	Sunnyside Creek	WS-24	9/5 – 9/12	Aerial
	MF Salmon River	Boundary Creek	Headwaters/Marsh Creek	WS-15a	9/5 – 9/12	Float /UAS
		Indian Creek	Boundary Creek	WS-15b	9/5 – 9/12	Float /UAS
MFSR Below Indian Creek	MF Salmon River	Loon Creek	Indian Creek	WS-15c	9/5 – 9/12	Float /UAS
		Big Creek	Loon Creek	WS-15d	9/5 – 9/12	Float /UAS
		Goat Creek	Big Creek	WS-15e	9/5 – 9/12	Float /UAS
Big Creek	Big Creek	Logan Creek	Jacobs Ladder Creek	WS-13	9/5	Ground
		Smith Creek	Logan Creek	WS-14a	9/5	Ground
		Monumental Creek	Smith Creek	WS-14b	9/5	Aerial
		Rush Creek	Monumental Creek	WS-14c	9/5	Aerial
		Mouth	Rush Creek	WS-14d	9/5	Aerial
Camas Creek	Camas Creek	Hammer Creek	Castle Creek	WS-8	9/5	Aerial
Loon Creek	Loon Creek	Canyon downstream of Falconberry Ranch	Cabin Creek	WS-6	9/5	Aerial
		Cabin Creek	Upper Loon Creek Guard Station	WS-7	9/5	Aerial

Appendix Table B1. Continued.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		Middle Fork Salmon River MPG continued				
Sulphur Creek	Sulphur Creek	Sulphur Cr Ranch at trail crossing	1.5 miles upstream at trail crossing	OS-4	8/21	Ground
		3 miles downstream of ranch at stream and hill convergence	Sulphur Cr Ranch at trail crossing	WS-12	8/21	Ground
Bear Valley Creek	Bear Valley Creek	Bottom of mine exclosure	Top of mine exclosure	WS-9a	8/27	Ground
		Cub Creek	Bottom of mine exclosure	WS-9b	8/27	Ground
		Sack Creek	Cub Creek	WS-9c	8/27	Ground
		Elk Creek	Sack Creek	WS-9d	8/27	Ground
		Poker Meadows Bridge/568	Elk Creek	WS-10a	8/27	Ground
		Fir Creek	Poker Meadows Bridge/568	WS-10b	8/27	Ground
	Elk Creek	Twin Bridges	WF Elk Creek	WS-11a	8/27	Ground
		Elk Creek Guard Station	Twin Bridges	WS-11b	8/27	Ground
		Mouth	Elk Creek Guard Station	WS-11c	8/27	Ground
Marsh Creek	Marsh Creek	Knapp Creek	Dry Creek	WS-2a	8/21	Ground
		Cape Horn Creek	Knapp Creek	WS-2b	8/21	Ground
	Cape Horn Creek	Mouth	Banner Creek	WS-3	8/21	Ground
	Knapp Creek	Mouth	Top of meadow/trend	WS-4	8/21	Ground
	Beaver Creek	Beaver Creek CG Bridge (008)	Bear Creek	WS-5	8/21	Ground
		Upper Salmon River MPG				
Panther Creek	Panther Creek	Moyer Creek	Fourth of July Creek	NS-11a	9/8	Aerial/UAS
		Blackbird Creek	Moyer Creek	NS-11b	9/8	Aerial/UAS
		Deep Creek	Blackbird Creek	NS-11c	9/8	Aerial/UAS
		Clear Creek	Deep Creek	NS-11d	9/8	Aerial/UAS
North Fork Salmon River	NF Salmon River	Johnson/Crone Gulch	Pierce Creek	NS-25a	9/8	Ground

Appendix Table B1. Continued.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		Upper Salmon River MPG continued				
		NF Ranger Station/Hughes Cr	Johnson/Crone Gulch	NS-25b	9/8	Ground
		Mouth	NF Ranger Station/Hughes Creek	NS-25c	9/8	Ground
Lemhi River	Lemhi River	Cottam Lane Bridge	Leadore Bridge N of town	NS-9	9/8	Aerial/UAS
		Lemhi Store	Cottam Lane Bridge	NS-10	9/8	Aerial/UAS
	Hayden Creek	Bridge below Hayden ponds	HC10/11 Bridge	NS-35a	9/8	Ground
		Mouth	Bridge below Hayden ponds	NS-35b	9/8	Ground
Salmon River Mainstem Below Redfish Lake Creek	Salmon River	Valley Creek	Redfish Lake Creek	NS-17	9/8	Aerial/UAS
		Yankee Fork Creek	Valley Creek	NS-18	9/8	Aerial/UAS
		Warm Springs Creek	Yankee Fork Creek	NS-19	9/8	Aerial/UAS
		East Fork Salmon River	Warm Springs Creek	NS-20	9/8	Aerial/UAS
		Hwy 93 bridge upstream of Challis	East Fork Salmon River	NS-21	9/8	Aerial/UAS
		Morgan Creek	Hwy 93 bridge upstream of Challis	NS-22	9/8	Aerial/UAS
		Pahsimeroi River	Morgan Creek	NS-23	9/8	Aerial/UAS
		Lemhi River	Pahsimeroi River	NS-24	9/8	Aerial/UAS
Pahsimeroi River	Pahsimeroi River	Mouth	Hooper Lane Bridge	NS-33a	9/20	Aerial/UAS
	Patterson Creek	Mouth	Hooper Lane Bridge	NS-33b	9/20	Aerial/UAS
East Fork Salmon River	EF Salmon River	3.5 downstream of Big Boulder Creek	East Fork Weir	NS-1a	9/8	Aerial/UAS
		East Fork Weir	Bowery Guard Station	NS-1b	9/8	Aerial/UAS
		Mouth	Herd Creek	NS-2a	9/8	Aerial/UAS
		Herd Creek	3.5 downstream of Big Boulder Creek	NS-2b	9/8	Aerial/UAS

Appendix Table B1. Continued.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		Upper Salmon River MPG continued				
	Herd Creek	Mouth	East Pass Creek	NS-2c	9/8	Aerial/UAS
Yankee Fork Salmon River	Yankee Fork Salmon River	Jordan Creek	Twelve-mile Creek	NS-5	9/8	Aerial/UAS
		Polecamp Creek	Jordan Creek	NS-6	9/8	Aerial/UAS
	WF Yankee Fork	Lightning Creek	Cabin Creek	NS-7	9/8	Aerial/UAS
		Mouth	Lightning Creek	NS-8	9/8	Aerial/UAS
Valley Creek	Valley Creek	Ford 90m upstream of Meadow Creek	East Fork Valley Creek	NS-3a	9/8	Aerial/UAS
		Stanley Lake Creek	Ford 90m upstream of Meadow Creek	NS-3b	9/8	Aerial/UAS
		Mouth	Stanley Lake Creek	NS-4	9/8	Aerial/UAS
Salmon River Mainstem Above Redfish Lake	Alturas Lake Creek	Mouth	Cabin Creek Road Bridge	NS-12	9/8	Aerial/UAS
		Cabin Creek Road Bridge	ALC Diversion dam	OS-1	9/8	Ground
		ALC Diversion Dam	Alturas Lake Outlet	OS-2	9/8	Ground
		Alturas Lake Inlet	Alpine Creek	OS-3	9/8	Ground
	Pole Creek	Mouth	Fish Screen (SPC-01)	NS-13a	9/8	Aerial/UAS
		Fish Screen (SPC-01)	Rainbow Cr Road Bridge (FS197a)	NS-13b	9/8	Aerial/UAS
Salmon River Mainstem Above Redfish Lake	Salmon River	Sawtooth Weir	Hell Roaring Lake Creek – Decker Flat Bridge	NS-15a	9/8	Aerial/UAS
		Hell Roaring Lake Creek – Decker Flat Bridge	Alturas Lake Creek	NS-15b	9/8	Aerial/UAS
		Alturas Lake Creek	Breckenridge Diversion	NS-15c	9/8	Aerial/UAS
		Redfish Lake Creek	Sawtooth Weir	NS-16	9/8	Aerial/UAS
		Breckenridge Diversion	Pole Creek	OS-5	9/8	Aerial/UAS
		Pole Creek	HWY 75 Bridge upstream of Frenchman Creek	OS-6	9/8	Ground

Appendix Table B1. Continued.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		Upper Salmon River MPG continued				
		Dry Clearwater MPG				
Upper South Fork Clearwater River	Red River	Gold Point - Cole 66 Bridge	Red River Weir	NC-1	9/3	Ground
		Red River Campground	Shissler Bridge	NC-2a	9/3	Ground
		Red River Weir	Red River Campground	NC-2b	9/3	Ground
	South Fork Red River	Mouth	Trapper Creek	NC-3	9/3	Ground
	American River	Kirks Fork American R	Lick Creek	NC-4	9/3	Ground
	Crooked River	Mouth	Headwaters/EF Crooked River/Umatilla Creek	NC-6	9/3	Ground
	Newsome Creek	Mouth	Radcliff Creek	NC-8	9/3	Ground
		Wet Clearwater MPG				
Lolo Creek	Lolo Creek	Pheasant Camp Sign	Yoosa Creek	NC-14	9/3	Ground
Lochsa River	Crooked Fork Creek	Rock Creek	Cliff Hole	NC-10	9/3	Ground
	Brushy Fork Creek	1 mile downstream of Elk Meadows Bridge	Elk Meadows Road bridge (FS373)	NC-11	9/3	Ground
	Colt Killed (White Sands) Creek	Mouth	Beaver Creek	NC-13c	9/3	Ground
		Beaver Creek	Colt Creek	NC-13b	9/3	Ground
Lochsa River	Colt Killed (White Sands) Creek	Colt Creek	Big Flat Creek	NC-13a	9/3	Ground
Moose Creek	East Fork Moose Creek	Mouth	0.5 mi upstream of Fitting Creek	WC-3c	9/8	Ground
		Cedar Creek	East Fork Moose Falls	WC-3d	9/8	Ground

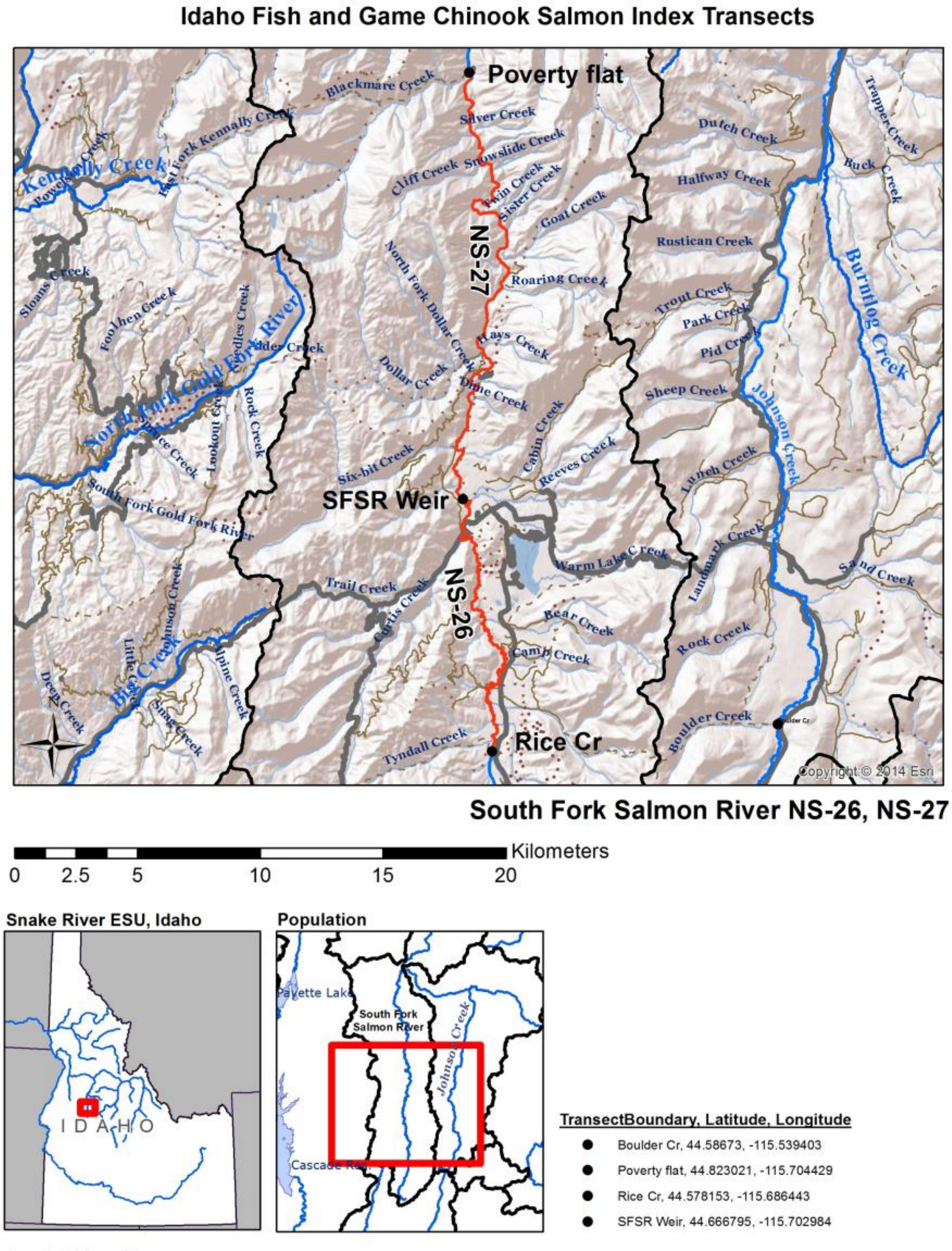
Appendix Table B1. Continued.

Population	Waterbody	Lower Boundary	Upper Boundary	Transect name	Target survey date	Method
		Wet Clearwater MPG continued				
Upper Selway River	Bear Creek	Mouth	Cub Creek	WC-2	9/8	Ground
	Selway River	Magruder Ranger Station	Thompson Flat Guard Station	WC-5	9/8	Ground
		Little Clearwater River	Magruder Crossing (FS468)	WC-7	9/8	Ground

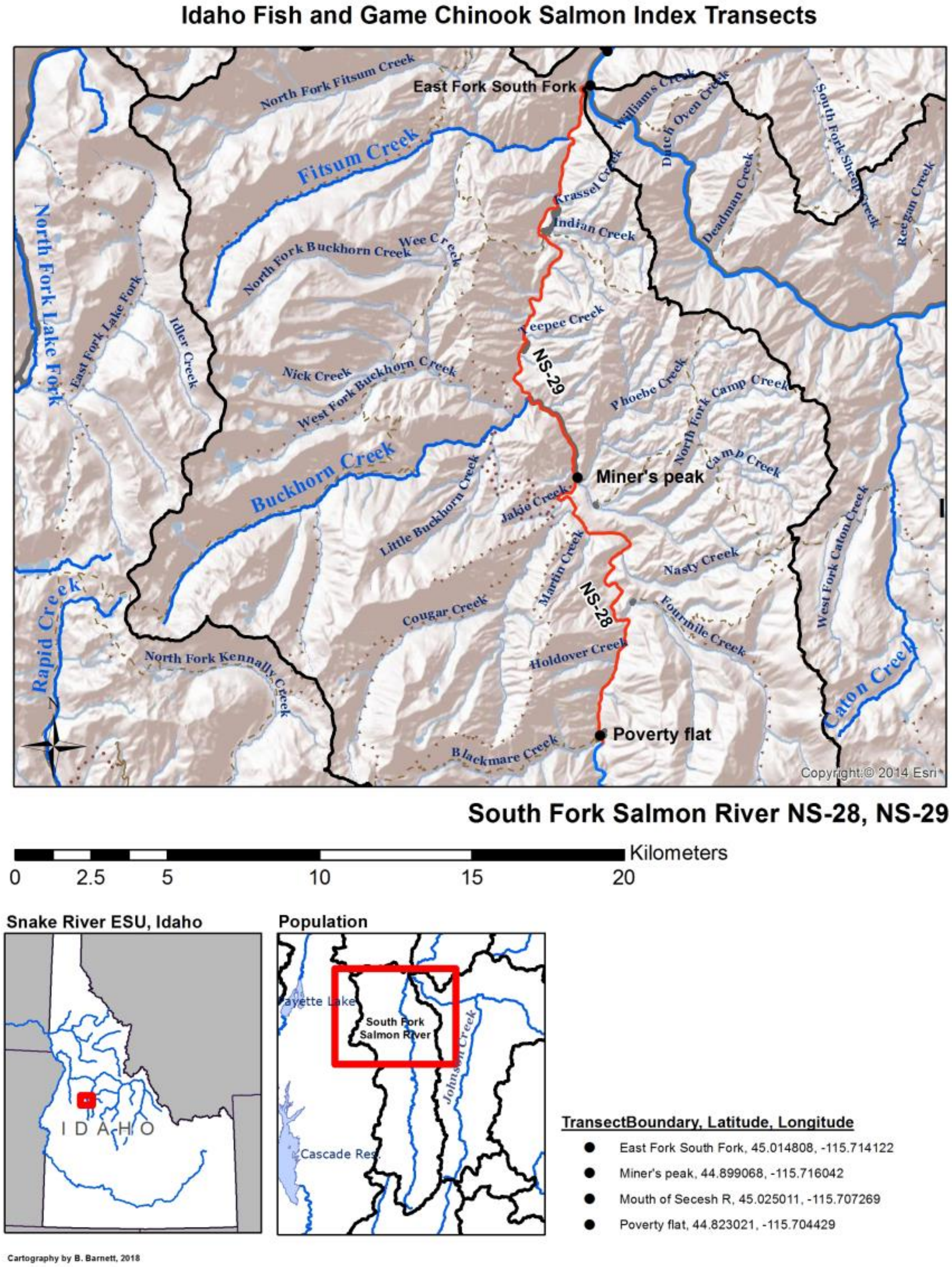
Appendix C. Current trend transect maps by population for IDFG spring-summer Chinook Salmon redd count index surveys. These maps are stored at K:\Fishery\Wild SS monitoring\Maps\Chinook Index Maps along with more detailed transect maps.

Appendix C. South Fork Salmon River MPG

South Fork Salmon River Mainstem Population, 1 of 2

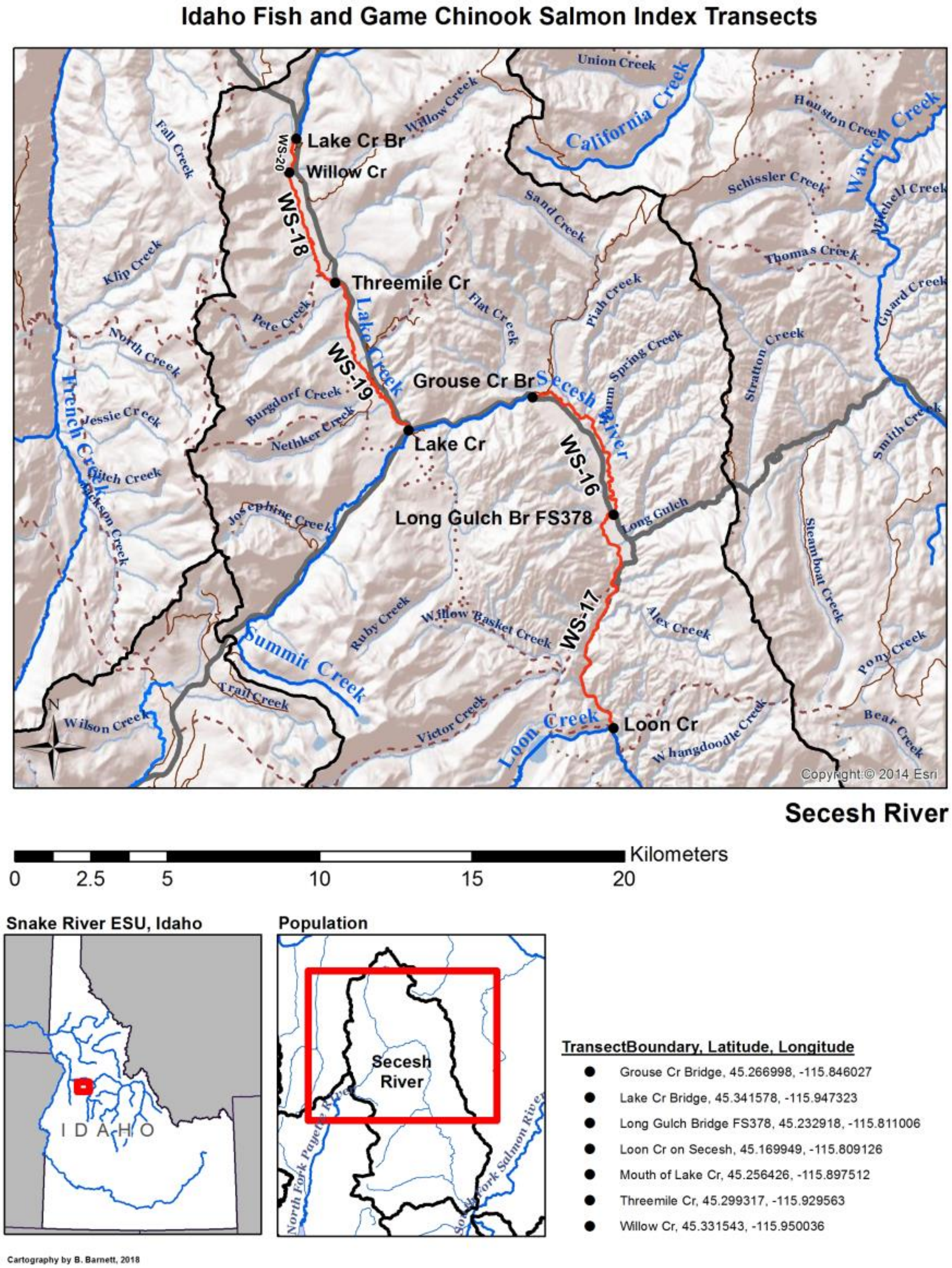


South Fork Salmon River Mainstem Population, 2 of 2



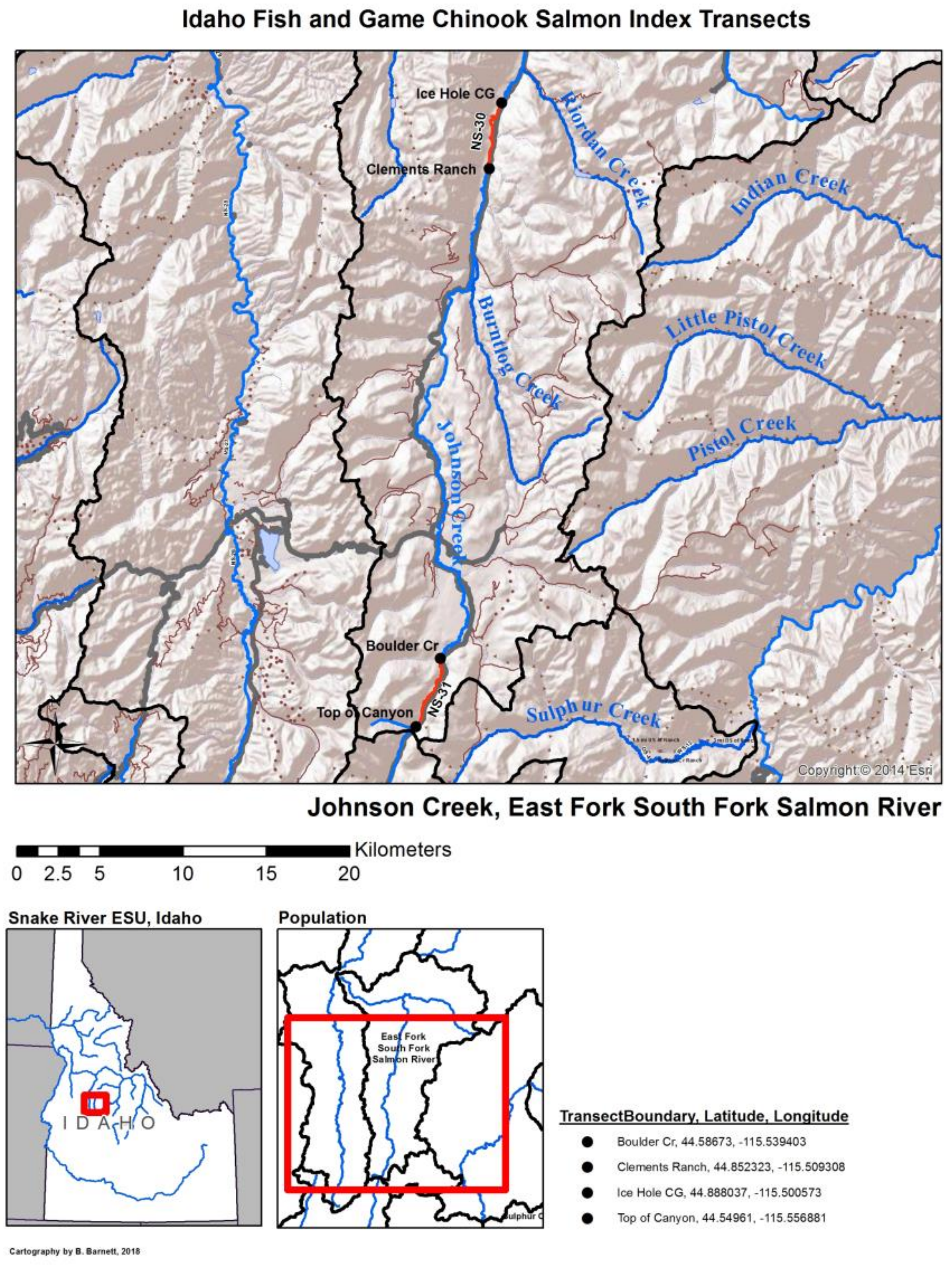
Appendix C. South Fork Salmon River MPG

Secesh River Population

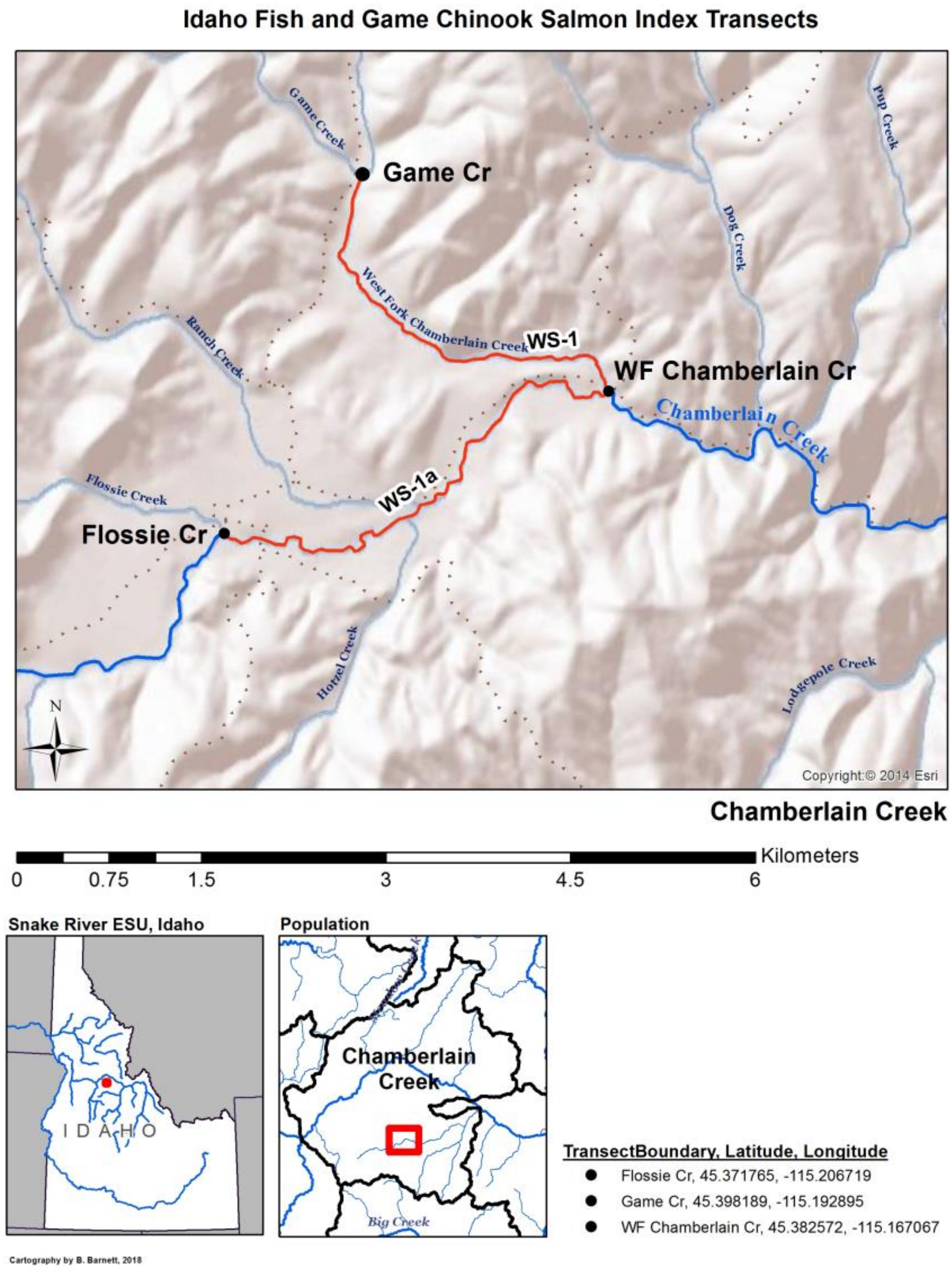


Appendix C. South Fork Salmon River MPG

East Fork South Fork Salmon River Population

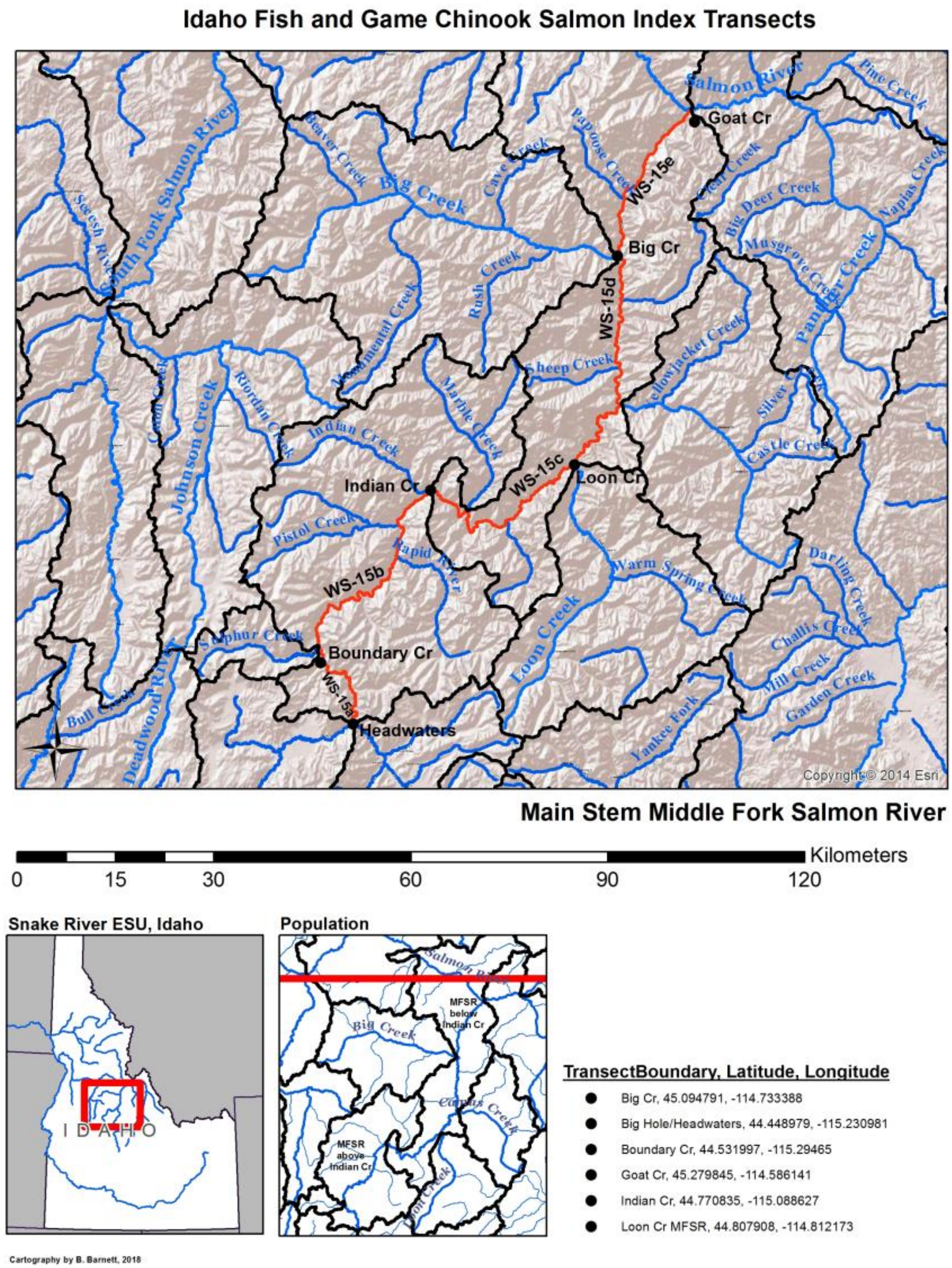


Chamberlain Creek Population



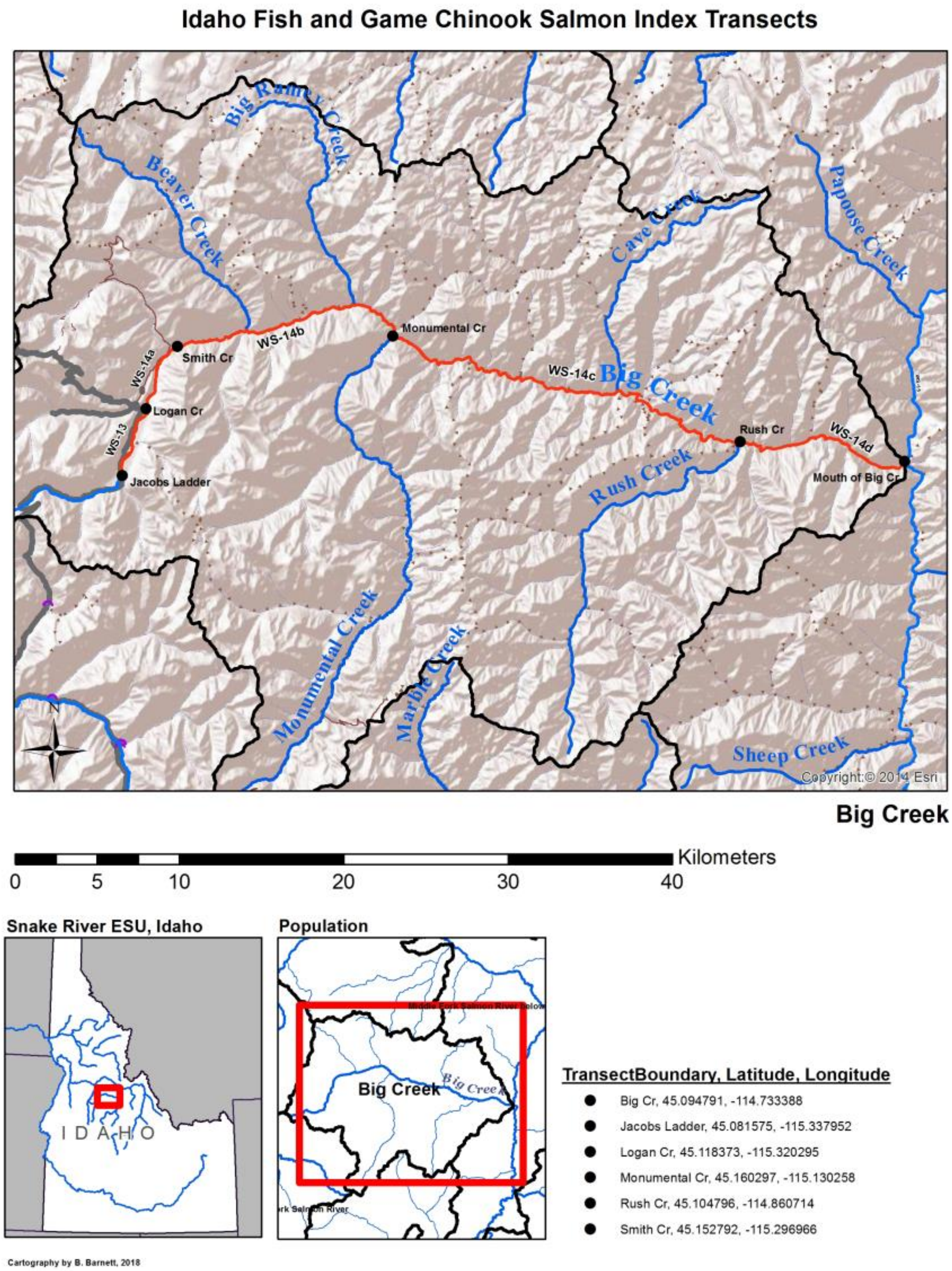
Appendix C. Middle Fork Salmon River MPG

Upper and Lower Middle Fork Salmon River Mainstem populations



Appendix C. Middle Fork Salmon River MPG

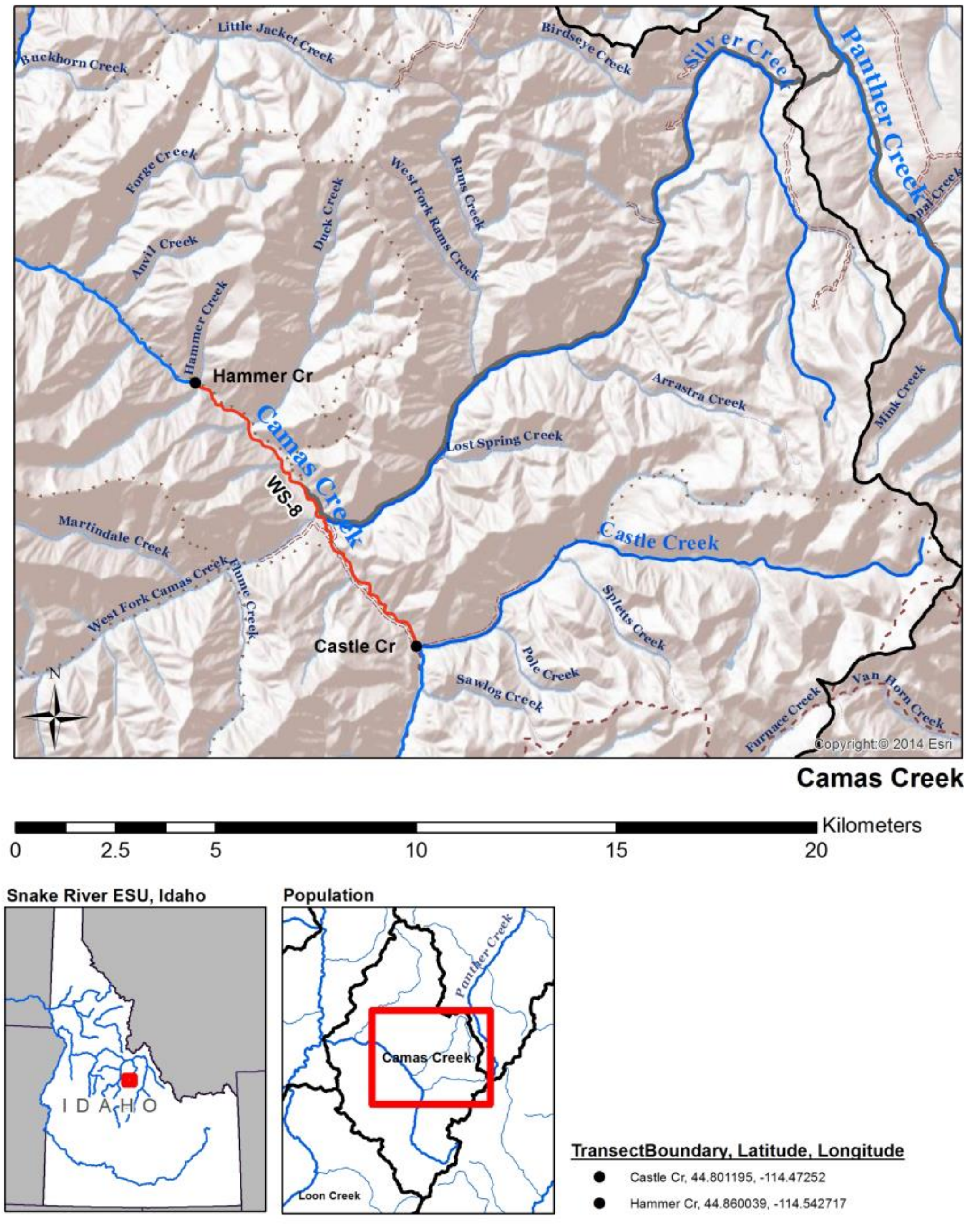
Big Creek Population



Appendix C. Middle Fork Salmon River MPG

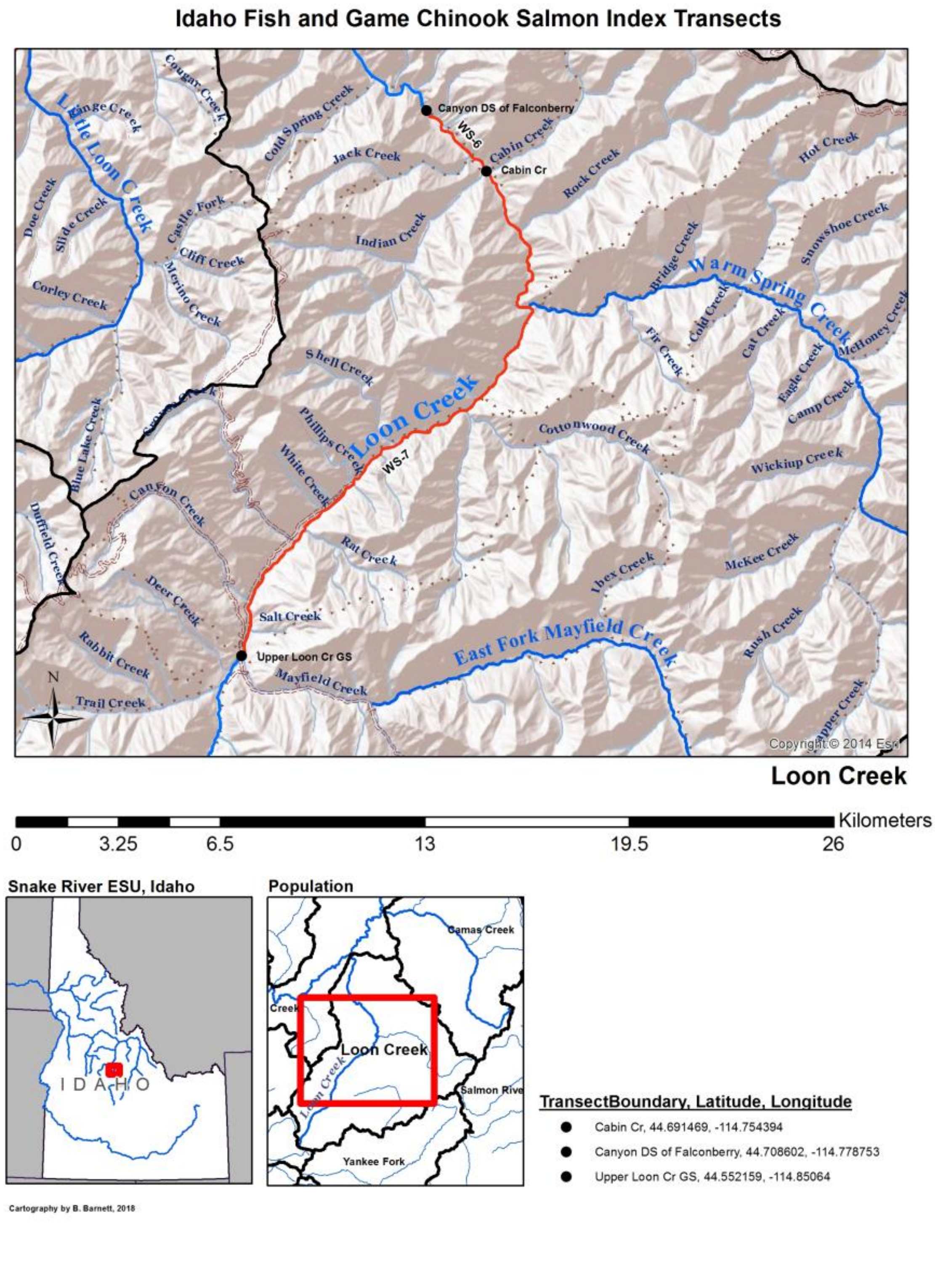
Camas Creek Population

Idaho Fish and Game Chinook Salmon Index Transects



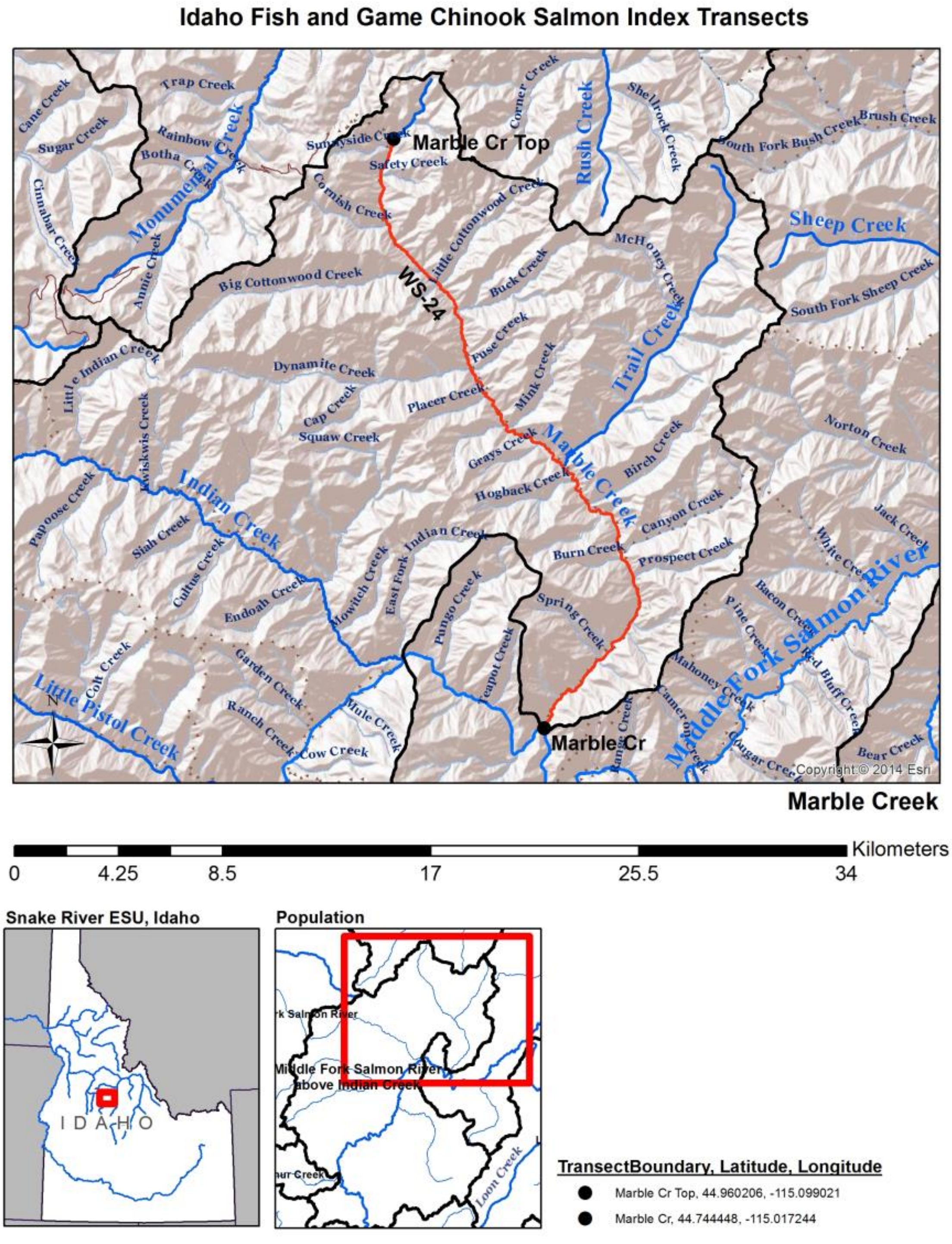
Appendix C. Middle Fork Salmon River MPG

Loon Creek Population



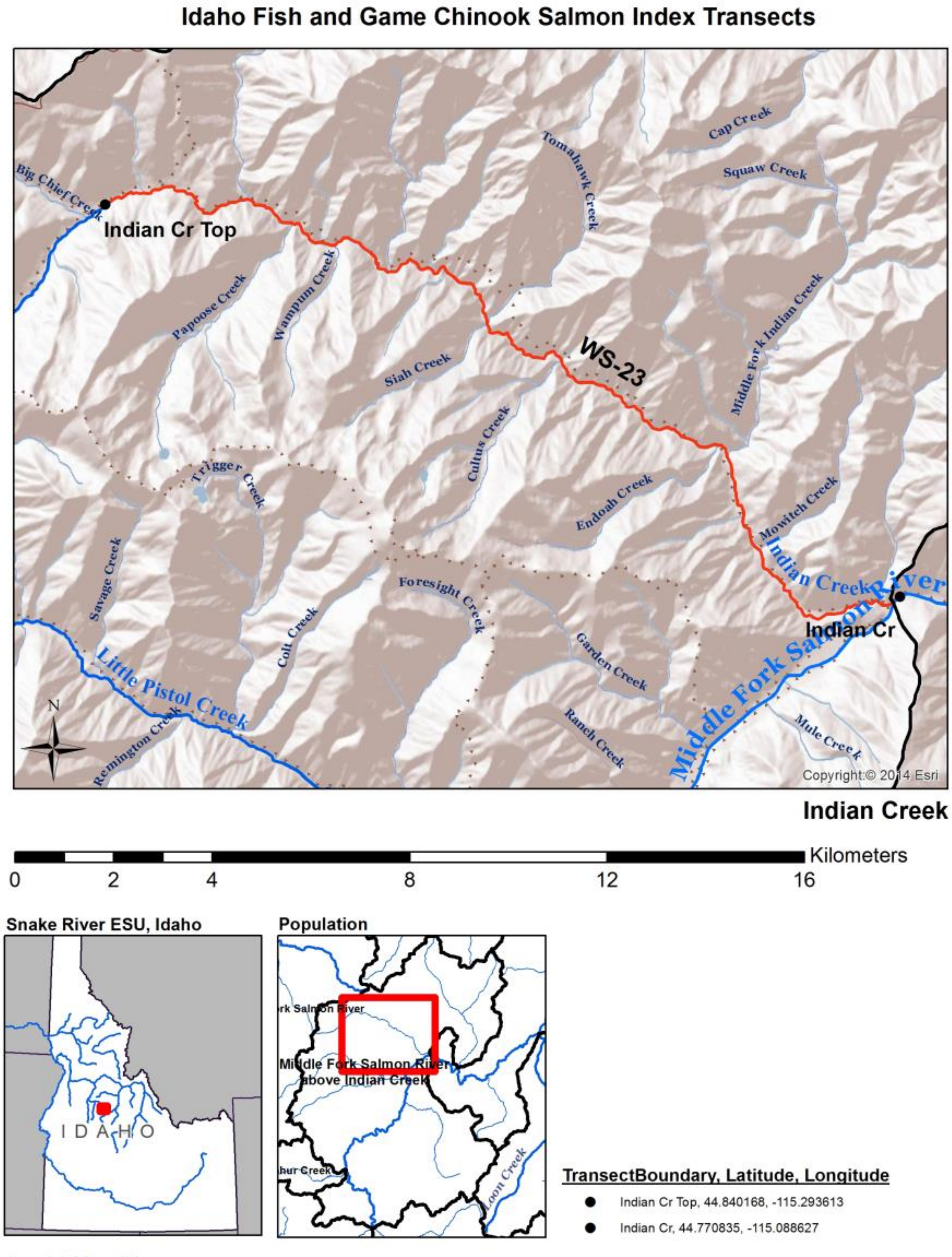
Appendix C.   Middle Fork Salmon River MPG

Marble Creek, part of the Upper Mainstem Middle Fork population



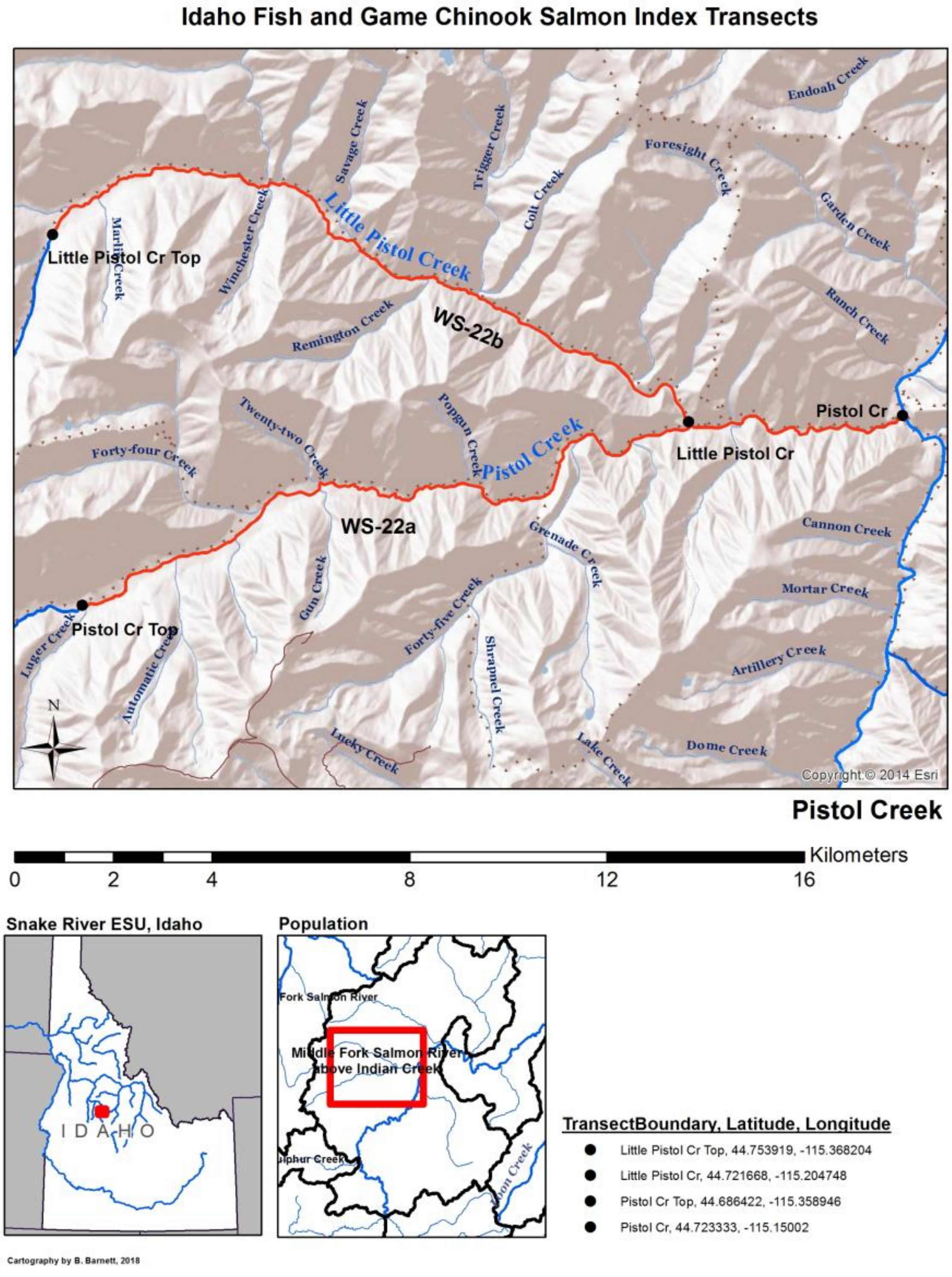
Appendix C. Middle Fork Salmon River MPG

Indian Creek, part of the Upper Mainstem Middle Fork population



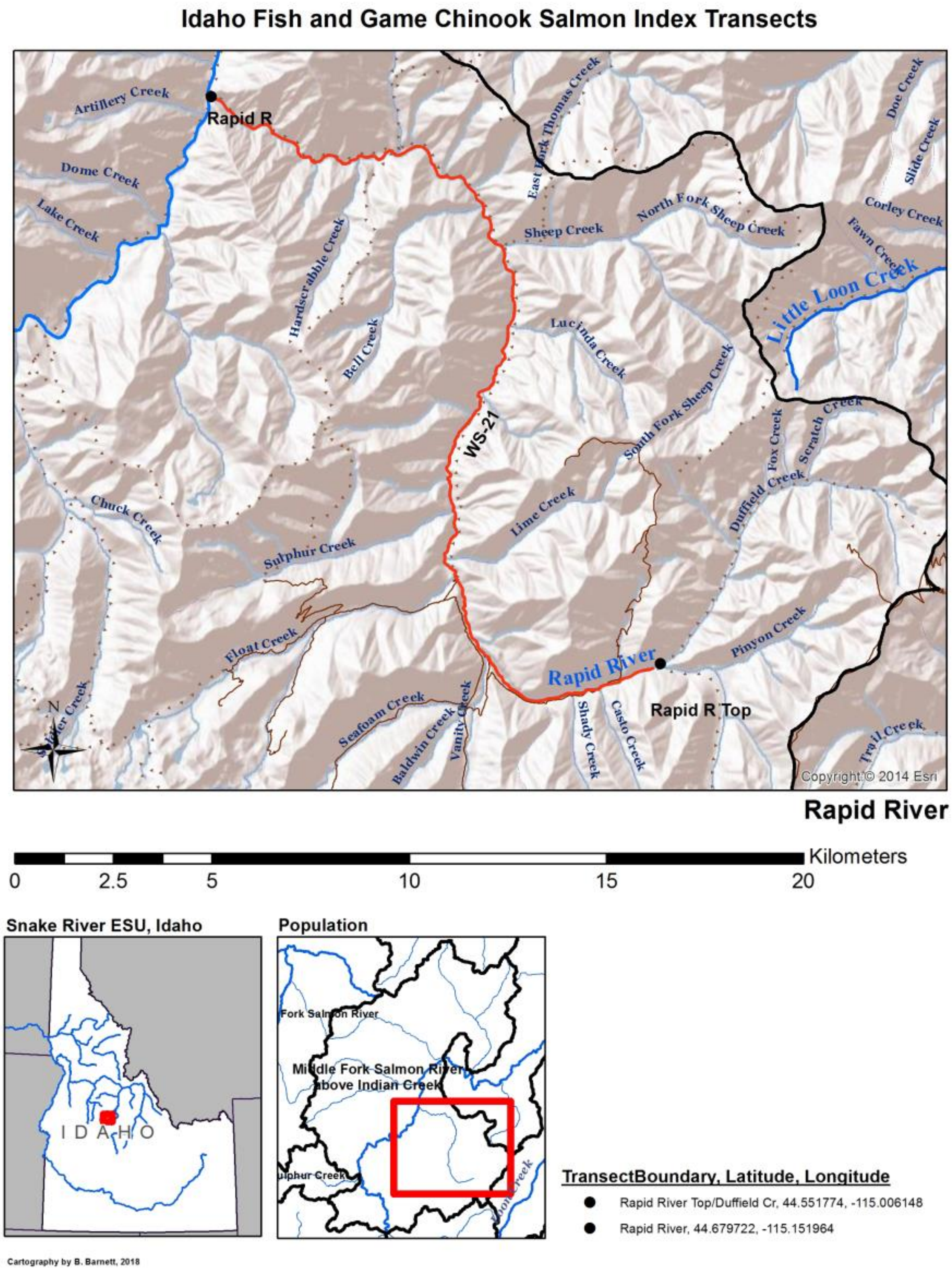
Appendix C. Middle Fork Salmon River MPG

Pistol Creek, part of the Upper Mainstem Middle Fork population



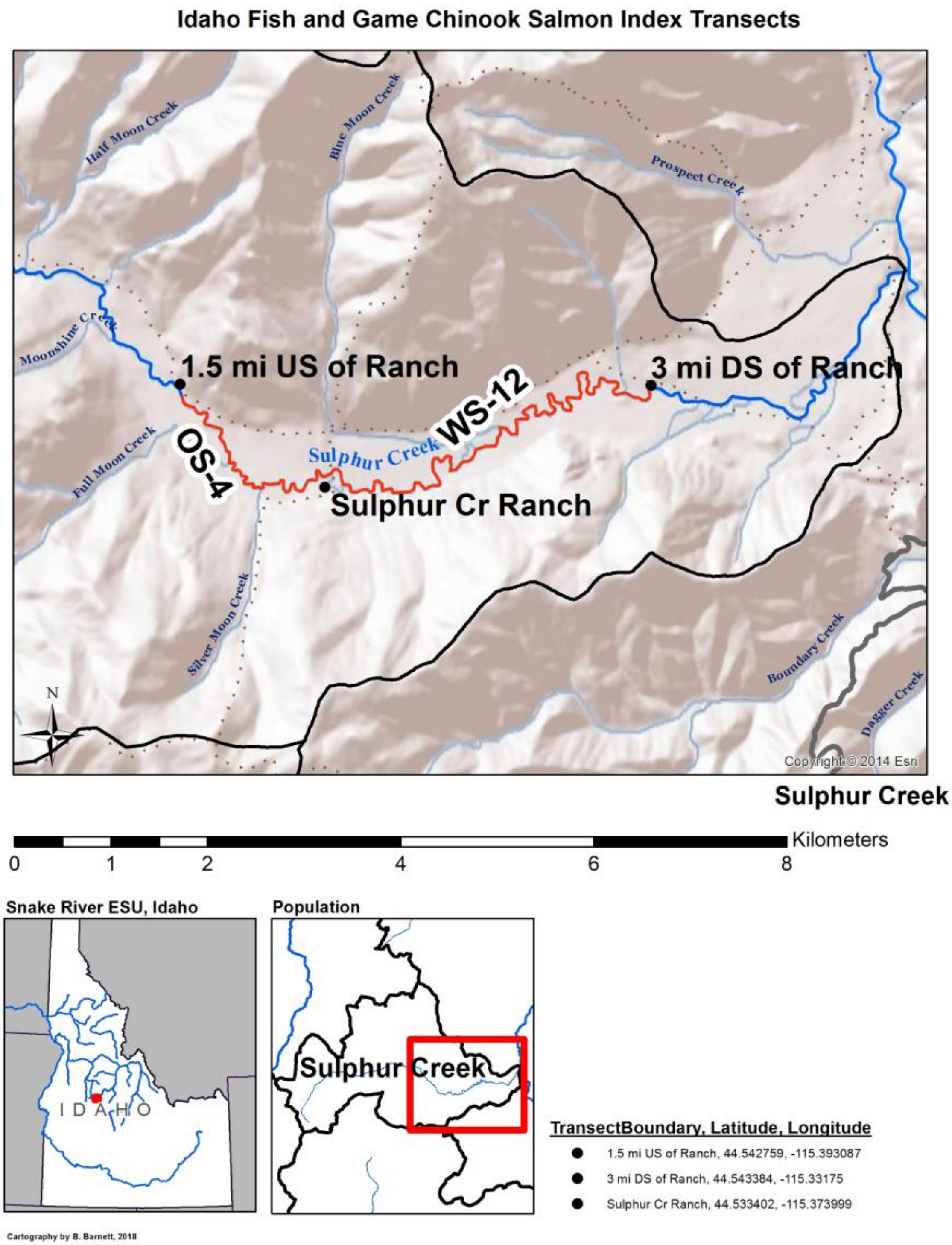
Appendix C. Middle Fork Salmon River MPG

Rapid River, part of the Upper Mainstem Middle Fork population



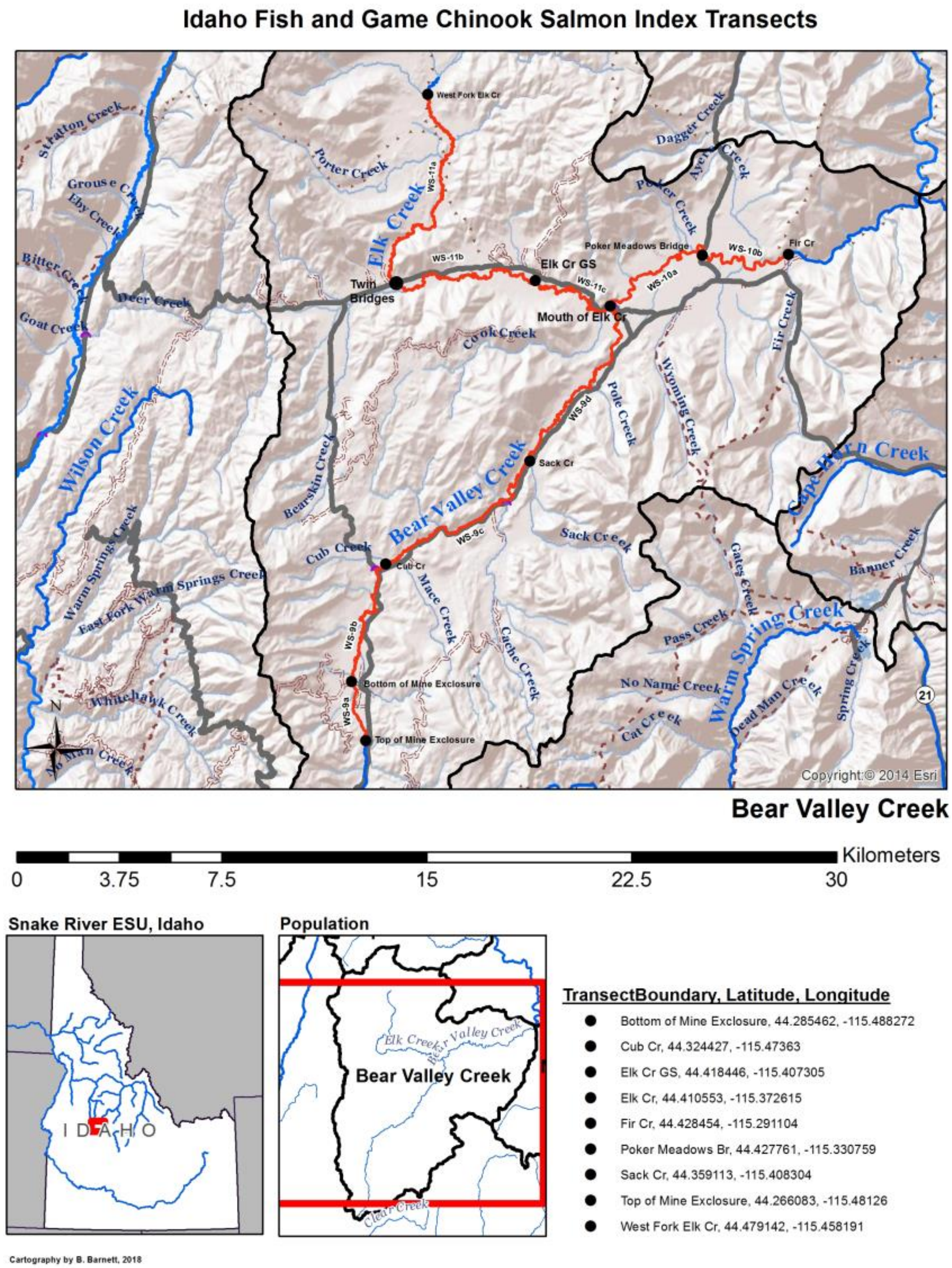
Appendix C. Middle Fork Salmon River MPG

Sulphur Creek Population



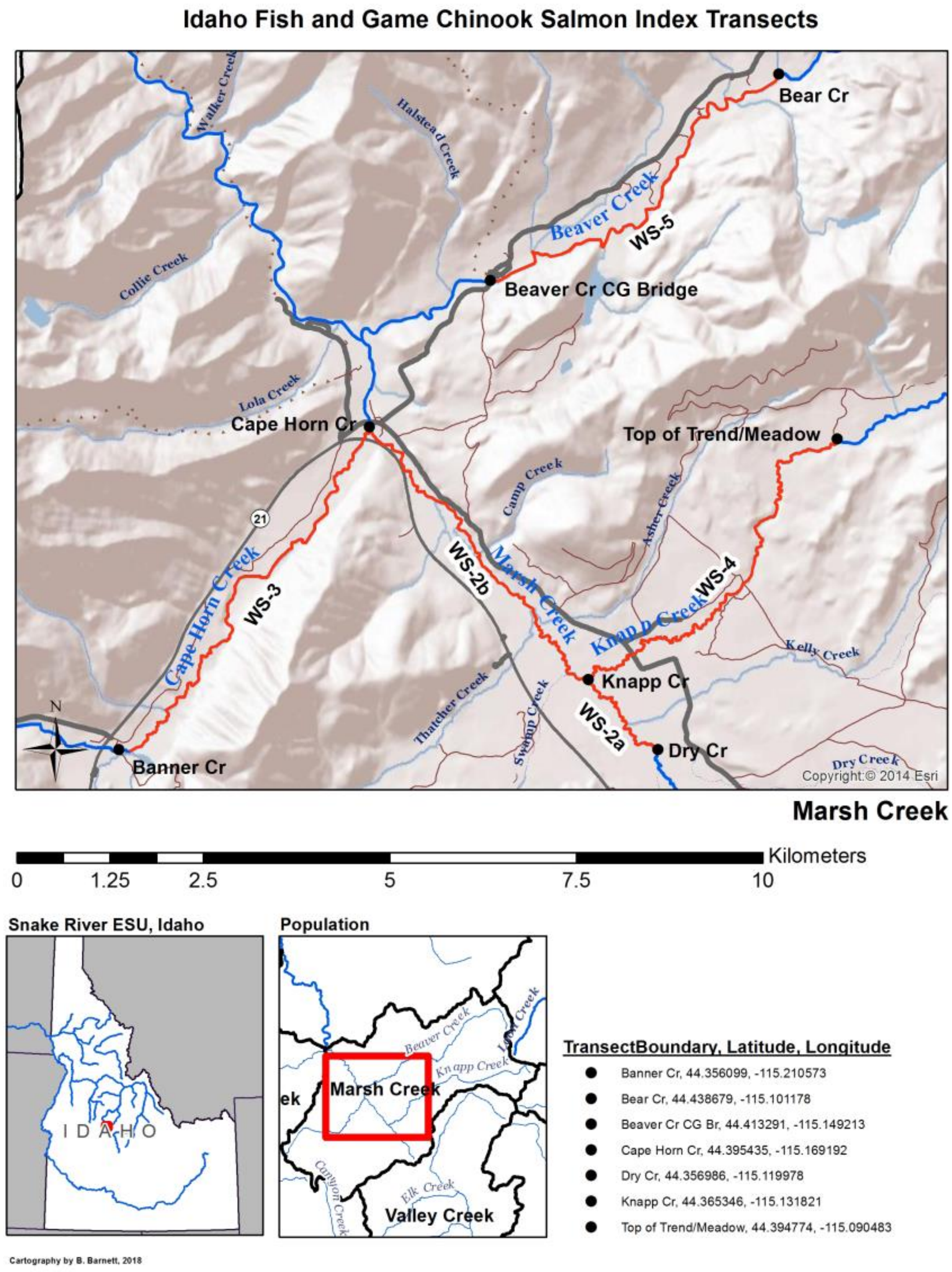
Appendix C. Middle Fork Salmon River MPG

Bear Valley Creek Population



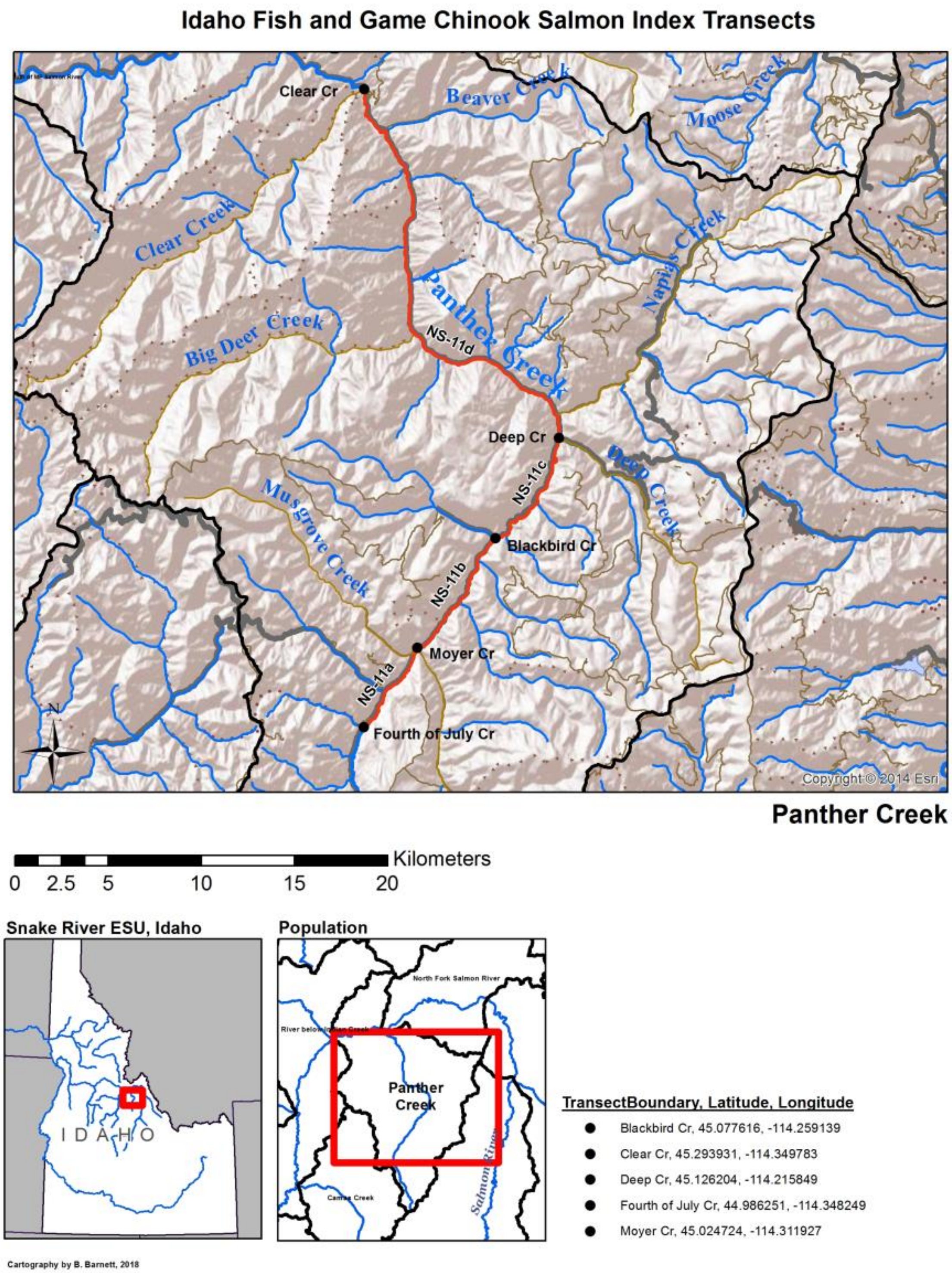
Appendix C. Middle Fork Salmon River MPG

Marsh Creek Population



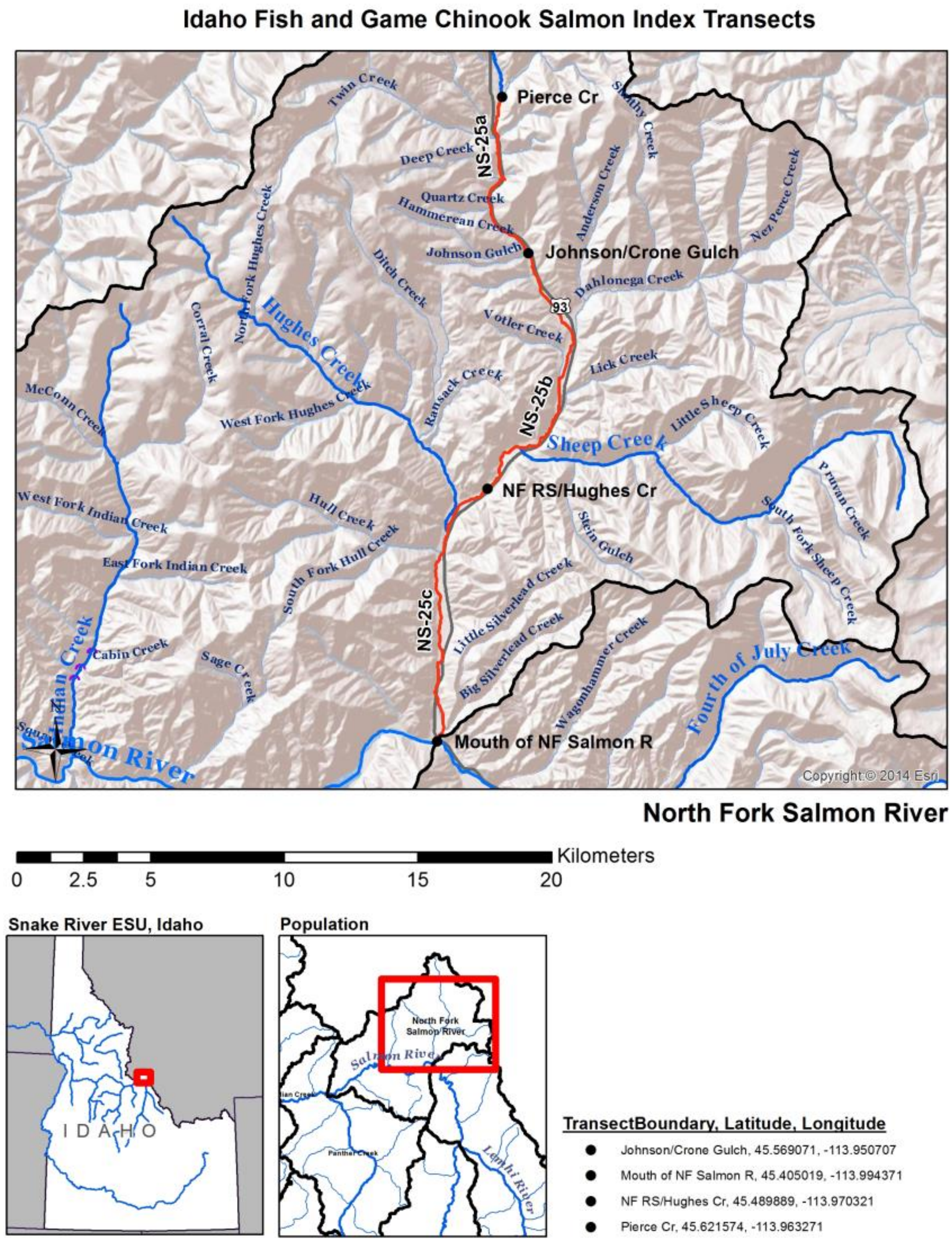
Appendix C. Upper Salmon River MPG

Panther Creek Population



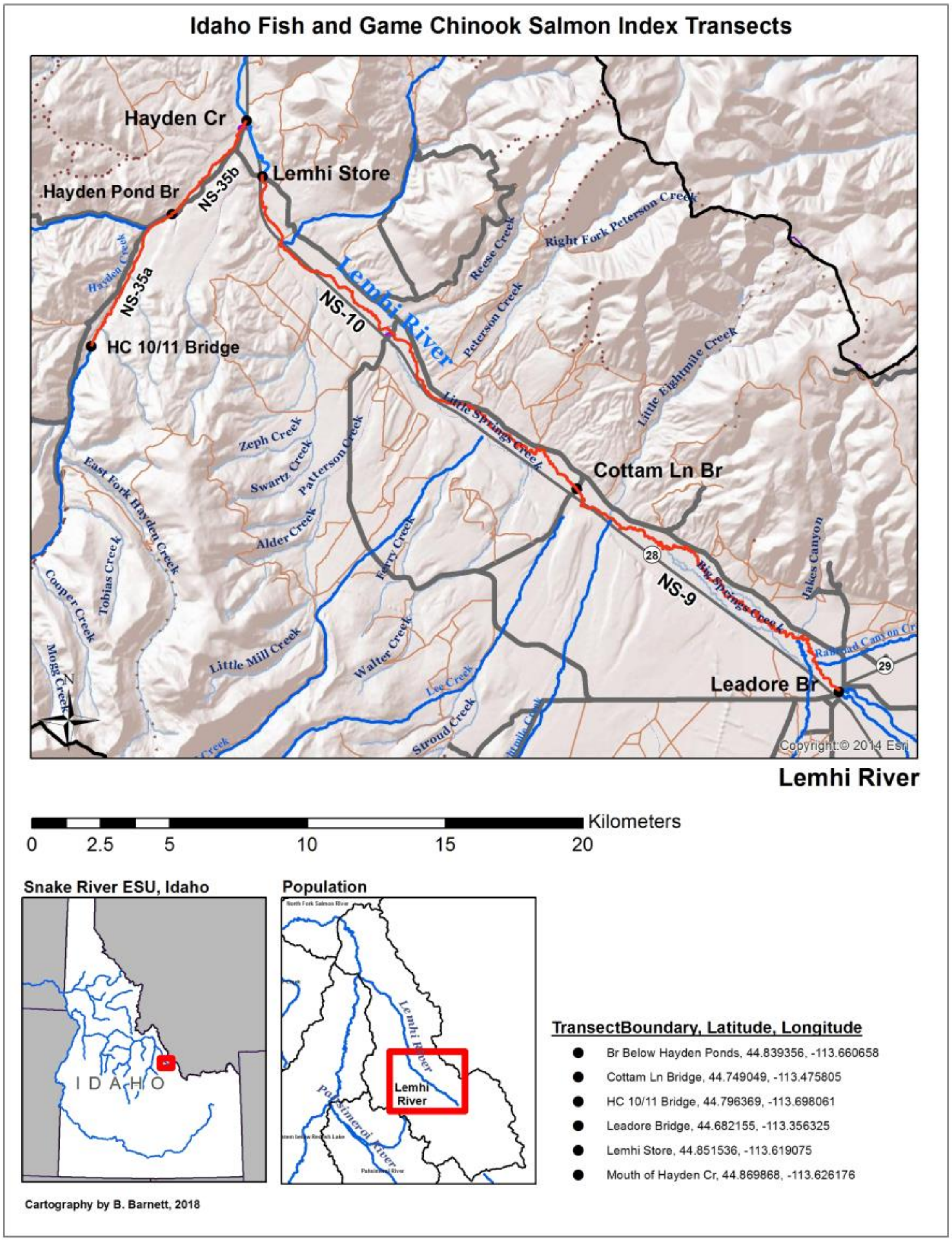
Appendix C. Upper Salmon River MPG

North Fork Salmon River Population



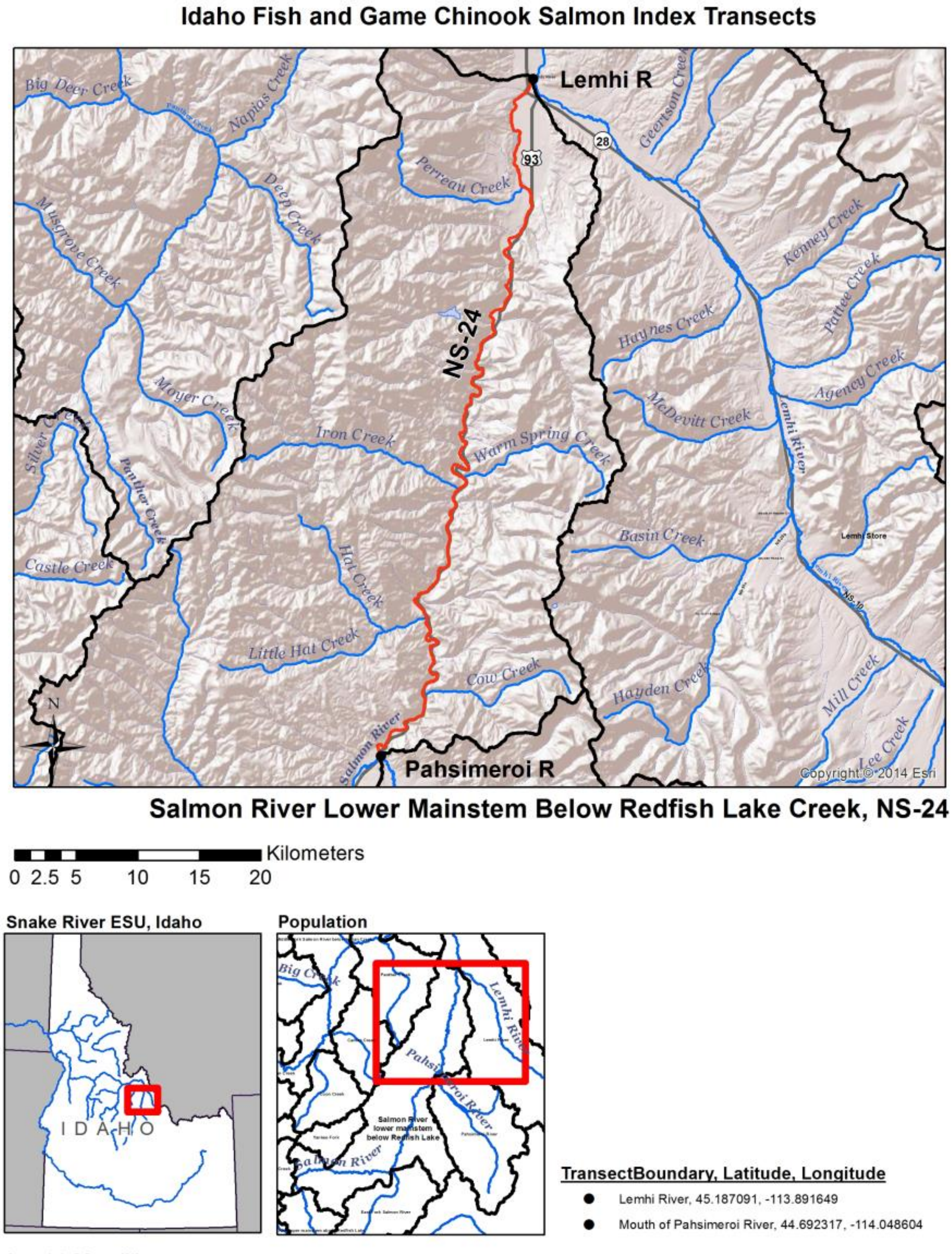
Appendix C. Upper Salmon River MPG

Lemhi River Population



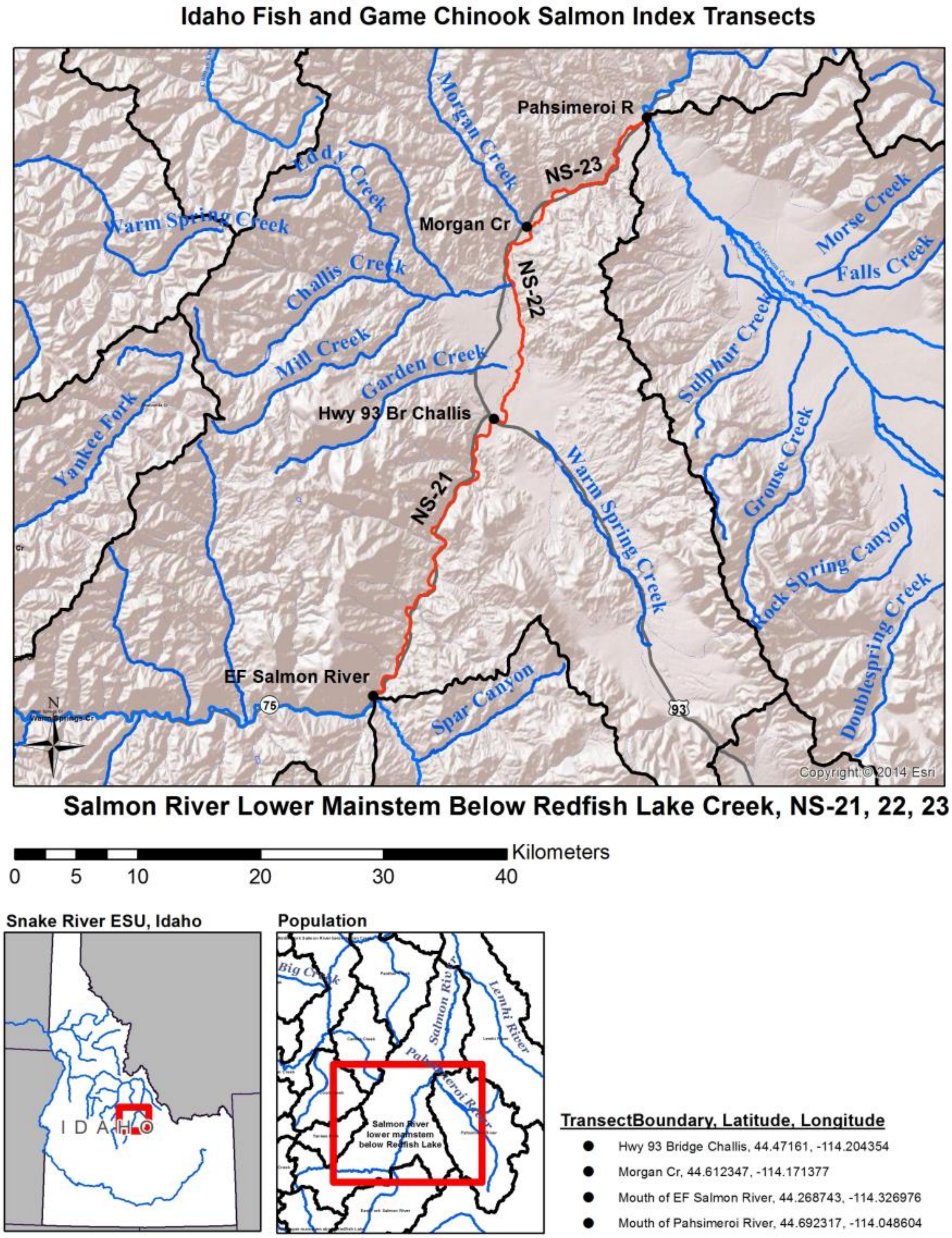
Appendix C. Upper Salmon River MPG

Salmon River Lower Mainstem Below Redfish Lake Population, 1 of 3



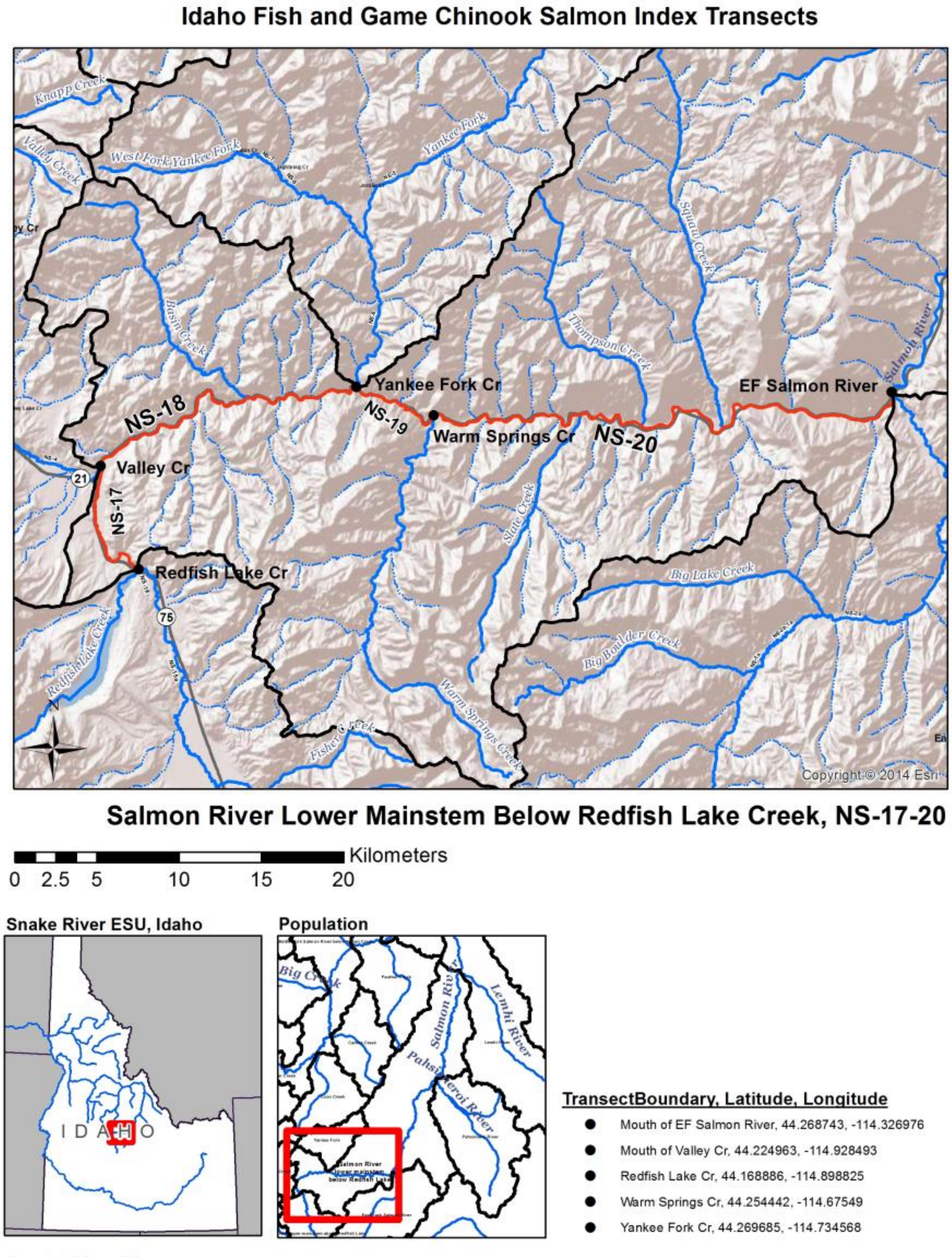
Appendix C. Upper Salmon River MPG

Salmon River Lower Mainstem Below Redfish Lake Population, 2 of 3



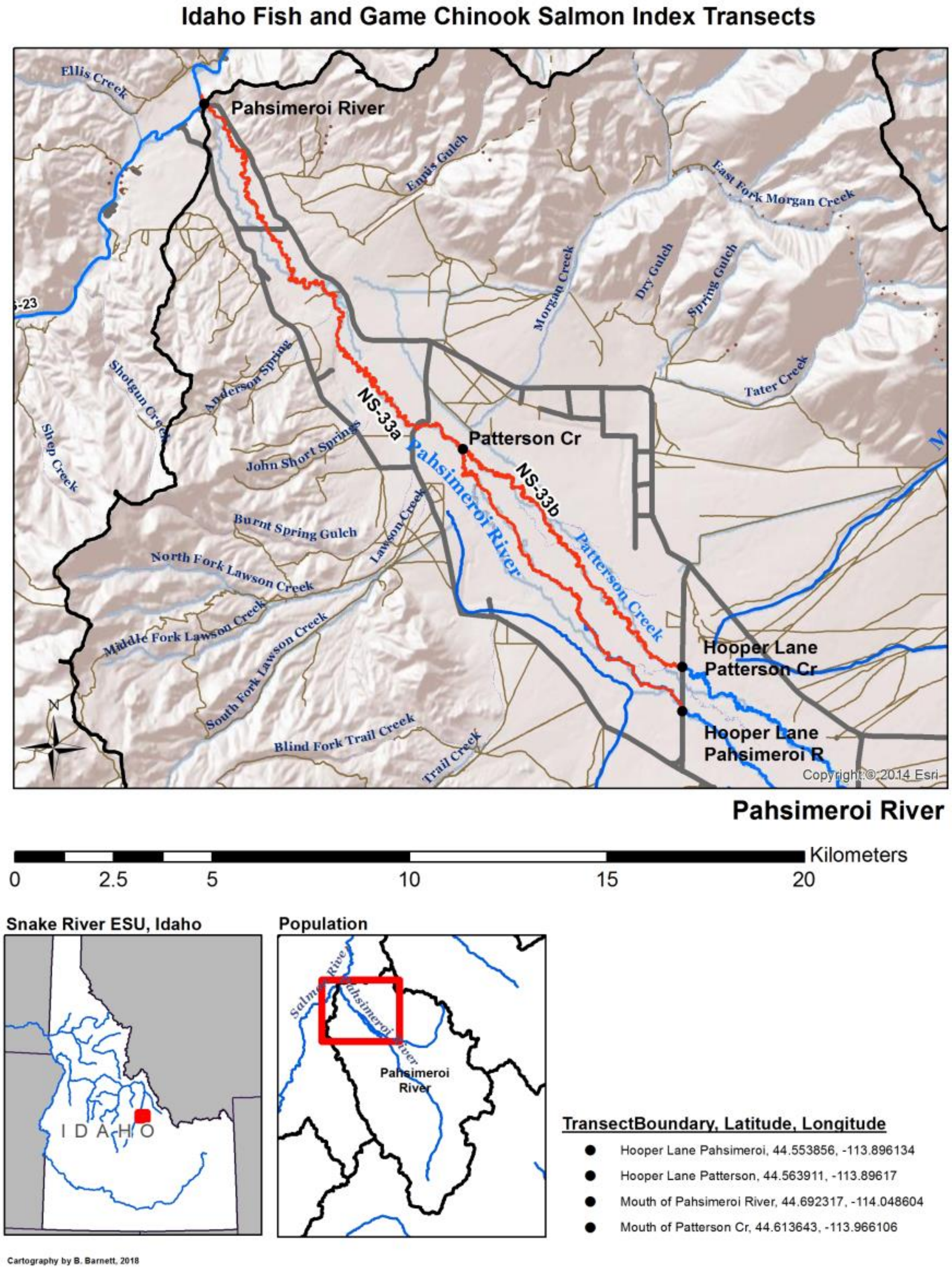
Cartography by B. Barnett, 2018

Salmon River Lower Mainstem Below Redfish Lake Population, 3 of 3



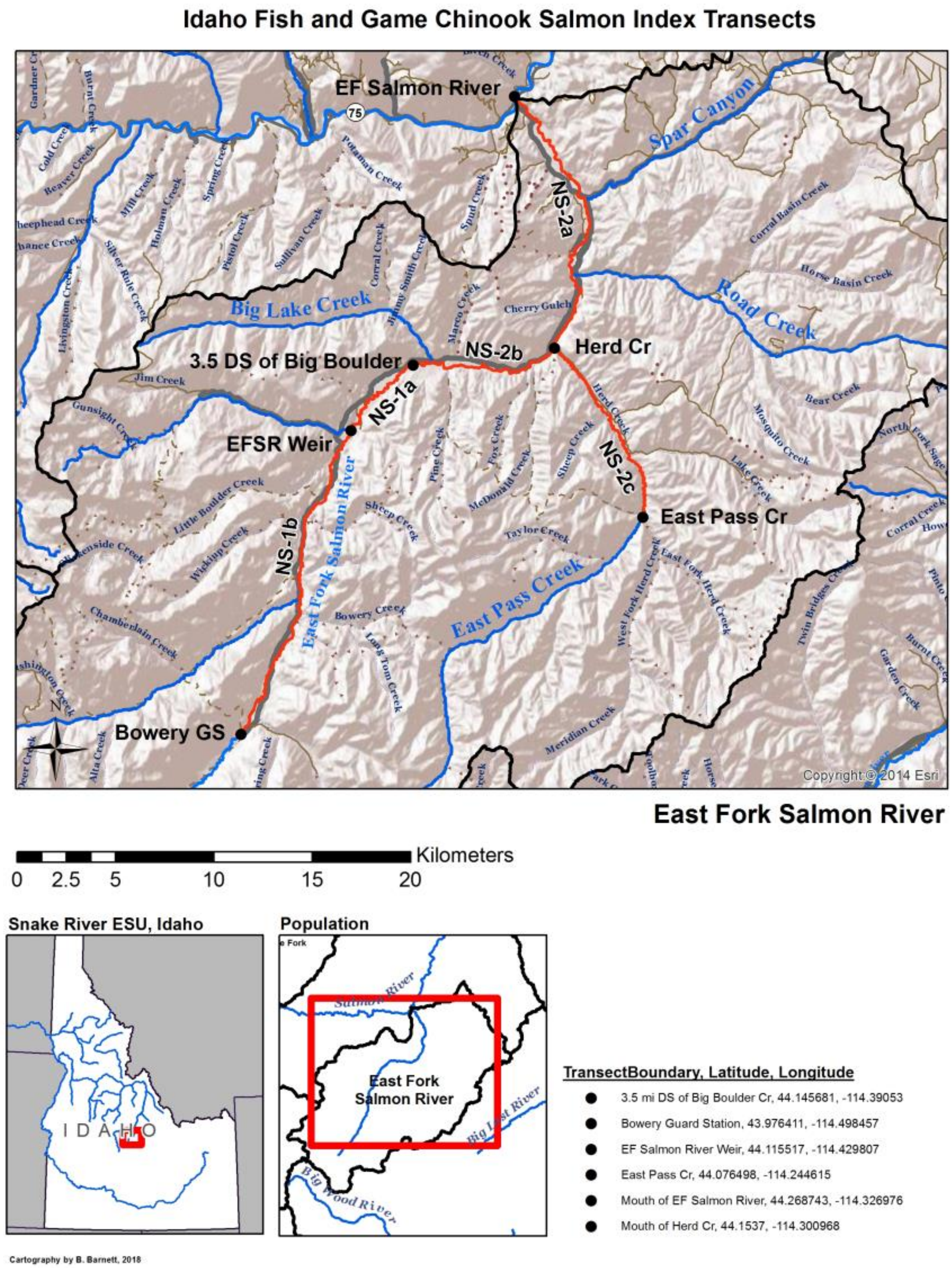
Appendix C. Upper Salmon River MPG

Pahsimeroi River Population



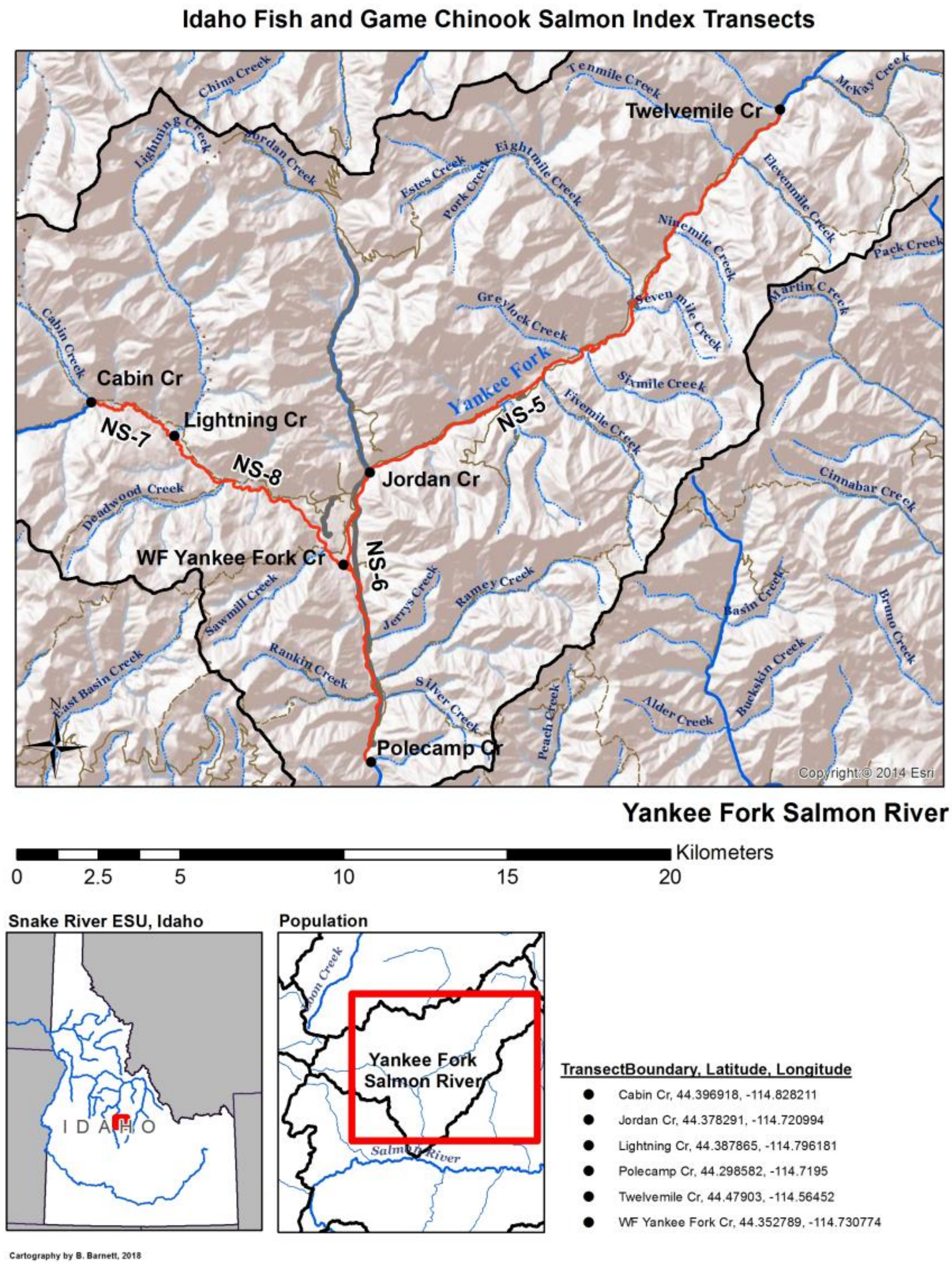
Appendix C. Upper Salmon River MPG

East Fork Salmon River Population



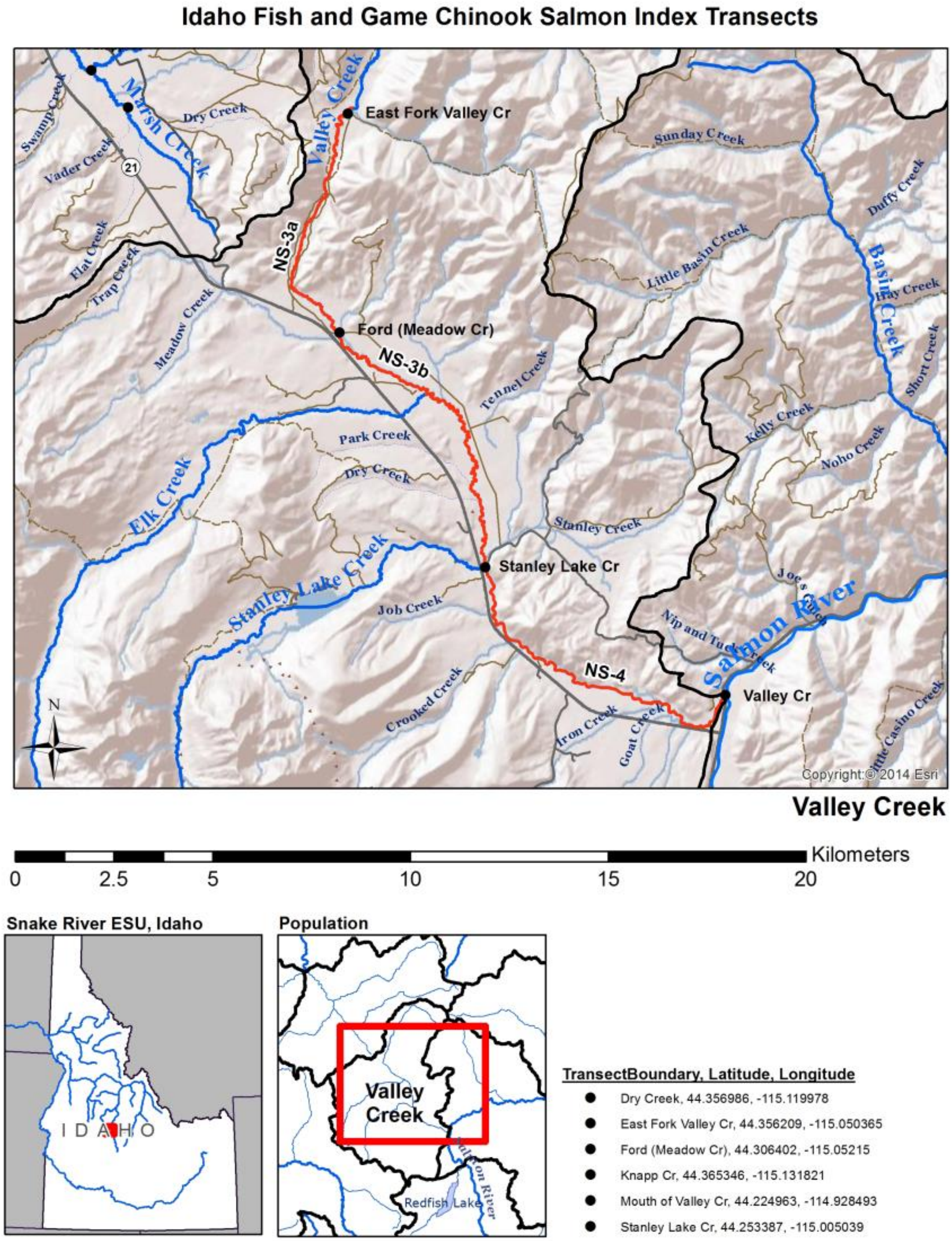
Appendix C. Upper Salmon River MPG

Yankee Fork Salmon River Population



Appendix C. Upper Salmon River MPG

Valley Creek Population

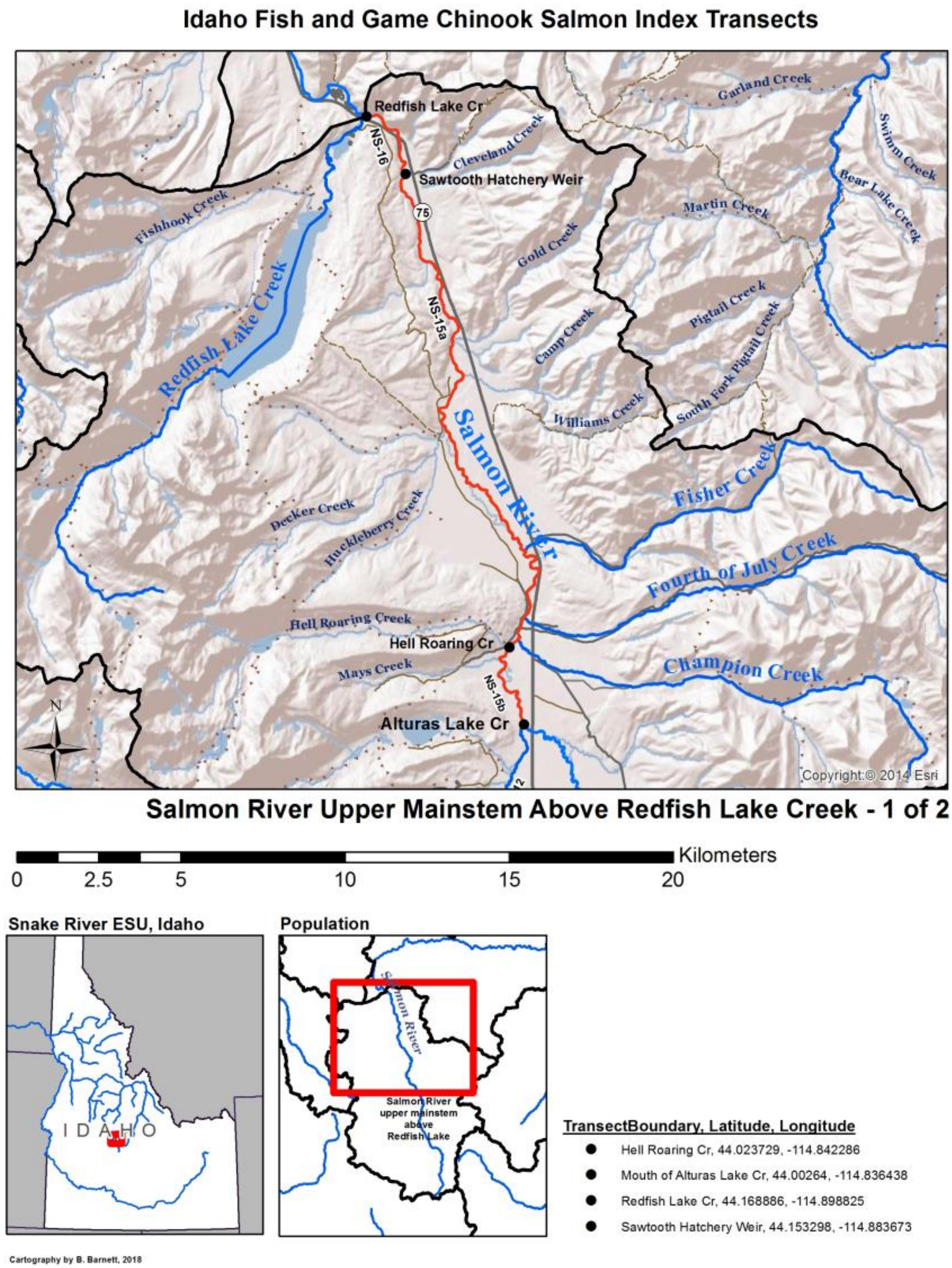


TransectBoundary, Latitude, Longitude

- Dry Creek, 44.356986, -115.119978
- East Fork Valley Cr, 44.356209, -115.050365
- Ford (Meadow Cr), 44.306402, -115.05215
- Knapp Cr, 44.365346, -115.131821
- Mouth of Valley Cr, 44.224963, -114.928493
- Stanley Lake Cr, 44.253387, -115.005039

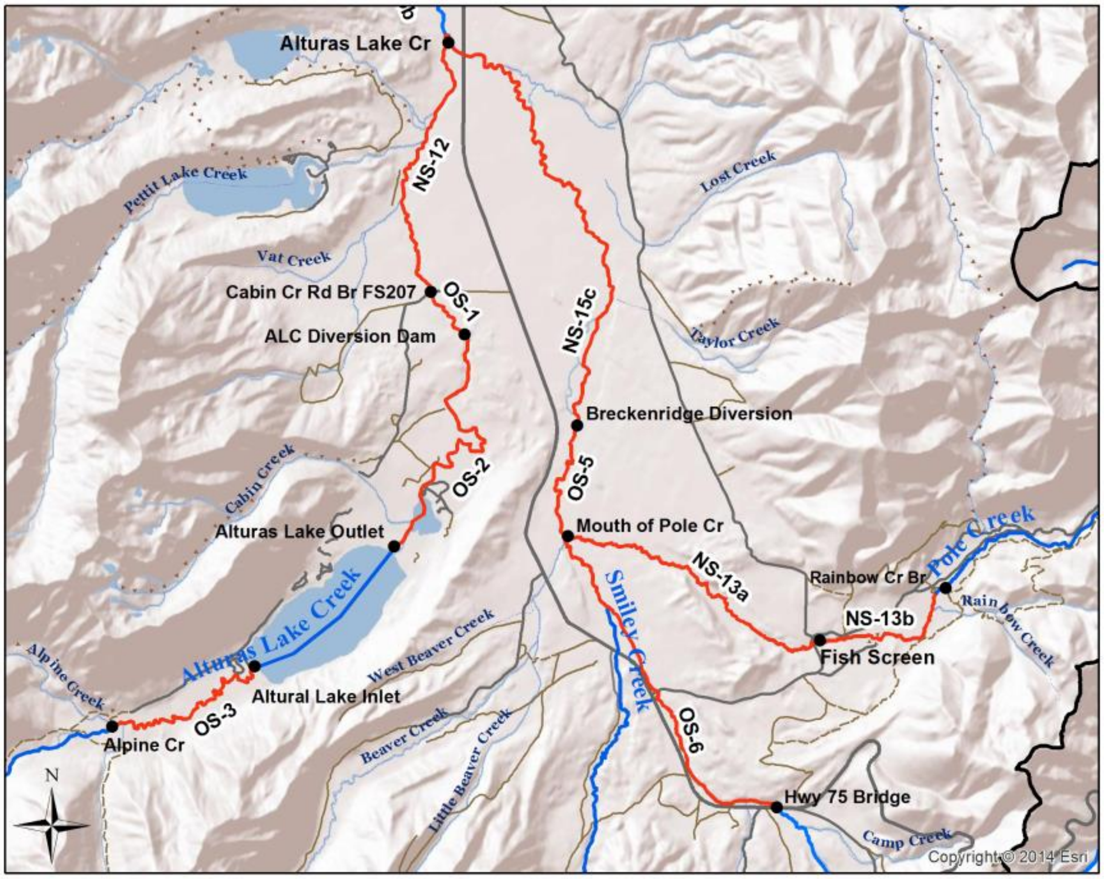
Cartography by B. Barnett, 2018

Salmon River Upper Mainstem Above Redfish Lake Population, 1 of 2

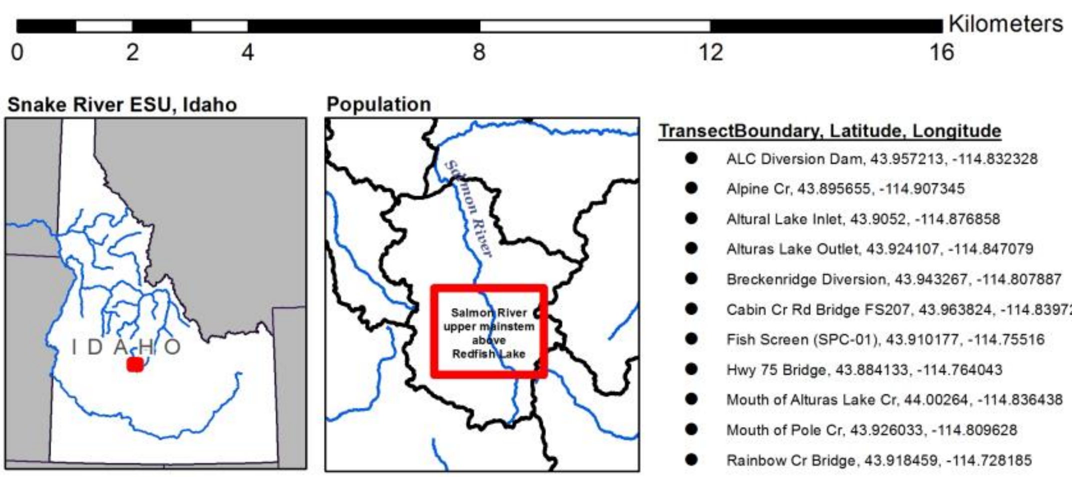


Salmon River Upper Mainstem Above Redfish Lake Population, 2 of 2

Idaho Fish and Game Chinook Salmon Index Transects



Salmon River Upper Mainstem Above Redfish Lake Creek - 2 of 2



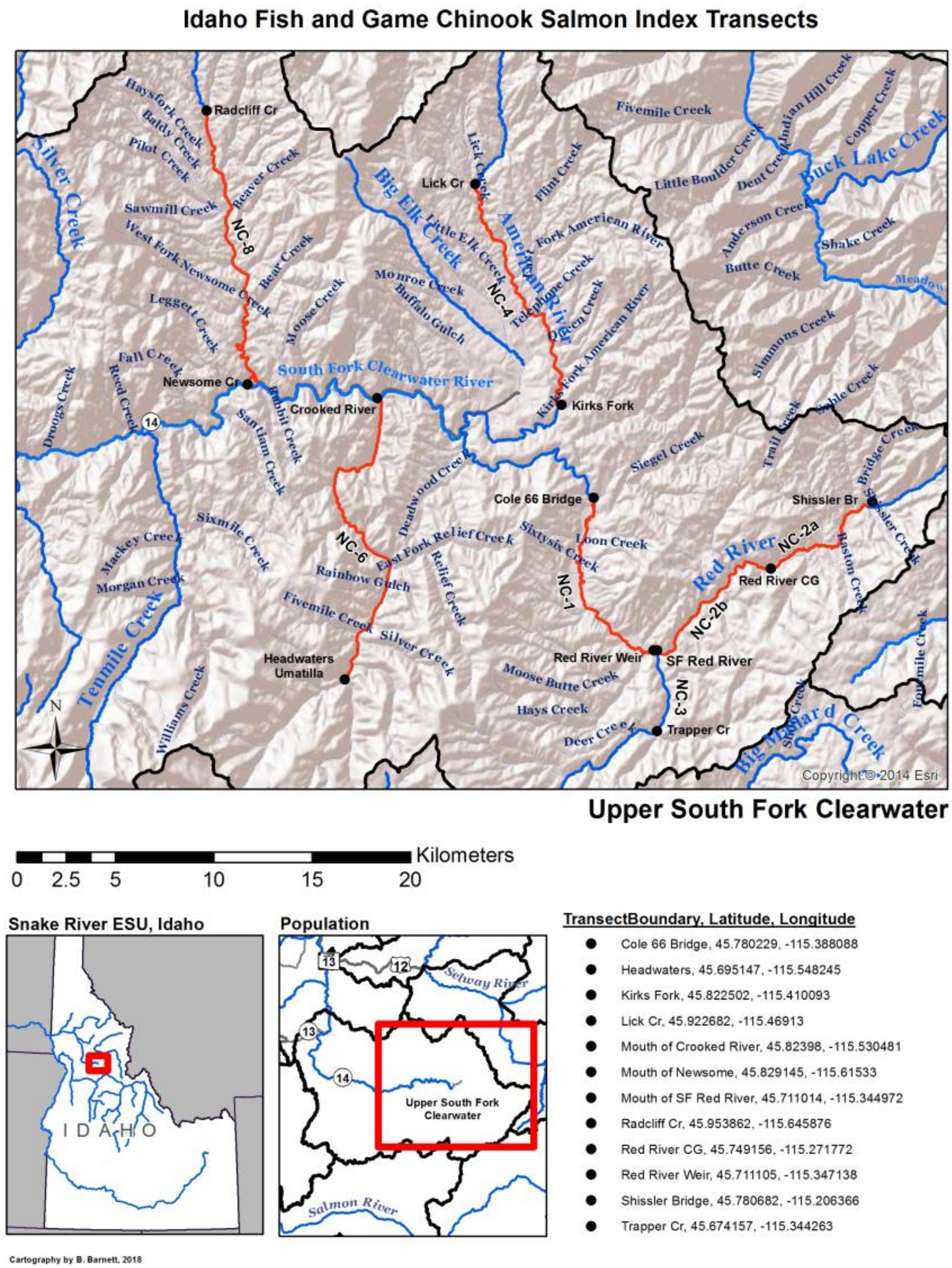
TransectBoundary, Latitude, Longitude

- ALC Diversion Dam, 43.957213, -114.832328
- Alpine Cr, 43.895655, -114.907345
- Altural Lake Inlet, 43.9052, -114.876858
- Alturas Lake Outlet, 43.924107, -114.847079
- Breckenridge Diversion, 43.943267, -114.807887
- Cabin Cr Rd Bridge FS207, 43.963824, -114.839725
- Fish Screen (SPC-01), 43.910177, -114.75516
- Hwy 75 Bridge, 43.884133, -114.764043
- Mouth of Alturas Lake Cr, 44.00264, -114.836438
- Mouth of Pole Cr, 43.926033, -114.809628
- Rainbow Cr Bridge, 43.918459, -114.728185

Cartography by B. Barnett, 2018

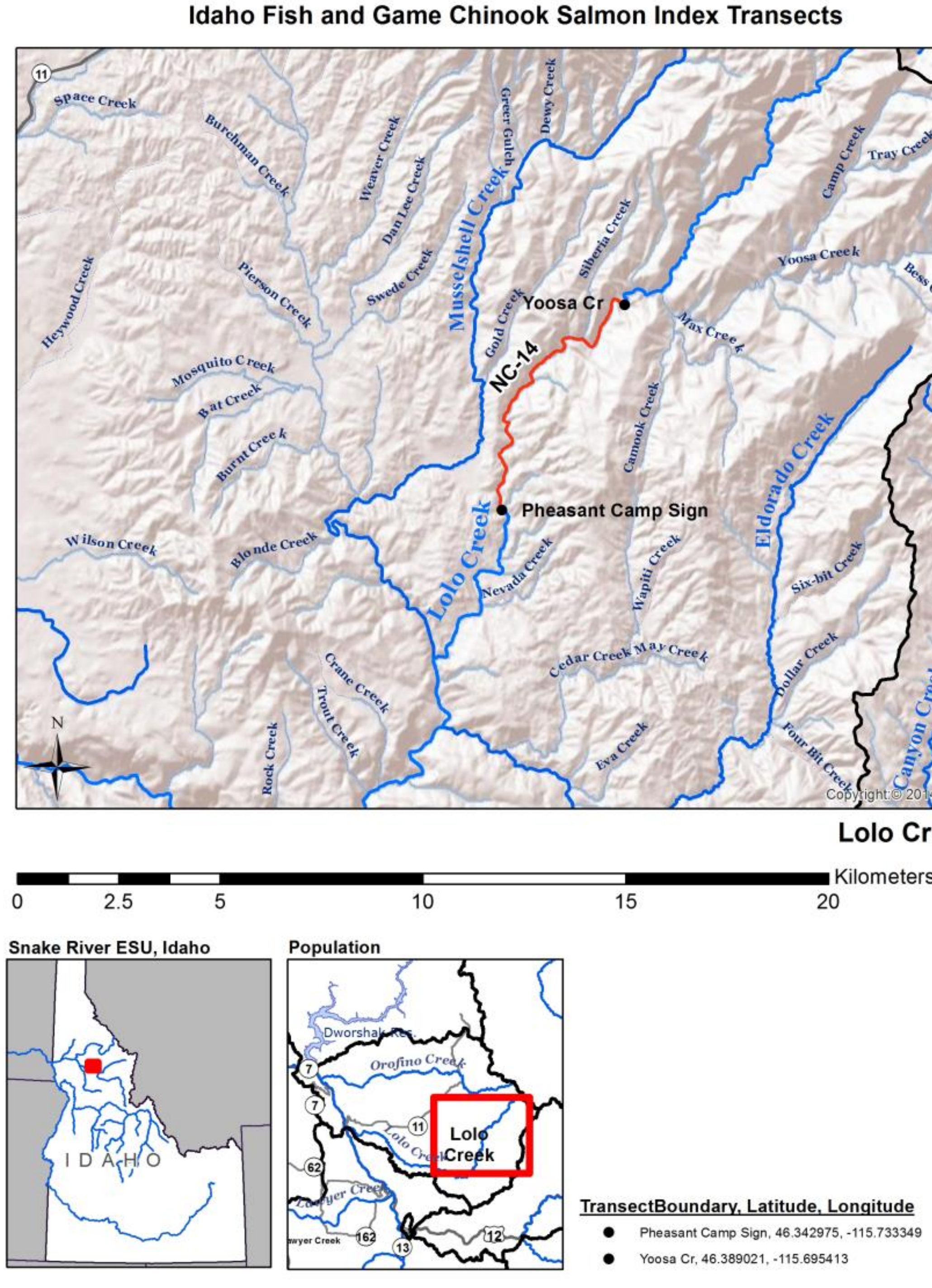
Appendix C. Dry Clearwater River MPG

Upper South Fork Clearwater River Population



Appendix C. Wet Clearwater River MPG

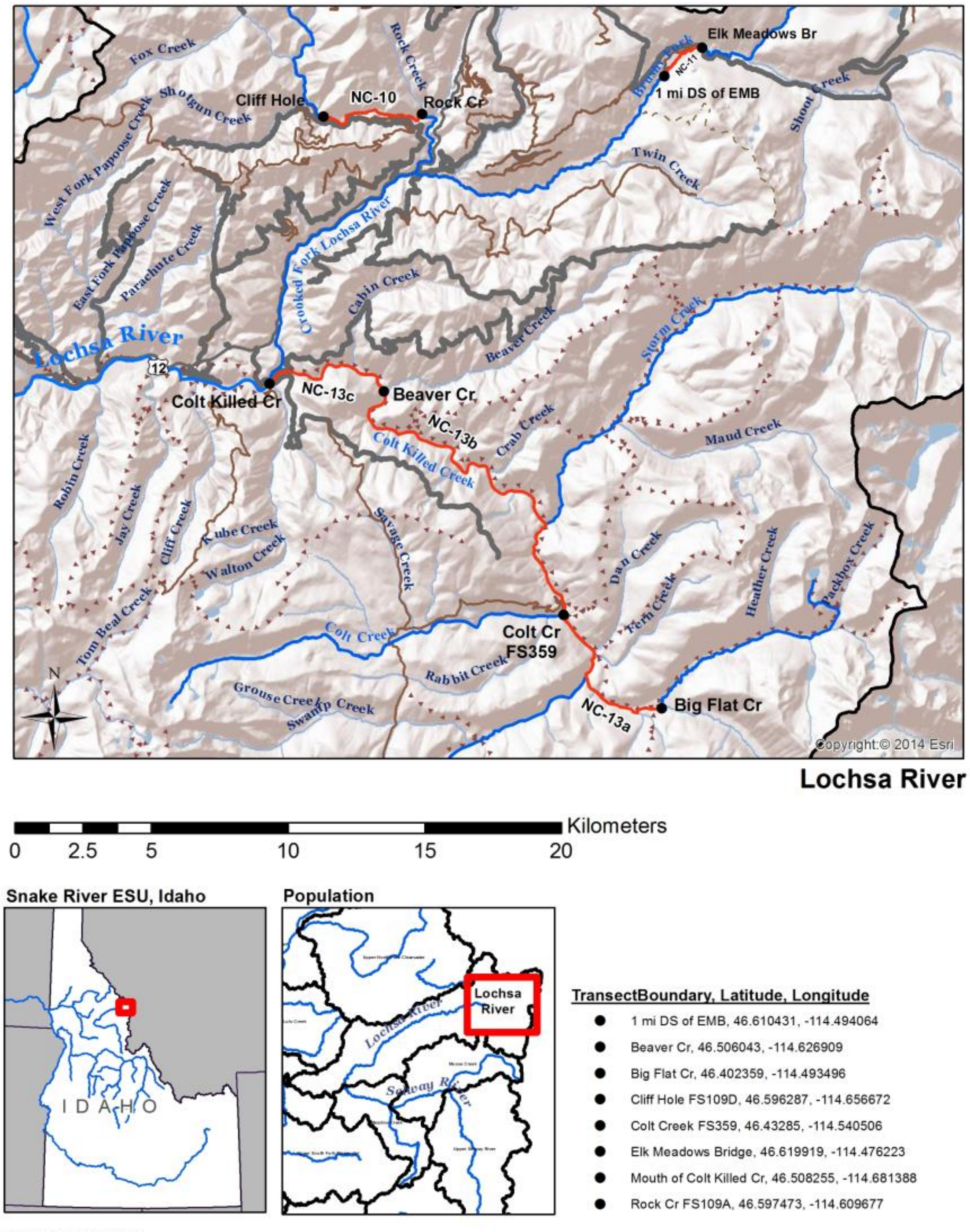
Lolo Creek Population



Appendix C. Wet Clearwater River MPG

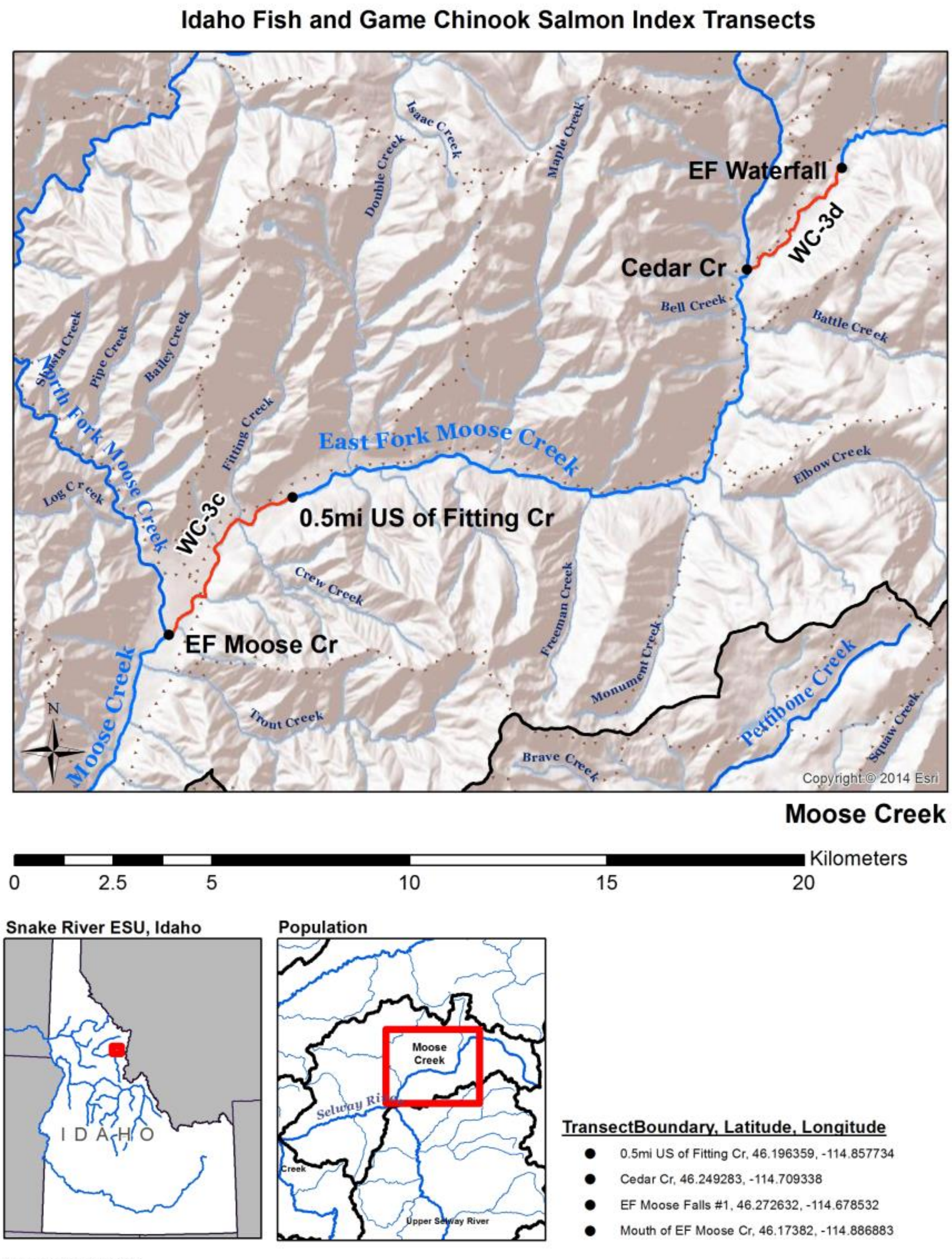
Lochsa River Population

Idaho Fish and Game Chinook Salmon Index Transects



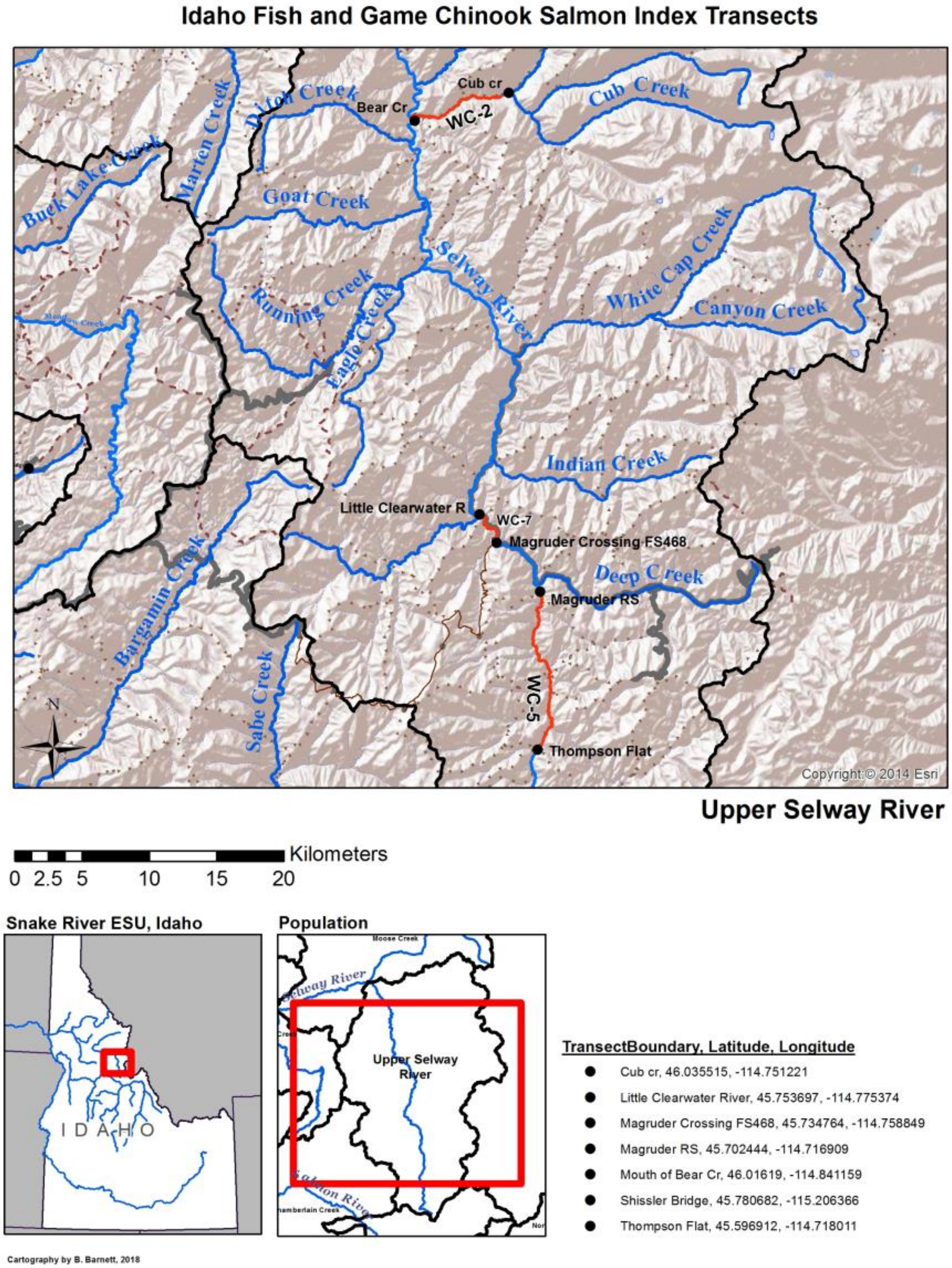
Appendix C. Wet Clearwater River MPG

Moose Creek Population



Appendix C. Wet Clearwater River MPG

Upper Selway River Population



Prepared by:

Timothy Copeland
Fisheries Program Coordinator

William C. Schrader
Principal Fisheries Research Biologist

Bruce Barnett
Fisheries Data Coordinator

Micah T. Davison
Fisheries Biologist

Kimberly A. Apperson
Fisheries Biologist

Matthew Belnap
Fisheries Biologist

Evan Brown
Senior Fisheries Data Coordinator

Eli A. Felts
Fisheries Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

J. Lance Hebdon
Anadromous Fisheries Manager

James P. Fredericks, Chief
Bureau of Fisheries