FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

2012 Annual Project Progress Report

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PART 1—SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM OVERVIEW

The Idaho Department of Fish and Game (IDFG) initiated the Snake River Sockeye Salmon *Oncorhynchus nerka* Captive Broodstock Program in May 1991, in response to the decline of anadromous returns to the Sawtooth Valley in central Idaho. Historically, Redfish, Alturas, Pettit, Stanley, and Yellowbelly lakes supported Sockeye Salmon in the Sawtooth Valley (Chapman et al. 1990; Evermann 1895; Bjornn et al. 1968; Figure 1). Historical observations and discussions with local residents by Evermann (1895; 1896) described the Sawtooth Valley lakes as being important spawning and rearing areas for Sockeye Salmon; however, actual adult escapement enumeration or estimations were not conducted at this time. Adult sockeye salmon escapement to Redfish Lake was enumerated from 1954 through 1966 by the IDFG, University of Idaho, and the United States Bureau of Commercial Fisheries. During this time, adult escapement ranged from a high of 4,361 in 1955 to a low of 11 in 1961 (Bjornn et al. 1968). Adult escapement enumeration was reinitiated in 1985 by the IDFG. Between 1985 and 1990, 61 adults were estimated to have returned to the Sawtooth Valley (Table 1). This number declined to zero redds or anadromous adults observed in Redfish Lake in 1990. Hydropower development, water withdrawal and diversions, water storage, harvest, predation, and inadequate regulatory mechanisms were outlined as factors contributing to the decline of Snake River Sockeye Salmon (Federal Register 1991).

As a result of the declines, the National Marine Fisheries Service (NMFS) listed Snake River Sockeye Salmon as an endangered evolutionarily significant unit (ESU) under the Endangered Species Act in November of 1991 (Federal Register 1991). To be considered an ESU for listing determinations, a stock must satisfy two criteria: 1) it must be reproductively isolated from other conspecific population units; and 2) it must represent an important component in the evolutionary legacy of the biological species (Waples 1991). At the time of listing, the Redfish Lake Sockeye Salmon population was the only remaining population of Snake River Sockeye Salmon stock. Snake River Sockeye Salmon are also only one of three remaining stocks of Sockeye Salmon in the Columbia River system; the other two stocks, Okanogan Lake and Wenatchee Lake Sockeye Salmon, are located in tributaries of the upper Columbia River. Approximately 1,127 river kilometers separate Snake River Sockeye Salmon from the nearest Sockeye Salmon populations in the upper Columbia River. Genetic analysis showed genetic differentiation of Snake River Sockeye Salmon from the upper Columbia River stocks (Waples et al. 2011; Winans et al. 1996). Mitochondrial DNA analyses confirmed the genetic isolation of the upper Columbia River stocks from the Snake River Sockeye Salmon stock (Faler and Powell 2003). Sockeye Salmon returning to Redfish Lake travel a greater distance from the Pacific Ocean (1,448 river kilometers) and to a higher elevation (2,138 meters) than any other Sockeye Salmon population in the world. Additionally, Redfish Lake supports the species' southernmost population within its recognized range (Burgner 1991). Together these characteristics presented a strong argument for the reproductive discreetness and ecological uniqueness of the Snake River habitat and for the unique adaptive genetic characteristics of the Snake River Sockeye Salmon stock (Waples et al. 1991).

Three distinct life of O. nerka (Sockeye Salmon) have been observed in Redfish Lake. Anadromous *O. nerka* spawn on the shoals of the lake in October and November. Juveniles out-migrate during the spring from their nursery lake at age-1+ or age-2+ and remain in the ocean for one to three years before returning to their natal area to spawn. Residual *O. nerka* can spawn with the anadromous life history on the shoals of the lake in October and November. Residual *O. nerka* spend their entire life in their nursery lake. Variable proportions of anadromous and residual progeny may conform to a residual life history pattern. Resident *O.*

nerka (kokanee) also complete their life cycle in freshwater. They remain in Redfish Lake until maturation and spawn in Fishhook Creek, a tributary creek to Redfish Lake, in August and September. Kokanee are indigenous to Redfish Lake but were periodically stocked from a range of non-indigenous hatchery sources beginning in 1930 and continuing through 1972 (Bowler 1990). Redfish Lake anadromous, residual, and out-migrant Sockeye Salmon were determined to be genetically similar, whereas Kokanee were found to be genetically different (Brannon et al. 1992, 1994; Cummings et al. 1997; Waples et al. 1997). Because of their genetic similarity, residual Sockeye Salmon were added to the ESU listing in 1992.

At the initiation of the program, IDFG collected fish from the following sources for broodstock and reintroduction purposes: 1) all anadromous adult returns that were trapped between 1991 and 1998 were retained for hatchery spawning, 2) residual adults trapped between 1992 and 1995 were retained for hatchery spawning, and 3) smolts trapped between 1991 and 1993 were reared until maturity and spawned in the hatchery. Both IDFG and National Oceanic and Atmospheric Administration (NOAA) Fisheries maintain Snake River Sockeye Salmon captive broodstocks. Groups of fish were reared at two facilities to avoid the potential catastrophic loss of the unique genetics of the stock. Idaho Department of Fish and Game rears annual captive broodstocks from the egg stage to maturity at Eagle Fish Hatchery (EFH) in Eagle, Idaho (Johnson 1993; Johnson and Pravecek 1995, 1996; Pravecek and Johnson 1997; Pravecek and Kline 1998; Kline and Heindel 1999; Kline et al. 2003a, 2003b; Kline and Willard 2001; Willard et al. 2003; Baker et al. 2005a, 2005b, 2006, 2007, 2009a). Additionally, NOAA Fisheries rears duplicate captive broodstock from the egg stage to maturity at the Manchester Research Station (MRS) and Burley Creek Hatchery (BCH) near Seattle, Washington (Flagg 1993; Flagg and McAuley 1994; Flagg et al. 1996, 2001; Frost et al. 2002, 2008). Eyed eggs were shipped to two production hatcheries, including Oxbow Fish Hatchery (OFH) located near Cascade Locks, Oregon and Sawtooth Fish Hatchery (SFH) located near Stanley, Idaho for rearing captive broodstock progeny (produced at EFH and BCH) to the full-term smolt life stage. Eyed eggs used to source the presmolts released in Redfish Lake during 2012 were collected and reared at EFH.

PROJECT GOALS

The initial goals of the program were to utilize captive broodstock technology to avoid extinction and conserve genetic diversity and fitness. Long-term goals include increasing the number of individuals in the population with future plans to recover and de-list the ESU and provide sport and treaty harvest opportunity. Draft ESA delisting criteria for Snake River Sockeye Salmon includes a minimum spawning abundance threshold measured as a ten-year geometric mean of 1,000 natural-origin spawners in Redfish and Alturas Lakes and 500 natural-origin spawners in Pettit Lake (NMFS 2014). In addition, population growth needs to be stable or increasing with low to moderate risk ratings for spatial structure and diversity. Current research and monitoring focuses on quantifying natural production and producing Viable Salmonid Population (VSP) metrics used to evaluate delisting criteria.

PROJECT OBJECTIVES

1. Develop captive broodstocks from Redfish Lake Sockeye Salmon, culture broodstocks, and produce progeny for reintroduction.

2. Determine the contribution hatchery-produced Sockeye Salmon make toward avoiding population extinction and increasing population abundance.

3. Describe *O. nerka* population characteristics for Sawtooth Valley lakes in relation to carrying capacity and broodstock program reintroduction efforts.

4. Utilize genetic analysis to discern the origin of natural and hatchery Sockeye Salmon to provide maximum effectiveness in their utilization within the broodstock program.

5. Transfer technology through participation in the technical oversight committee process, provide written activity reports, and participate in essential program management and planning activities.

Idaho Department of Fish and Game's participation in the Snake River Sockeye Salmon Captive Broodstock Program is comprised of three areas of effort: 1) captive broodstock culture, 2) Sockeye Salmon research and evaluations, and 3) genetic evaluations. Although objectives and tasks from all three components overlap and contribute to achieving the same goals, work directly related to Snake River Sockeye Salmon captive broodstock culture appears under a separate cover (Baker et al. 2013). Research and genetic evaluation activities associated with Snake River Sockeye Salmon are permitted under NOAA permit Nos. 1120, 1124, FMEP, and 1454. This report details Snake River Sockeye Salmon research and genetic investigations conducted between January 1 and December 31, 2012 and describes the following research activities: *O. nerka* population monitoring and sport fishery investigations on Redfish Lake, Sockeye Salmon juvenile out-migrant monitoring and evaluation, anadromous trapping and natural production monitoring and evaluations, and predator surveys in tributaries to Redfish and Alturas lakes.

STUDY AREA

The program's recovery efforts focus on Redfish, Pettit, and Alturas lakes in the Sawtooth Valley located within the Sawtooth National Recreation Area (Figure 1). These lakes provide critical spawning and rearing habitat. Lakes in the Sawtooth Valley are glacial-carved and considered oligotrophic. The three lakes range in elevation from 1,996 m (Redfish Lake) to 2,138 m (Alturas Lake) and are located 1,448 km (Redfish Lake) to 1,469 km (Alturas Lake) from the Pacific Ocean. Redfish Lake is the largest of the three lakes (615 ha), Pettit Lake is the smallest (160 ha), and Alturas Lake (338 ha) is intermediate in surface area (Table 2). Reintroduction efforts have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997.

In addition to *O. nerka*, numerous native and nonnative fish reside in the study lakes and streams within the Sawtooth Valley. Native fish present in Sawtooth Valley waters include: Chinook Salmon *O. tshawytscha*, Rainbow Trout/steelhead *O. mykiss*, Westslope Cutthroat Trout *O. clarkii lewisi*, Bull Trout *Salvelinus confluentus*, Sucker *Catostomus* spp., Northern Pikeminnow *Ptychocheilus oregonensis*, Mountain Whitefish *Prosopium williamsoni*, Redside Shiner *Richardsonius balteatus*, Dace *Rhinichthys* spp., and Sculpin *Cottus* spp. Nonnative species present in Sawtooth Valley waters include Lake Trout *S. namaycush* (Stanley Lake only) and Brook Trout *S. fontinalis*. Rainbow Trout were released into Pettit, Alturas, and Stanley lakes in the summer to increase sportfishing opportunities. Sportfishing on Pettit, Alturas, and Stanley lakes are covered by Idaho's statewide general fishing regulations, which allow harvest of six trout per day (excluding Bull Trout, which must be released if caught) and 25 kokanee per day with no seasonal closures. Sportfishing regulations on Redfish Lake restrict kokanee fishing/harvest to January 1 through August 7 to protect the residual component of the listed population. No trout have been stocked in Redfish Lake since 1992.

Table 1. Trapped and observed anadromous adult Snake River Sockeye Salmon returns by origin to the Sawtooth Valley from 1985-2012.

Year	Anadromous adult trapped	Natural origin	Hatchery origin	Observed
1985	14	14	-	0
1986	29	29	-	0
1987	16	16	-	0
1988	1	1	-	0
1989	1	1	-	0
1990	0	0	-	0
1991	4	4	-	0
1992	1	1	-	0
1993	8	8	-	0
1994	1	1	-	0
1995	0	0	-	0
1996	1	1	-	0
1997	0	0	-	0
1998	1	1	-	0
1999	7	0	7	0
2000	243	10	233	14
2001	23	4	19	3
2002	15	6	9	7
2003	2	0	2	1
2004	24	4	20	3
2005	6	2	4	0
2006	3	1	2	0
2007	4	3	1	0
2008	598	140	458	51
2009	817	86	731	16
2010	1,322	178	1,144	33
2011*	1,099	142	954	18
2012	242	52	190	15

* Three adults trapped in 2011 were missing origin data and were included in the number trapped but not included in the natural or hatchery origin columns.

Table 2. Physical and morphometric characteristics of three study lakes located in the Sawtooth Valley, Idaho.

Lake	Surface Area (ha)	Elevation (m)	Volume ($m^3 \times 10^6$)	Mean Depth (m)	Maximum Depth (m)	Drainage Area (km^2)
Redfish Lake	615	1,996	269.9	44	91	108.1
Alturas Lake	338	2,138	108.2	32	53	75.7
Pettit Lake	160	2,132	45.0	28	52	27.4

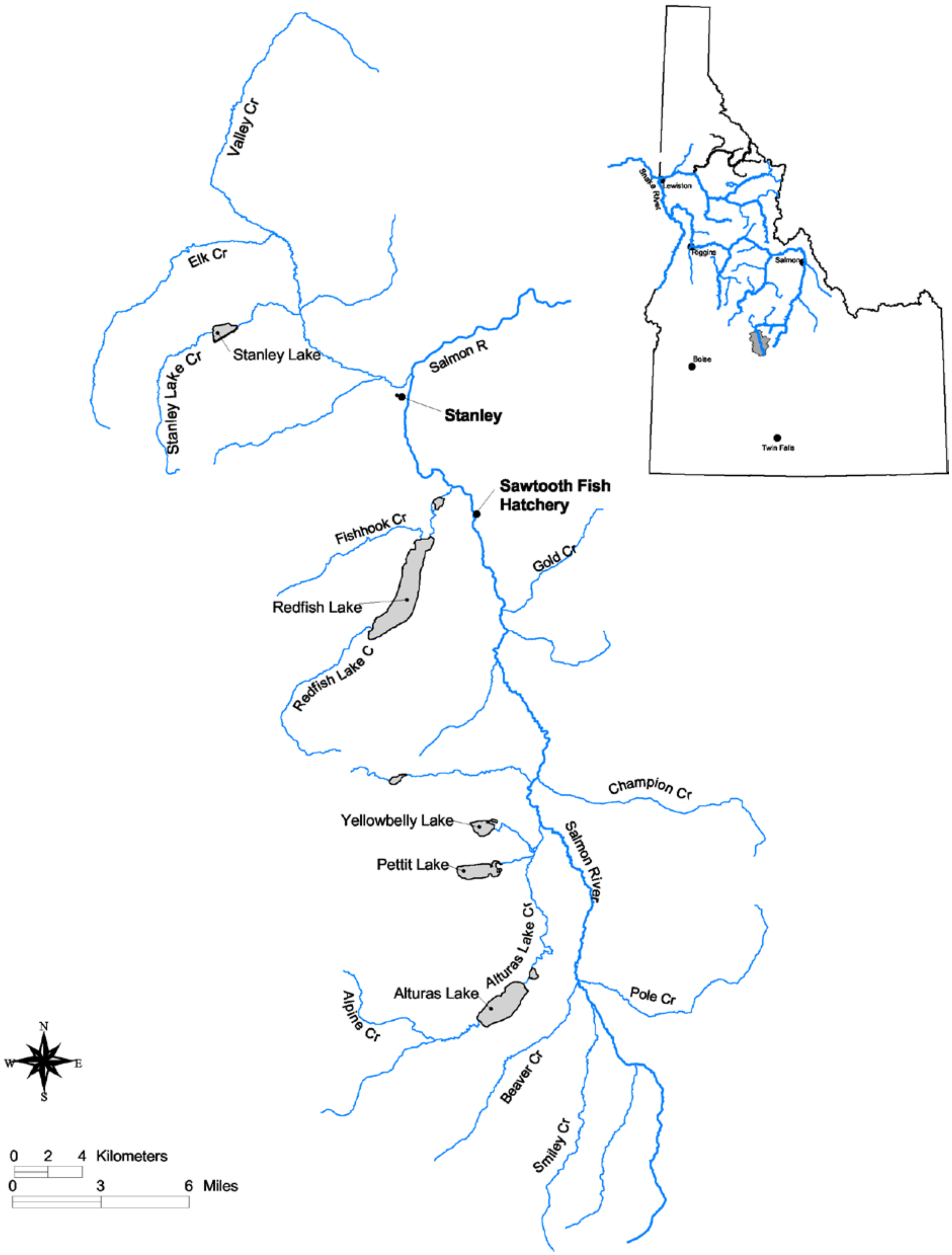


Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

PART 2—*ONCORHYNCHUS NERKA* POPULATION MONITORING AND REDFISH LAKE SPORT FISHERY INVESTIGATIONS

INTRODUCTION

Understanding the dynamics of *O. nerka* populations in the Sawtooth Valley lakes is a vital part of Sockeye Salmon restoration efforts. Knowledge of juvenile *O. nerka* abundance coupled with limnology data (collected and reported by the Shoshone-Bannock Tribes [SBT]) is important for understanding abundance, biomass and the carrying capacity of each lake. All three historic Sawtooth Valley Lakes (Redfish, Alturas and Pettit lakes) currently support both ESA-listed Sockeye Salmon as part of the program's reintroduction efforts and non-listed native, resident, kokanee populations. Productivity in the lakes varies annually and the presence of kokanee in the nursery lakes can create increased competition for limited food sources between kokanee and Sockeye Salmon in these oligotrophic systems. During years in which a lake experienced low productivity and/or high kokanee abundance, the program has historically released hatchery-produced offspring into more productive lakes or actively controlled kokanee escapement. In this section, we report the use of midwater trawl techniques to collect biological sample data and generate annual estimates of abundance, density, and biomass. This was coupled with genetic and scale aging data to provide stock composition (by age and lake). As there can be limitations associated with midwater trawling (such as lake morphology or lake size), hydroacoustics can also be used to generate complementary data (collected and reported by the SBT). Hydroacoustic data was collected and reported by the SBT under a separate report.

The second part of this section describes the impacts from sport fishing for kokanee on the Snake River Sockeye Salmon population. Monitoring the kokanee sport fishery is another important monitoring component to understanding the dynamics of both the listed and unlisted *O. nerka* populations found within Redfish Lake. The kokanee fishery on Redfish Lake was closed in 1993 due to the presence of ESA listed residual Sockeye Salmon but was reopened in 1995 (NOAA Fishery Management and Evaluation Plan; hereafter FMEP). The kokanee fishery was reopened based on the recommendation of the SBSTOC to reduce kokanee competition with Sockeye Salmon by removing spawning age kokanee through angler harvest. NOAA Fisheries requires IDFG to monitor angler harvest of listed Sockeye Salmon in Redfish Lake during the kokanee fishing season. The kokanee season on Redfish Lake opens on January 1 and closes on August 7, when mature kokanee initiates spawning in Fishhook Creek, while residual Sockeye Salmon remain in the lake. In 2012, a roving creel survey was conducted on Redfish Lake. This survey was designed to estimate total kokanee harvest and to collect tissue samples for genetic analysis from angler-harvested kokanee. The genetic analysis was used to estimate the number of unmarked Sockeye Salmon harvested incidental to the kokanee fishery within the lake.

METHODS

***Oncorhynchus nerka* Population Monitoring**

Midwater trawling was conducted at night during the dark (new) phase of the moon in August to estimate total *O. nerka* (kokanee and Sockeye Salmon) abundance, density, and biomass in Sawtooth Valley lakes. Anadromous adult Sockeye Salmon returning to Redfish Lake Creek may be released after August 7^{th} of each year; therefore, trawling was conducted in August to reduce the risk associated with collection or disturbance of post-released adults in the trawl catch. Surveys were also conducted in August because juvenile *O. nerka* were tightly stratified during this time of the year due to water temperatures. Redfish, Pettit, and Alturas lakes were sampled from August 13–16, 2012. Trawling was performed in a stepped-oblique fashion as described by Rieman and Myers (1992) and Kline (1994). Pettit and Alturas lakes were towed for a total of six trawl transects each, while in Redfish Lake, 18 transects were conducted (Figure 2). Due to the small surface area and width across the lakes, random towing direction and starting location for each transect was not possible. Therefore, the same transects each year were used utilizing GPS starting coordinates.

Total *O. nerka* abundance, density, and biomass were estimated using a program developed by Rieman (1992). Abundance estimates generated by this program were extrapolations of actual trawl catch data to the total area of the lake mid-depth in the observed *O. nerka* stratum. Density and biomass estimates were expressed in relation to lake surface area. Confidence intervals were calculated using the following formula of Scheaffer et al. (1996):

$$\bar{x} \pm t_{\gamma}\sqrt{\frac{s^2}{n}}$$

Abundance, density, and biomass were also estimated for each age class (assuming representation in the trawl). Fork length (to the nearest 1 mm) and weight (0.1 g) were recorded for all trawl-captured *O. nerka*; scales were removed from a subsample (a minimum of five fish from every 10 mm length group over 50 mm) and returned to the laboratory. Research suggests that sockeye start developing scales at a fork length ranging from 36-40 mm (Clutter and Whitesel 1956); therefore, fish under 50 mm were assumed to be age-0 for these analysis. Two program technicians aged scales to determine length ranges for age classification. Scales were mounted between microscope slides before aging and viewed with a microfiche (n = 23 Redfish, 26 Alturas, and 12 Pettit). Stomachs were removed and preserved for diet analysis by SBT biologists. Fin clips were also taken from sampled individuals and stored in 100% ethanol and delivered to the IDFG Genetics Laboratory for DNA analysis (Redfish Lake; N =121, Alturas Lake; N =119, and Pettit Lake; N = 12).

DNA was extracted using a Nexttec DNA isolation kit according to the manufacturer's instructions (http://www.nexttec.biz). Following DNA extraction, each sample was amplified with 16 microsatellite loci: One103, One104, One108, One111, One112, One114, One115, Oki1, One13, One110, One106, Omy77, Ots103, Omm1070, Ssa408, Ssa407 (Scribner et al. 1996; Smith et al. 1998; Beacham et al. 1998; Cairney et al. 2000; Olsen et al. 2000; Perry et al. 2001; Rexroad et al. 2001). Multiplex reactions were carried out for four combinations of loci (contact the authors for PCR concentrations and thermocycler profiles). Following amplification, PCR fragments were diluted at 1 1:30 ratio and size fractionated using an ABI3730 capillary DNA sequencer and internal size standard (GS500) genotypes were scored by GeneMapper software version 3.0 (Applied Biosystems) Individuals representing ~10% of the sampled fish were re-amplified and scored a second time.

Genetic assignment methods were used to assign each sample to either the Redfish Lake stock or Fishhook Creek kokanee stock. The software, STRUCTURE, was performed using a baseline of captive broodstock (N = 15,792 genotypes) and kokanee from each lake (N = 1,285 genotypes). STRUCTURE was forced to run at K = 2 in order to allocate each fish to the kokanee or Sockeye Salmon group with a 50,000 burn in and 50,000 MCMC runs. Fish with greater than 90% assignment to a group were assigned to the group. Any fish with less than the 90% threshold were unassigned. Once genetic assignment data and scale age data for each sampled fish was developed, proportions of kokanee and Sockeye Salmon in each age class for each lake were calculated. These data will be used to develop status and trends over time.

Redfish Lake Sport Fishery Investigations

A roving creel survey was conducted from May 27 through August 7, 2012 on Redfish Lake. The creel census was stratified by 14-day intervals, broken into weekday and weekend day types and morning (0800 to 1400) and evening (1401 to 2000) instantaneous count periods. Angler counts were conducted four weekdays, two weekend days, and any holiday during each 14-day interval. On each angler count day, the number of boats and bank anglers were counted from a boat for each day period (morning and evening strata). Angler count dates and times were selected randomly. Angler interviews were conducted following the completion of each instantaneous count. Anglers were asked how many fish they had harvested and/or released by species, how many hours they had fished, what their preferred target species was, whether or not they were aware of the Redfish Lake kokanee fishery, and the type of gear they used. All responses were recorded by creel personnel. Creel data were analyzed using the Creel Application Software computer program developed by Soupir and Brown (2002) and used to estimate angler effort, catch rates, and harvest.

Fin clips were taken from harvested *O. nerka* that were checked by creel survey personnel. Fin clips were stored in 100% ethanol and delivered to IDFG Genetics Laboratory personnel for DNA analysis. Depending on the number of tissue samples collected, genetic analyses were performed to determine the number and proportion of ESA listed Sockeye Salmon in the creel.

During 2012, a volunteer angler response program aimed at collecting complete trip data for the creel analyses utilizing postage prepaid angler survey postcards was initiated (Figure 3). We typically only receive incomplete trip data utilizing the survey methods described above, which may lead to biased estimates of both catch and harvest (Keefe et al. 2009). During every interview conducted in 2012, we handed out one postcard and instructed the angler to include only trip data from the point of contact to the end of their fishing trip for that particular day. They were then instructed where to return the postcards (collection boxes located around the lake or to place the cards in the US mail).

RESULTS

Oncorhynchus nerka Population Monitoring

Redfish Lake

August trawl catch on Redfish Lake included 122 natural origin and zero hatchery origin (adipose fin-clipped) *O. nerka* (Appendix A). Based upon this catch data, *O. nerka* abundance was estimated at 46,861 fish (95% CI ± 15,310). The *O. nerka* population estimate was higher in 2012 (up 7.3%) from the estimated abundance levels in 2011 (43,671 fish); however, this was not statistically different due to overlapping confidence bounds (Table 3). Density and biomass were estimated at 76.2 fish/ha and 0.17 kg/ha, respectively (Table 4). This represented an increase of 7.3% for density and of 55.5% in biomass from estimated levels in 2011 (Peterson et al. 2012b). Age-0, age-1 and age-2 *O. nerka* were represented in the trawl sample from Redfish Lake. Age-0 fish had the highest average density (90.5 fish/ha) and the highest biomass (0.09

kg/ha; Table 4). While presmolts were released into the lake in the fall of 2010 and summer of 2011, none of the midwater trawl samples from 2012 collected hatchery origin O. nerka.

In 2012, 121 fin samples were collected and analyzed from trawl captured *O. nerka* on Redfish Lake. Three of the samples were either contaminated, or could not be assigned due to incomplete genotypic information. Of the 118 samples, 37 samples had genotypes indicative of protected Snake River Sockeye Salmon (31% with 95% confidence bounds ranging from 24% to 40%; Figure 4) and 81 samples were identified as kokanee (69% with 95% CIs ranging from 60% to 76%). Scale aging and genetic assignment data indicated that the proportion of age-0 and age-1 Sockeye Salmon observed in the trawl sample was 33% and 28%, respectively (Figure 5). None of the age-2 fish were identified as Sockeye Salmon. When applying the proportion of fish to the age-specific abundance estimates (Table 4), 14,876 Sockeye Salmon were estimated in the total abundance (12,302 age-0+ and 2,574 age-1+).

Alturas Lake

August trawl catch on Alturas Lake included 120 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) Sockeye Salmon (Appendix A). Estimates of *O. nerka* abundance, density, and biomass were 70,895 fish (95% CI ± 21,658), 209.8 fish/ha, and 0.73 kg/ha, respectively (Table 3). Age-0, age-1, and age-2 *O. nerka* were represented in the trawl sample (Table 4). Age-0 fish had the highest density (252.2 fish/ha) and contributed 32% of the biomass (Table 4). The estimates for abundance and density were 48.5% higher and biomass was 1.6 fold higher than 2011 estimates, respectively. The abundance estimates were not statistically different between these years (Table 3).

In 2012, 120 fin samples were analyzed from trawl captured *O. nerka* on Alturas Lake and none of the sample fish had genotypes indicative of protected Snake River Sockeye Salmon. There were five samples that could not be assigned. Eyed eggs were released in 2010 and 2011, yet none of the samples were identified as Sockeye Salmon in the midwater trawl.

Pettit Lake

August trawl catch on Pettit Lake included 12 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) Sockeye Salmon (Appendix A). Estimates of *O. nerka* abundance, density, and biomass were 4,995 fish (95% CI ± 3,119), 31.2 fish/ha, and 0.82 kg/ha, respectively (Table 3). Age-1 and age-2 *O. nerka* were represented in the trawl sample. Age-2 fish had the highest density at 24.8 fish/ha and a biomass of 0.57 kg/ha (Table 4). The estimates for abundance and density were 33.8% higher and biomass was 2.4 fold higher than 2011 estimates, respectively. The estimate of abundance was not statistically different than that observed in 2011 (Table 3).

In 2012, 12 fin samples were analyzed from trawl captured *O. nerka* on Pettit Lake and four had genotypes indicative of protected Snake River Sockeye Salmon (33% with 95% confidence bounds ranging from 14% to 61%). The small sample size captured with the midwater trawl in 2012 may have resulted in the low proportion of Sockeye Salmon observed. Additionally, there were eight samples that were not assigned to a specific population (kokanee or Sockeye Salmon). The proportion of Snake River Sockeye Salmon in the sample was similar to the observed proportion from 2011 (29% with 95% confidence bounds ranging from 8% to 64) but statistically lower from the proportion observed in 2010 (89% with 95% confidence bounds ranging from 71% to 96%; Figure 6). When applying the proportion of fish to the overall abundance, 1,648 Sockeye Salmon were estimated in the total abundance (all age 1+).

Redfish Lake Sport Fishery Investigations

In 2012, only 34 angler parties (68 individual anglers) were contacted on Redfish Lake. Boat anglers made up 72.1% of those interviewed. Most anglers used lures (54.3%) followed by bait (42.8%). Total angler effort was estimated at 1,244 hours (95% CI ± 387; Table 5). This estimated effort represents a 59.6% decrease in fishing pressure between 2012 and 2011 (Table 6), which follows a decreasing trend since 1999 (Figure 7). Boat anglers expended more effort (930.5 hours) than bank anglers (313.5 hours), which was similar to the 2011 results (Peterson et al. 2012b).

The season catch rate for all fish (caught) was 0.11 fish/hour (95% CIs ±0.07). Catch rates decreased 87% over the estimate from 2011 (0.82 fish/hour*).* Kokanee catch rates (harvested and released) averaged 0.03 kokanee/hour for the season (Table 7). The 2012 season estimate of 0.00 kokanee/hour kept was the same as the 2011 estimate. Bull Trout catch and release rates were 0.21 Bull Trout/hour for weekdays and 0.01 Bull Trout/hour for weekends, for a season estimate of 0.06 Bull Trout/hour (IDFG regulations prohibit harvesting Bull Trout; Table 7). A total of 72 Bull Trout were estimated to be caught and released within Redfish Lake during 2012 (Table 8). The season catch rate for Bull Trout was lower than observed rates from 2010 and 2011 (0.73 and 0.48 Bull Trout/hour, respectively). However, a trend of overall increase in Bull Trout catch rates has been observed since monitoring began in 1996 (Figure 8). Westslope Cutthroat Trout had catch rates of <0.01 fish/hour caught (an estimated 3.5 Westslope Cutthroat Trout were harvested in 2012) for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 132 fish (95% CI ± 126). This was a decrease of 94.8% from the 2011 estimate (2,516 fish caught). The majority (84.1%) of fish caught in 2012 were released. Kokanee harvest was estimated at zero fish and the number of kokanee released was estimated at 36.5 (Table 8).

Only nine postcards, of the 34 interviews we conducted during 2012, were returned. The overall response rate was 27% and a total of seven out of nine postcards did not report any additional catch. Due to the limited sample size and lack of additional information, no further comparisons or analysis was conducted.

The direct impact of the kokanee fishery on residual Sockeye Salmon (through incidental harvest) was evaluated using genetic analysis of tissue samples (if available) collected from *O. nerka* in the creel. In 2012, tissues for genetic analysis were collected from zero *O. nerka* encountered during the sport fishery by IDFG personnel (creel personnel did not observe kokanee from the sport fishery).

DISCUSSION

Oncorhynchus nerka Population Monitoring

Midwater trawl surveys have been conducted to quantify *O. nerka* abundance, density, and biomass within Redfish, Alturas, and Pettit lakes since the initiation of the captive broodstock program in 1991. The mean abundance since 1991 for Redfish, Alturas and Pettit lakes has been 47,235, 57,167 and 22,866 *O. nerka*, respectively. During 2012, the estimates of abundance, density, and biomass that were produced for each lake fell within the ranges observed during that time period (Table 3). The fish detected in the midwater trawl were all naturally produced juveniles. In 2011, 50,054 summer direct-release presmolts were released into Redfish Lake but none of those fish were detected in 2012, indicating that these fish may have already emigrated from the lake, had poor survival, or were at low density and were not captured using the midwater trawl gear (or a combination of all three scenarios). Presmolts have not been released into Pettit or Alturas Lake since 2010.

These population estimates represent both the non-listed resident kokanee and Snake River Sockeye Salmon stocks found within the lakes. The lack of morphological or phenotypic differences (e.g. no size differences at age) makes it difficult to differentiate between stocks. However, incorporating the use of genetic microsatellite DNA analysis has led to the development of proportions for each stock identified within our trawl sample and overall abundance by stock within each lake. Based upon this information, estimates of the Snake River Sockeye Salmon stock within Redfish and Pettit lakes were determined to be 14,876 fish (12,302 age-0+ and 2,574 age-1+) and 1,648 fish (all age-1+), respectively. While total abundance fell within the range of *O. nerka* estimates and was similar to past years, the abundance estimate for the Snake River Sockeye Salmon stock was lower than previous years (2010 and 2011) despite the large number of adults released into Redfish Lake in 2011 (N = 1,548; 691 females and 857 males; unpublished program data).The abundance estimate of Sockeye Salmon in Pettit Lake was also lower than previous years. No presmolts or eyed eggs were released into Pettit Lake in prior years, so this estimate reflects a small number of natural (e.g. residual) spawners that may be present within the lake. In Alturas Lake, none of the fish captured using trawl equipment were assigned to Snake River Sockeye Salmon stock. Snake River Sockeye Salmon have not been observed in trawl samples from Alturas Lake since initiating genetic monitoring in 2006. However, samples collected in 2008 indicated that Snake River Sockeye Salmon were in the smolt out-migration (after being planted as eyed eggs in December of 2006) and made up 22% (unpublished program data) of the total out-migration. This suggests that fish present in the lake may not always be sampled and some caution may be warranted before interpretation of these numbers.

There are a variety of reasons why fish may not be sampled. Two possible scenarios (or a combination of both) may be responsible for some of the difficulty of collecting samples in Pettit Lake. First, *O. nerka* become more difficult to sample at lower densities (Rieman 1992) and it appears that densities have decreased (significantly for the 2011 estimate but not statistically significant for 2012) since the 2010 estimate (Table 3). Second, we have observed that the *O. nerka* layer that we target for sampling has been relatively shallow (within 5 m of the surface) and *O. nerka* may be sounding to avoid the net when the boat approaches. Parkinson et al. (1994) suggested this was not a problem for kokanee within Coeur d'Alene Lake; however they did not identify how deep the kokanee layer was observed. Some marine species have been found to sound to avoid sampling vessels (Olsen et al. 1983). Investigations should continue to identify possible causes for the decreased sampling rate observed within Pettit Lake. There may also be size selectivity (Rieman 1992; Parkinson et al. 1994) where both small fish were falling through larger mesh net panels and larger fish may be able to avoid the net altogether (Rieman 1992). Rieman (1992) estimated the least-biased abundance estimates using midwater trawl methods were for fish between 50 mm and 220 in length. Within Redfish and Alturas lakes, 48% and 32% (respectively) of the *O. nerka* collected were smaller than 50 mm in length (Appendix A), suggesting that small fish may be captured but it was uncertain as to how many additional smaller fish may not have been sampled, potentially causing our estimate to be biased low for the age-0+ component of the population. However, in both Redfish and Alturas lakes, the age-0+ fish make up the largest component of the trawl sample, indicating that the gear does collect at least a portion of the fish under 50 mm. All of the fish sampled within Pettit Lake were larger than 50 mm in 2012. Size-selectivity should continue to be investigated to identify the biases associated with our estimates

Acknowledging that there may be some biases in our midwater trawl estimates, the long-term data set still provides an opportunity to identify drastic changes in abundance, densities, and biomass within the surveyed lakes. Prior to 2006, midwater trawling methods ranged from conducting one tow up to 6 tows per lake. Beginning in 2006, Redfish, Alturas and Pettit lakes were standardized to use a minimum of 6 tows per lake. Standardization has been shown to be important to produce data sets that can be used to infer changes within the *O. nerka* population over time (Parkinson et al. 1994). Sampling has been conducted at nearly the same time of the year (within the new moon period of August), using the same equipment, trawling the same speed for each tow, and the *O. nerka* layer was completely surveyed to reduce any additional biases that may occur. With the high variance surrounding trawl catches (Rieman 1992; Parkinson et al. 1994), increased sampling occurred in 2012 in an effort to reduce our confidence bounds surrounding the estimates and provide for greater precision in estimating the proportions of each stock. Sampling effort increased to 18 tows on Redfish Lake; however, we did not see the anticipated change in our confidence bounds around the total estimate, which remained similar to the estimates for 2011 (Peterson et al. 2012b). We were able to get a larger sample size for genetic analyses but the sample size was still low; given the low densities of *O. nerka* within the lake. Additional analyses may be needed to estimate how many tows and samples are needed at different population densities to identify a specific population change once the desired level of precision has been identified and the low densities within these lakes may preclude rigorous analyses of changes through time. *O nerka* abundance monitoring, using midwater trawl and genetic microsatellite DNA analysis, should remain a priority for the program to understand zooplankton abundance, stock proportions, and changes within the two stocks present in the Sawtooth Valley lakes. Our understanding of how these populations change and interact will become paramount as we move forward with adaptive management. This long-term data set and standardized methods should allow for interpretations of trend information that may emerge regardless of sampling biases associated with the methodology (Rieman 1992).

Redfish Lake Sport Fishery Investigations

Fishing pressure within Redfish Lake has been trending down since 1999 (Figure 7). Reduced fishing pressure limits the number of *O. nerka* captured in the fishery and the number of tissue samples collected by creel personnel to monitor potential impacts to the listed Sockeye Salmon population. To increase tissue sample collection, creel personnel will try to collect genetic samples from angler caught kokanee and capture kokanee using angling gear for genetic analysis during the 2013 creel survey.

The purpose of the kokanee fishery on Redfish Lake was to reduce competition for resources between non-listed resident kokanee and Snake River Sockeye Salmon. The creel investigation conducted in 2012 marks the third survey in the last four years where zero kokanee were estimated as harvested (Table 9). There has not been a negative impact resulting from the non-listed resident kokanee fishery within Redfish Lake on the Snake River Sockeye Salmon population since it was reestablished in 1995 and this fishery should continue to be a fisheries option in the upper Salmon River Basin.

During 2012, an investigation using postage prepaid postcards to collect non-biased complete trip data was conducted. Unfortunately, due to the low number of interviews that were collected during the survey, only nine postcards were turned in with additional information. The response rate was 27% and was similar to those reported by others (Carline 1972; Zale and Bain 1994). Of the nine postcards that were returned, seven anglers indicated that no additional fish were captured and approximately 51 additional hours of effort (not expanded) were listed. It was difficult to establish any definitive conclusions from this investigation due to the low sample size. However, the use of complete trip data would not have resulted in much additional harvest; these results suggest that our creel survey design is sufficient to monitor the fishery impacts on the Snake River Sockeye Salmon population. Perhaps, if fishing pressure increases, the use of postcards to collect additional catch information and potential modifications to the current survey design may be warranted.

Table 3. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2012.

Year	Population (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
1990	24,431 (11,000)	39.7	0.8
1992	39,481 (10,767)	64.2	1.0
1993	49,628[a]	80.7	1.6
1994	51,529 (33,179)	83.8	1.4
1995	61,646 (27,639)	100.2	4.4
1996	56,213 (28,102)	91.4	2.8
1997	55,762 (13,961)	90.7	2.5
1998	31,486 (11,349)	51.2	1.8
1999	42,916 (13,177)	69.7	0.9
2000	10,268 (5,675)	16.7	<0.1
2001	12,980 (11,982)	21.1	<0.1
2002	50,204 (28,485)	81.6	1.0
2003	81,727 (25,995)	132.9	1.6
2004	82,258 (35,922)	133.0	0.3
2005	56,220 (na)	91.4	0.3
2006	82,796 (47,407)	134.6	2.4
2007	73,702 (24,195)	119.8	0.8
2008	26,284 (13,226)	42.7	0.3
2009	28,923 (32,197)	47.0	0.1
2010	30,194 (16,139)	49.1	0.2
2011	43,671 (18,630)	71.0	0.1
2012	46,861 (15,310)	76.2	0.2
	Alturas Lake (338 surface hectares)		
1990	126,644 (31,611)	374.7	3.3
1991	125,045 (30,708)	370.0	3.9
1992	47,237 (61,868)	139.8	2.4
1993	49,037 (13,175)	145.1	2.6
1994	5,785 (6,919)	17.1	0.4
1995	23,061 (9,182)	68.2	1.7
1996	13,012 (3,860)	38.5	1.4
1997	9,761 (4,664)	28.9	2.1
1998	65,468 (34,284)	193.7	1.4
1999	56,675 (43,536)	167.7	0.4
2000	125,462 (27,037)	371.0	2.1
2001	70,159 (18,642)	207.6	2.4
2002	24,374 (16,968)	72.1	2.2
2003	46,234 (26,442)	136.8	5.5
2004	36,206 (14,170)	107.1	1.9
2005	20,956 (na)	98.8	0.3
2006	105,779 (50,702)	313.0	3.5
2007	124,073 (23,327)	367.1	3.4
2008	71,088 (34,189)	210.3	2.7
2009	39,781 (11,697)	117.7	3.5
2010	10,366 (8,047)	30.7	1.4
2011	47,739 (31,520)	141.2	0.3
2012	70,895 (21,658)	209.8	0.7

Table 3. Continued.

Year	Population (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Pettit Lake (160 surface hectares)		
1992	3,009 (2,131)	18.8	2.5
1993	10,511 (3,696)	65.7	0.8
1994	14,743 (3,683)	92.1	3.1
1995	59,002 (15,735)	368.8	14.7
1996	71,654 (9,658)	447.8	15.3
1997	21,730 (11,262)	135.8	5.1
1998	27,654 (8,764)	172.8	9.7
1999	31,422 (21,280)	196.4	6.3
2000	40,559 (11,717)	253.5	10.2
2001	16,931 (7,556)	105.8	6.1
2002	18,328 (2,351)	114.5	12.1
2003	11,961 (3,225)	136.8	5.5
2004	46,065 (22,258)	287.9	9.8
2005	23,970 (na)	149.8	2.2
2006	33,246 (12,416)	207.8	7.4
2007	14,746 (7,099)	92.2	3.8
2008	8,470 (4,640)	52.9	1.3
2009	4,623 (4,536)	40.2	0.1
2010	13,246 (5,961)	82.8	0.6
2011	3,733 (3,307)	23.3	0.2
2012	4,995 (3,119)	31.2	0.8

[a] Confidence limits not calculated—single transect estimate.

Table 4. Estimated 2012 *O. nerka* abundance, density (fish/ha), and biomass (kg/ha) by age class in Redfish, Alturas, and Pettit lakes.

	Age-0 BY11	**Age-1 BY10**	**Age-2 BY09**	**Age-3 BY08**	**Age-4 BY07**	**Total**
			Redfish Lake (615 surface ha)			
No. captured	97	24	1	0	0	122
Mean length (mm) (±95 CI)	47	86	125	NA	NA	55
Mean weight (g) (±95 CI)	1	6.4	18.2	NA	NA	2.2
Abundance	37,279	9,194	388	NA	NA	46,861
95% CI High	51,334	13,275	1,206	NA	NA	62,171
95% CI Low	23,224	5,113	0	NA	NA	31,551
Density (fish/ha)	60.6	14.9	0.7	NA	NA	76.2
Biomass (kg/ha)	0.06	0.09	0.01	NA	NA	0.17
			Alturas Lake (338 surface ha)			
No. captured	91	27	2	0	0	120
Mean length (mm) (±95 CI)	52	95.5	117.5	NA	NA	62.9
Mean weight (g) (±95 CI)	1.4	9.3	17.5	NA	NA	3.5
Abundance	53,475	16,539	882	NA	NA	70,895
95% CI High	78,183	35,362	1,896	NA	NA	92,553
95% CI Low	28,767	0	0	NA	NA	49,237
Density (fish/ha)	158.3	48.9	2.6	NA	NA	209.8
Biomass (kg/ha)	0.24	0.45	0.04	NA	NA	0.73
			Pettit Lake (160 surface ha)			
No. captured	0	5	7	0	0	12
Mean length (mm) (±95 CI)	NA	118.4	142.9	NA	NA	132.7
Mean weight (g) (±95 CI)	NA	19.2	31.8	NA	NA	26.5
Abundance	NA	2,134	2,861	NA	NA	4,995
95% CI High	NA	4,091	5,859	NA	NA	8,114
95% CI Low	NA	177	0	NA	NA	1,876
Density (fish/ha)	NA	13.3	17.9	NA	NA	31.2
Biomass (kg/ha)	NA	0.25	0.57	NA	NA	0.82

Table 5. Estimated angler effort on Redfish Lake for the 2012 fishing season.

Redfish Lake	Boat	Bank	Tube	Total
Estimated Hours fished	930.5	313.5	0	1,244
± 95%	329.5	216.6	0	387

Table 6. Historical kokanee catch rates and harvest estimates, Bull Trout catch rates, and angler effort for the Redfish Lake fishery.

	Kokanee Catch Rates (Fish/Hour)					
	Harvested (Fish/Hour)	Released (Fish/Hour)	Kokanee Harvested	Bull Trout Catch Rate (Fish/Hr)	Angler Parties Interviewed	Estimated Hours Fished/Season
1996	0.19	0.08	844	0.09	107	3,351
1997	0.19	0.37	466	0.08	117	2,874
1998	0.13	0.17	1,362	0.08	205	7,963
1999	0.38	0.15	1,187	0.28	227	3,951
2000	0.02	0.06	67	0.08	63	3,063
2001	0.00	0.06	0	0.27	88	2,391
2002	0.09	0.16	129	0.16	100	2,127
2003	0.10	0.05	424	0.24	98	2,477
2004	0.13	0.26	621	0.31	96	2,791
2005	0.21	0.09	637	0.09	85	3,620
2006	0.07	0.24	222	0.35	131	2,635
2007	0.03	0.09	56	0.12	53	1,922
2008	0.05	0.04	106	0.08	41	2,424
2009	0.00	0.00	0	0.55	32	1,219
2010	0.02	0.00	57	0.73	58	2,816
2011	0.00	0.00	0	0.48	48	3,083
2012	0.00	0.03	0	0.06	34	1,244

Table 7. Catch rates (fish/hour) for summer 2012 on Redfish Lake categorized by day type and species.

	Kokanee		Cutthroat Trout		Bull Trout		All Fish	
Day Type	Kept	Released	Kept	Released	Kept	Released	Kept	Released
Weekday	0.00	0.00	<0.01	0.00	0.00	0.21	0.00	0.21
Weekend day	0.00	0.04	0.00	0.00	0.00	0.01	0.02	0.05
Season Avg.	0.00	0.03	<0.01	0.00	0.00	0.06	0.02	0.09

Table 8. Estimated number of fish harvested and released on Redfish Lake during summer 2012.

Redfish Lake	**Kokanee**	**Cutthroat Trout**	**Bull Trout**	**Other**	**All Fish ± 95% CI**
Harvested	0	3.5	0	18.4	21.9 ± 26.2
Released	36.5	0	72.2	1.8	110.5 ± 122.5

Table 9. Estimated *O. nerka* harvest in Redfish Lake kokanee fisheries, numbers of adipose-clipped hatchery Sockeye Salmon juveniles caught and released, % ESA-listed sockeye in harvest, and incidental mortality of ESA-listed *O. nerka*, 1997-2012.

Year	***O. nerka* harvest**	**Population Estimate**	**Exploitation Rate***	**Ad-clipped hatchery Sockeye Salmon released**	**% ESA-listed in harvest**	**Incidental mortality of ESA-listed Sockeye Salmon**
1997	866	55,762	1.55%	0	1.0%	9
1998	1362	31,486	4.33%	0	1.0%	14
1999	1187	42,916	2.77%	0	1.0%	12
2000	67	10,268	0.65%	0	0.8%	1
2001	0	12,980	0.00%	0	0.0%	0
2002	129	50,204	0.26%	0	0.8%	1
2003	424	81,727	0.52%	5	0.3%	1
2004	621	82,258	0.75%	10	0.3%	2
2005	785	56,220	1.40%	0	0.3%	4
2006	222	82,796	0.27%	0	0.3%	3
2007	56	73,702	0.08%	0	14.0%	8
2008	106	26,284	0.40%	0	13.0%	14
2009	0	28,923	0.00%	0	0.0%	0
2010	57	30,194	0.19%	0	13.5%	8
2011	0	43,671	0.00%	0	0.0%	0
2012	0	46,861	0.00%	0	0.0%	0

* Simple calculation of population estimate/# harvested

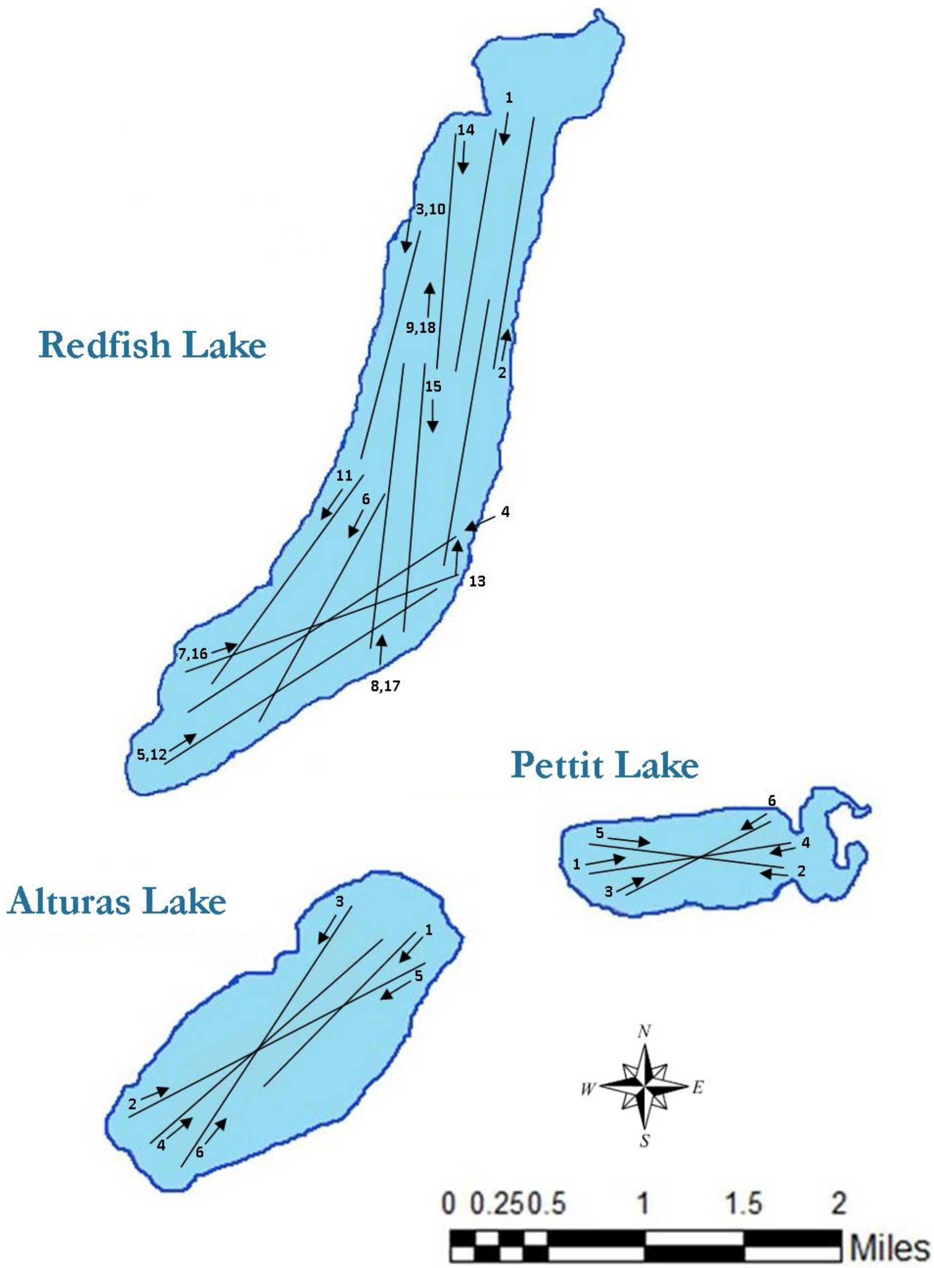
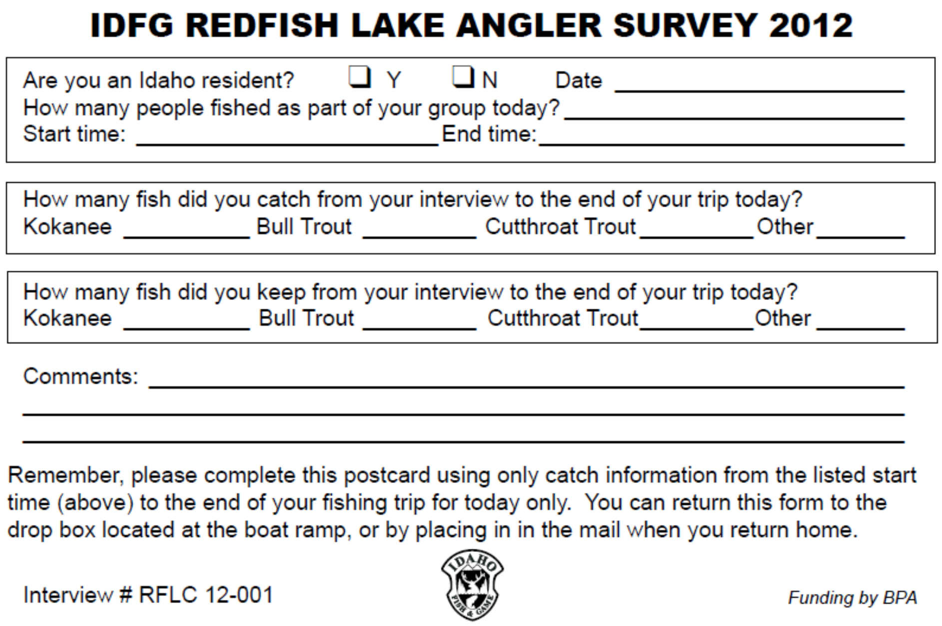


Figure 2. Map of the Sawtooth Valley lakes and the mid-water trawl transects that were conducted during 2012.



IDFG REDFISH LAKE ANGLER SURVEY 2012

Are you an Idaho resident? ❑ Y ❑ N Date ____________________
How many people fished as part of your group today? ____________________
Start time: ____________________ End time: ____________________

How many fish did you catch from your interview to the end of your trip today?
Kokanee ________ Bull Trout ________ Cutthroat Trout ________ Other ________

How many fish did you keep from your interview to the end of your trip today?
Kokanee ________ Bull Trout ________ Cutthroat Trout ________ Other ________

Comments: ____

Remember, please complete this postcard using only catch information from the listed start time (above) to the end of your fishing trip for today only. You can return this form to the drop box located at the boat ramp, or by placing in in the mail when you return home.

Interview # RFLC 12-001

Funding by BPA

Figure 3. Image of the postage prepaid postcards that were used to collect complete trip interview data during the creel survey conducted in 2012. Creel clerks filled out the start time on the postcard and matched the interview number (shown in the lower left corner) with the data collection form.

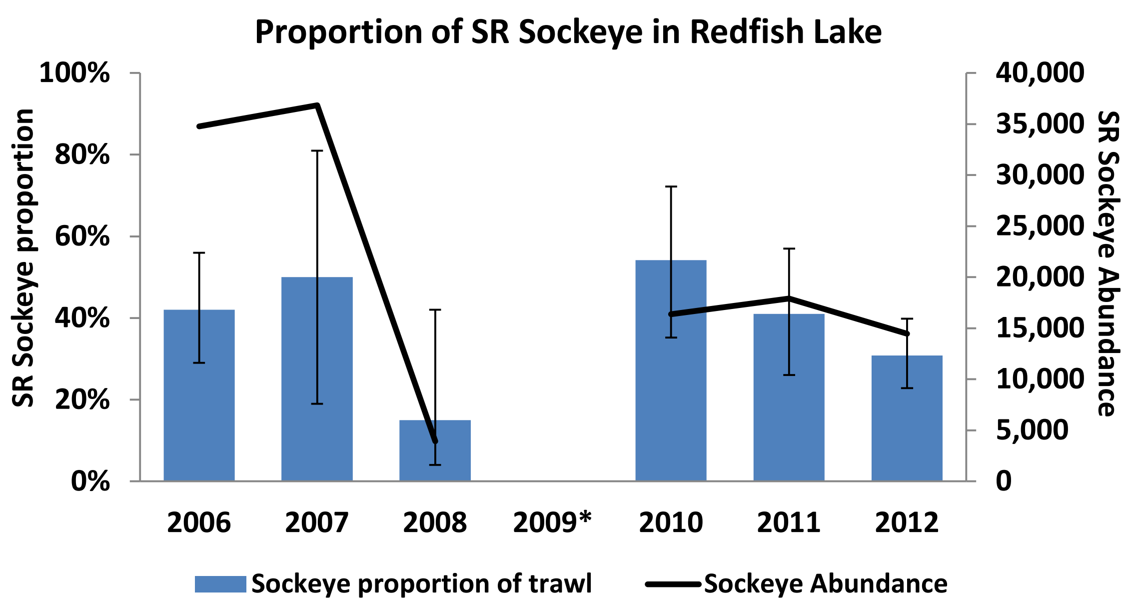


Figure 4. Proportions of Snake River Sockeye Salmon (assigned genetically) within Redfish Lake collected using mid-water trawl from 2006-2012 (primary axis). Error bars represent 95% confidence intervals around the proportions without continuity correction. The secondary axis represents the abundance of Snake River Sockeye Salmon estimated within the lake based off the genetic proportions. Proportion data in 2009 was not presented due to sample contamination.

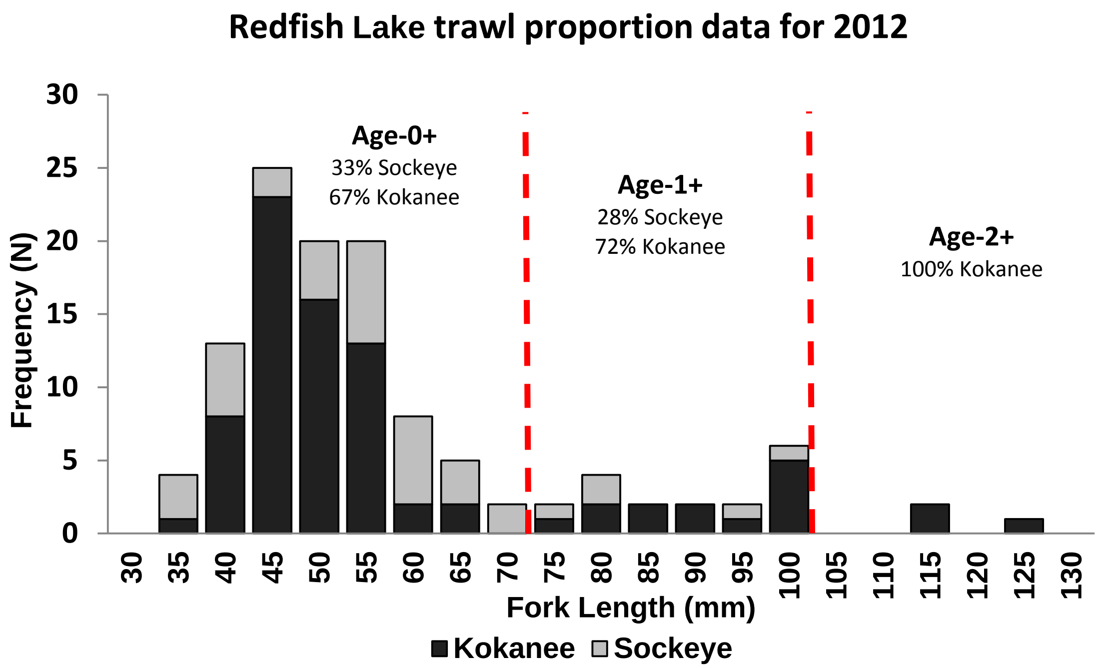


Figure 5. Proportions of Snake River Sockeye Salmon (assigned using scale and genetic data) by age-class collected using mid-water trawl during August 2012.

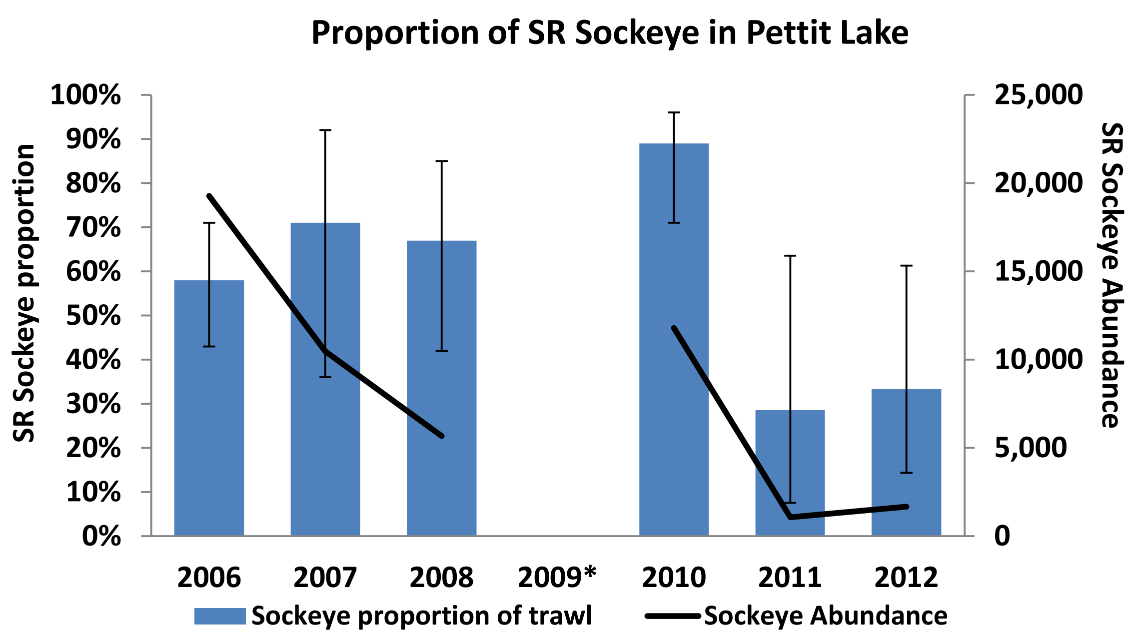


Figure 6. Proportions of Snake River Sockeye Salmon (assigned genetically) within Pettit Lake collected using mid-water trawl from 2006-2012 (primary axis). Error bars represent 95% confidence intervals around the proportions without continuity correction. The secondary axis represents the abundance of Snake River Sockeye Salmon estimated within the lake based off the genetic proportions. Proportion data in 2009 was not presented due to sample contamination.

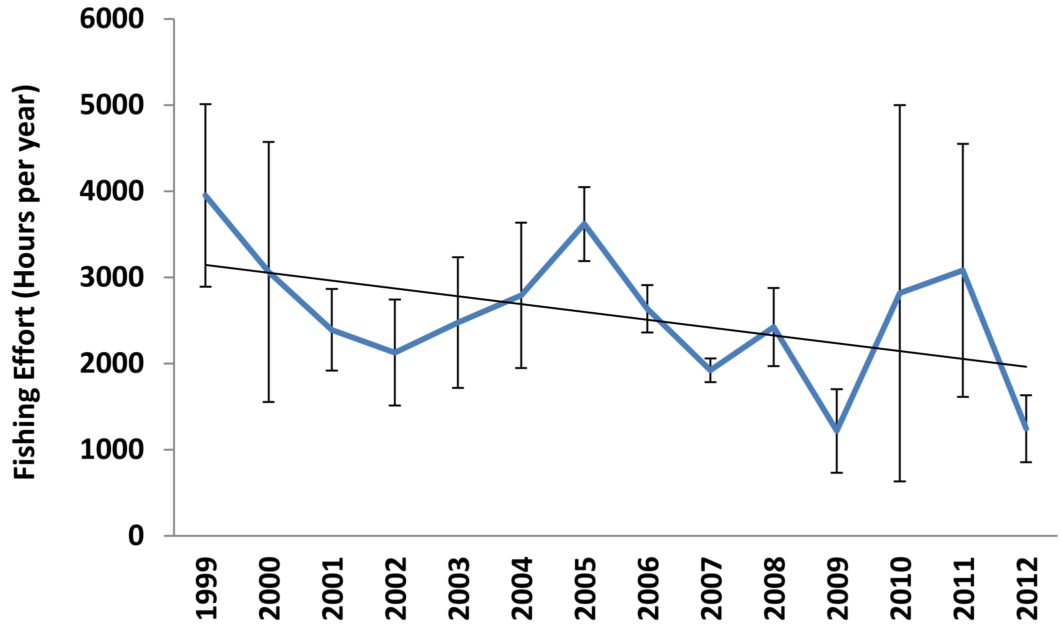


Figure 7. Estimates of fishing pressure derived from creel data from 1999-2012 within Redfish Lake. The trend line was used to show the decrease in effort within the lake. The equation for the trend line is $y = -90.899x + 3236.2$ with an R^2 of 0.24.

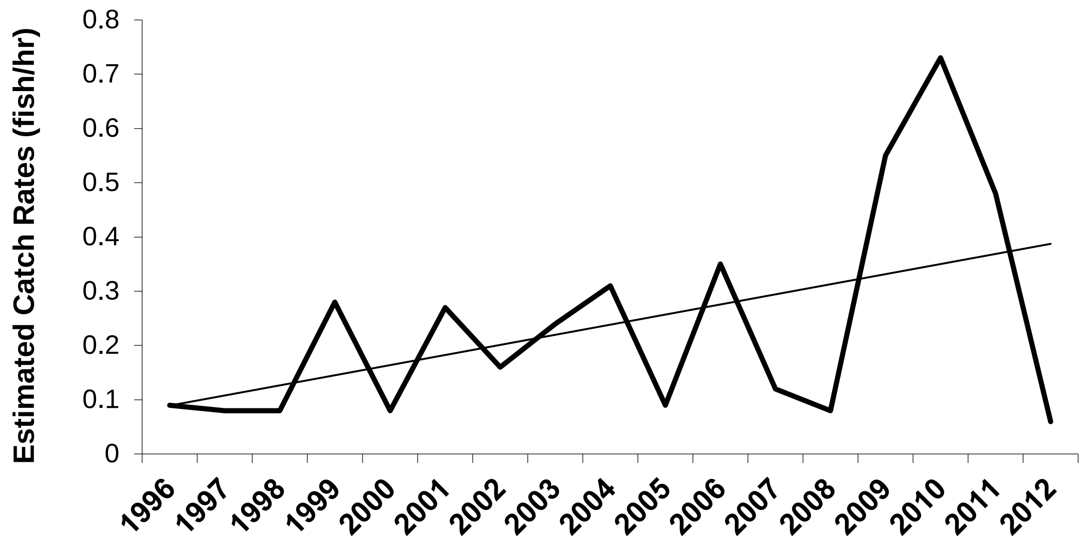


Figure 8. Bull Trout catch rates derived from creel data from 1996-2012 within Redfish Lake. The trend line was used to show the catch rate increase within the lake. The equation for the trend line is $y = 0.0186x + 0.0708$ with an R^2 of 0.23.

PART 3—SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

INTRODUCTION

The development of captive broodstock program reintroduction plans has followed a "spread-the-risk" philosophy incorporating multiple release strategies and multiple lakes over the course of the program (Hebdon et al. 2004). Both adults and eggs produced in excess of broodstock needs have been re-introduced into the environment to provide opportunities to increase the size and fitness of the population with returning anadromous adults. Progeny from the captive broodstock program are reintroduced to Sawtooth Valley waters at different life stages using a variety of release options including: 1) eyed egg plants to in-lake incubator boxes in Alturas and Pettit lakes in November and December, 2) presmolt releases into all three lakes primarily in October, 3) smolt releases to outlet streams in May, and 4) prespawn adult releases primarily in Redfish Lake (hatchery-reared) in September. Prespawn Sockeye Salmon adults were first released back to the wild in 1993. Beginning in 1999, anadromous Sockeye Salmon have been released into valley lakes (when available) along with captive adult Sockeye Salmon that were raised full-term to maturity in a hatchery. In addition to natural production (resulting from eyed egg and prespawn adult releases), hatchery-produced juveniles (smolts) are annually released into Redfish Lake Creek and the mainstem Salmon River. These hatchery releases constitute the largest proportion (between 80-95%) of out-migrants from the Sawtooth Valley each season.

Monitoring and evaluation of the release strategies has been an important part of the "spread-the-risk" philosophy (Hebdon et al. 2004). All hatchery-reared presmolt and smolt release groups were uniquely marked to identify release strategy and origin. Natural origin fish cannot be physically marked but currently are genetically marked (e.g. parental based tagging or PBT) to differentiate release strategies. Current evaluations of juvenile Sockeye Salmon focus on trapping out-migration juveniles from each of the three lakes and providing estimates of out-migration timing, smolt size, age composition, and abundance. The Shoshone Bannock Tribe conducts out-migration monitoring on Alturas and Pettit lakes each year while IDFG conducts out-migration monitoring on Redfish Lake. Out-migrant monitoring also provides overwinter survival information for presmolts released into the nursery lakes the year prior to out-migrant trapping. Lastly, out-migration monitoring allows for the tagging of natural-origin fish with PIT tags for subsequent analyses of survival and travel time from the nursery lakes to Lower Granite Dam (LGR; and through the hydrosystem). This information was used to compare the effectiveness of each release strategy in terms of survival and continue to characterize and build baseline data on naturally emigrating smolts. In this chapter, out-migration monitoring activities for Redfish Lake in 2012 were described as well as the out-migration estimates and PIT tag data produced by the Shoshone Bannock Tribe for Alturas and Pettit lakes.

In 2012, the following groups could be the source of natural origin out-migrants in Redfish Lake Creek: 1) age-1+ out-migrants produced from 1,581 adults released for volitional spawning in 2010, 2) age-2+ out-migrants produced from 1,330 adults released for volitional spawning in 2009, or 3) residual Sockeye Salmon spawning in 2009 or 2010. Hatchery-produced Sockeye Salmon smolts captured at Redfish Lake Creek trap originated primarily from: 1) 50,054 BY10 adipose fin-clipped presmolts (reared at EFH) released into the lake in July 2011 as age-1+ out-migrants, or 2) 31,413 BY09 adipose fin-clipped presmolts (reared at SFH) released into the lake in October of 2010. In Alturas Lake, any age-1+ natural origin out-migrants found within Alturas Lake could have been produced by residual Sockeye Salmon, kokanee, or the group of Snake River Sockeye Salmon eyed eggs planted in 2010 (N = 59,683). Any age-2+ natural origin out-migrants found within Alturas Lake would have been produced from residual Sockeye Salmon, kokanee, or egg-box plants in 2009 (N = 15,568). Hatchery-produced Sockeye Salmon smolts captured at the Alturas Lake Creek trap originated primarily from 16,363 adipose fin-clipped presmolts (reared at EFH) released into the lake in July 2010. Natural origin out-migrants produced from program fish releases to Pettit Lake included age-1+ out-migrants originating from residual Sockeye Salmon as no eyed eggs were planted in 2010. Any age-2+ out-migrants originated from eyed eggs planted in 2009 (N = 59,511) or residual Sockeye Salmon spawning in 2009 or 2010. Hatchery-produced Sockeye Salmon smolts captured at the Pettit Lake Creek trap originated primarily from the 18,075 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2010. No presmolts were released into Alturas Lake or Pettit Lake in 2011. In 2012, BY10 smolts were also released immediately below the Redfish Lake Creek trap. This release included smolts reared at the SFH. Additional releases of BY10 smolts, reared at OFH and NOAA, occurred at the bridge approximately 0.75 km downstream from the Redfish Lake Creek trap. All smolts released from SFH and OFH were adipose clipped and coded-wire-tagged, with a representative group PIT-tagged. Size at release statistics can be found in Baker et al. (2013).

METHODS

Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) was located 1.4 km downstream from the lake outlet at a permanent weir site. The trap functions as a juvenile trap for out-migrating fish, and with minor modifications, as a trap for returning adults (Craddock 1958; Bjornn et al. 1968; Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000, 2002, 2003; Willard et al. 2004, 2005; Peterson et al. 2008, 2010, 2012a). The trap was operated from April 7 through June 9, 2012 and contains nine bays, five of which were fitted with incline bar traps. IDFG staff checked the trap twice daily in 2012. The trap was fished until high water forced us to remove it, until fish stopped emigrating from the lake, or until mid-June (depending on the event that occurred first). Each fishing bay was fitted with an adjustable 1.70 m wide by 1.74 m long aluminum trap box on a winch and pulley system. The trap boxes were constructed of 3 mm aluminum sheeting and framework and 1.9 cm diameter hollow aluminum bars. The 30.5 cm x 169.5 cm x 30.5 cm live wells were also constructed of 3 mm aluminum with 5 mm holes drilled for aeration and water exchange in the live well. Bar spacing (19 mm) allowed debris and large fish to pass downstream, while low velocity water swept *O. nerka* smolts across the bars and into the live well for holding until personnel were able to empty the trap (Kline 1994).

All Sockeye Salmon smolts captured at RLCTRP were anesthetized in buffered tricaine methanesulfonate (MS-222; 50 mg/L), measured for fork length (1 mm), weight (0.1 g), and scanned for PIT tags. Scales were removed from a subsample of natural origin and adipose fin-clipped hatchery reared *O. nerka* (five per 5 mm length group) and returned to the laboratory for aging. In the lab, scales were pressed between microscope slides, two program employees individually aged the scales, and a third person viewed the image with the original two employees to finalize discrepancies (similar to Schrader et al. 2013). The proportions of age-1+ and age-2+ out-migrants were determined by using the MIX computer program developed by MacDonald and Green (1988). MIX software uses known ages (the scale ages in this case) and fits mixture distributions to grouped data by utilizing a maximum likelihood estimator. All captured non-target species were counted and released immediately. Fin-clip samples were taken from up to 50 natural smolts/day for future genetic analyses (N = 1,539 fish).

Up to 50 natural origin Sockeye Salmon smolts (determined by presence of an adipose fin) and 50 hatchery origin Sockeye Salmon smolts were PIT-tagged daily and released approximately 250 m upstream of the weir one-half hour after sunset to estimate trap efficiency. All remaining fish were identified (natural origin and hatchery origin), scanned for PIT tags, counted, and released 15 m below the weir one-half hour after sunset. Flow-through live boxes with locking lids were used to hold fish until the evening release. Trapping efficiencies were calculated for natural origin Sockeye Salmon smolts and summer direct-released Sockeye Salmon presmolts emigrating as smolts. Stream velocity was measured below the trap weekly. Out-migrant run size was derived using a modified Bailey estimator and 95% bootstrap confidence intervals using methods described by Steinhorst et al. (2004). In this methodology, trapping was divided into intervals. Intervals were selected based on stream discharge similarities and the number of PIT-tagged smolts released upstream of the weir that were available for recapture (trap efficiencies). Smolt out-migration estimates were calculated separately for natural origin and presmolt released hatchery origin Sockeye Salmon smolts. During the spring of 2012, normal flow conditions were experienced throughout the trapping season in Redfish Lake Creek.

On May 10, 2012 a total of 80,130 full-term hatchery smolts reared at SFH were released into Redfish Lake Creek, of which 52,167 were PIT tagged to determine survival to LGR. An additional group of 85,161 full-term hatchery smolts reared at OFH were released at the bridge approximately 0.75 km downstream of the Redfish Lake Creek trap on May 10, 2012, of which 10,551 were PIT-tagged to estimate survival. A total of 781 full-term hatchery smolts (100% PIT-tagged) reared at NOAA were also released at the bridge on Redfish Lake Creek on May 10, 2012. An additional 580 (of which 395 were radio tagged and 185 were PIT tagged) and 457 (of which 398 were radio tagged and 59 were PIT tagged) full-term hatchery smolts reared at the OFH and SFH, respectively, were also released on May 10, 2012 as part of a collaborative research project investigating survival from the Sawtooth Valley to LGR (Axel et al. 2013).

Alturas Lake Creek Trap

Sockeye Salmon out-migrant trapping and PIT tagging on Alturas Lake Creek was conducted by the SBT. The Alturas Lake Creek screw trap was located 13 km downstream from the Alturas Lake outlet and was operated from April 24 to May 27, 2012. Hatchery-produced Sockeye Salmon smolts captured at the trap originated primarily from 16,363 adipose fin-clipped presmolts (reared at EFH) released into the lake in July 2010. The Alturas Lake out-migrant population estimate was derived using the same estimator described above (Steinhorst et al. 2004). Activities conducted by the Shoshone-Bannock Tribes were reported under separate cover (Moreno et al. 2014).

Pettit Lake Creek Trap

Sockeye Salmon out-migrant trapping and PIT tagging on Pettit Lake Creek was conducted by the SBT. The Pettit Lake Creek trap was located 1 km downstream from the Pettit Lake outlet at a permanent weir site and was operated from April 25 to May 22, 2012. Hatchery-produced Sockeye Salmon smolts captured at the trap originated primarily from the 18,075 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2010. The Pettit Lake Creek weir traps at 100% efficiency under low spring flow conditions (D. Taki, Shoshone

Bannock Tribes, personal communication); therefore, out-migration run size for Pettit Lake was based on the census number of smolts trapped. However, during normal to high flow years, the trap must be removed and other means can be used to estimate the number of out-migrants. Activities conducted by the Shoshone-Bannock Tribes were reported under separate cover (Moreno et al. 2014).

SURPH Survival and Travel Time Estimation

In 2012, Sockeye Salmon smolts were transported (if collected in juvenile facilities within the hydrosystem corridor) and released below Bonneville Dam according to a USACE PIT tag study (methods and results can be found in BioMark and Quantitative Consultants, Inc. 2010). As a result, migration corridor survival evaluations were only conducted to Lower Granite Dam (LGR) for this project. Sockeye Salmon smolt survival and travel time to LGR was evaluated using PIT tag interrogation data collected at PIT tag detection facilities throughout the Snake and Columbia rivers. Interrogation data were retrieved from the PIT Tag Information System (PTAGIS) maintained by the Pacific States Marine Fisheries Commission (Portland, Oregon). This data was used by PitPro (Westhagen and Skalski 2009) to develop a data file for analysis using program SURPH (Lady et al. 2010), which estimates survival to LGR. These models utilize PIT tag detections at various dams to develop a Cormack/Jolly-Seber estimate of survival to LGR. PitPro also uses PIT tag detection data to estimate average travel time to LGR. Total smolt out-migration (for each smolt production, natural origin, and presmolt out-migrant group) to LGR was estimated using the SURPH survival estimate (for each respective release group) multiplied by the out-migration estimate of each release group at the out-migration trap sites found in the Stanley basin. Weighted survival was calculated by dividing the out-migration estimate (per group) by the total number of smolts leaving the Sawtooth Valley, then multiplied by the survival (by group) and summing all groups together. The weighted SURPH survival provides the program with a point estimate of survival for each year to monitor trends in survival.

RESULTS

Redfish Lake Creek Trap

A total of 8,053 Sockeye Salmon smolts (7,232 natural origin and 821 hatchery origin) were trapped during the 2012 out-migration season (Figure 9). Fork length of natural origin and hatchery origin Sockeye Salmon smolts captured averaged 105.6 mm (range 79 mm to 170 mm; Figure 10) and 115.0 mm (range 93 mm to 153 mm; Figure 10), respectively. Sockeye Salmon smolt lengths were statistically shorter for natural origin smolts and longer for hatchery origin presmolt out-migrants in 2012 than those observed during the 2011 out-migration season (Peterson et al. 2012b).

Of the 7,232 natural origin smolts handled in 2012, 1,272 were marked and released upstream of the weir to estimate trapping efficiency (Table 10). Based on observed trapping efficiencies and discharge during out-migration monitoring, three trapping intervals were used to develop the estimate for natural origin smolt out-migration (Table 10). Trapping efficiencies for the three intervals ranged from 18% to 27%. The 2012 total natural origin Sockeye Salmon smolt out-migration was estimated at 31,297 fish (95% CI 28,090-35,131; Table 10; Figure 11). A total of 76 natural origin smolts were aged using scales collected during out-migration. The proportion of age-1+ (BY10) natural origin smolts was estimated at 87.7%, which equals 27,447 smolts (CI ± 626 smolts); the proportion of age-2+ (BY09) natural origin smolts was estimated at

12.3%, which equals 3,850 smolts (CI ± 626). Natural origin fish typically start out-migrating earlier in the season than presmolts, which occurred again in 2012 (Figure 9).

Of the 821 presmolt out-migrants handled in 2012, 432 were marked and released upstream of the weir to estimate trap efficiency (Table 10). For this analysis, only one interval was chosen based on trapping efficiencies and discharge. Total fall direct-released smolt out-migration was estimated at 2,208 fish (95% CI 1,942–2,504; Table 10). A total of 61 presmolt out-migrants were aged using scales collected during the out-migration season. The proportion of age-1+ (BY10), adipose fin-clipped, hatchery-reared smolts was estimated at 94.3%, which equals 2,082 smolts (CI ± 77 smolts); the proportion of age-2+ (BY09), adipose fin-clipped, hatchery-reared smolts was estimated at 5.7%, which equals 126 smolts (CI ± 77 smolts). Overwinter survival and out-migration for the BY10 group equated to 4.4% of the number of the BY10 presmolts planted in 2011 (Table 11). The final survival for presmolts produced in BY 09 was 17%.

Alturas Lake Creek Trap

During the 2012 out-migration season, a total of 24 *O. nerka* smolts (22 natural origin and 2 hatchery origin) were PIT-tagged. Fork length of natural origin and hatchery fall released presmolt emigrating as smolts averaged 89 mm (range 78 mm to 100 mm) and 107 mm (range 88 mm to 125 mm), respectively. Scales were collected from five natural origin smolts and one presmolt out-migrant during 2012. All scales were aged as age-1+ out-migrants.

Due to the limited number of out-migrants from Alturas Lake in 2012, expansion estimates were not generated for either natural or hatchery origin smolts. However, one of the PIT-tagged smolts (out of the 22 tagged) was detected at LGR and subsequently used in the estimate of total smolts at LGR (Table 12; see SBT annual report for methods and calculations, Moreno et al. 2014). Genetic samples were collected from seven out-migrating *O. nerka* smolts during 2012 and transferred to the IDFG Genetics Laboratory for future analysis.

Pettit Lake Creek Trap

The total number of natural origin and presmolt out-migrant Sockeye Salmon smolts trapped leaving Pettit Lake in 2012 was 502 and 163, respectively (see SBT annual report for further information, Moreno et al. 2014; Table 12; Figure 11). Scales were collected for a total of nine natural origin and eight presmolt out-migrants. Four natural origin smolts were aged as age-1+ and four as age-2+; the remaining scale sample could not be aged due to a regenerated focus. All of the presmolt out-migrants were aged at age 2+. No further analysis was conducted to determine the proportions of each age group due to the low sample size. Fork length of natural origin and presmolt out-migrants captured averaged 134 mm (range 98 mm to 183 mm) and 147 mm (range 136 mm to 182 mm), respectively. Genetic samples were collected from 54 out-migrating *O. nerka* smolts during 2012 and transferred to the IDFG Genetics Laboratory for future analysis.

SURPH Survival and Travel Time Estimation

Out-migration success was estimated to LGR for natural origin and hatchery origin Sockeye Salmon smolt groups using PIT tag interrogation data (Table 12; Appendix B). Estimates reflect numbers of smolts that arrived at LGR based on results from data analyses using the SURPH model. Survival among release groups ranged from a low of 7.0% (Pettit Lake presmolts) to a high of 69.4% (Oxbow smolts; Table 12). An estimated 15,930 (50.9% survival) and 958 (43.4% survival) natural origin and presmolt out-migrants, respectively, survived to LGR from the Redfish Lake Creek trap. Survival from the Alturas Lake Creek trap to LGR was not estimated due to low recapture rates for natural or hatchery origin out-migrants at LGR; however, we did observe one PIT-tagged smolt at LGR; subsequently, one smolt was included in the number estimated at LGR. Survival from the Pettit Lake Creek trap to LGR was estimated at 22.2% survival for natural origin smolts and 7.0% survival for presmolt out-migrants. An estimated 59,376 (includes the production group, radio-tagged and PIT-tagged smolts) OFH smolts, 47,452 (includes the production group, radio-tagged and PIT-tagged fish) smolts from SFH, and 321 (41.1% survival) NOAA Sockeye Salmon smolts survived to LGR from the Redfish Lake Creek smolt release groups. Additional information regarding the survival and travel time for SFH and OFH full-term smolts released into Redfish Lake Creek in 2012 was reported in Axel et al. (2013). The total estimate of Sockeye Salmon smolts that out-migrated from the Sawtooth Valley and survived to LGR in 2012 was 124,160, of which 123,236 represent our trend monitoring groups resulting from Redfish Lake natural and presmolt production and our full term smolt production from SFH and OFH (Table 12). Estimated travel times ranged from 7.9 days (OFH full-term smolts) to 11.9 days (SFH full-term smolts), excluding the one PIT-tagged natural origin smolt from Alturas Lake, which had a travel time of 21 days. Differences in survival were observed for the second straight year between smolts planted as presmolts emigrating from the lakes and full-term hatchery smolts released directly into the creek for out-migration (Figure 12). The weighted SURPH estimate for all the release groups was 61.8% to LGR. This represents an overall decrease of approximately 8% from the 2011 weighted SURPH estimate of 69.8% survival to LGR; however, it remains much higher than the 5-year average of 48.2% (2007-2011; unpublished program data).

DISCUSSION

Out-migration resulting from natural production within Redfish Lake resulted in the largest estimate for the program to date (31,297; Figure 11). Full-term captive and anadromous adults have been released for volitional spawning since 2008 and a high correlation between adults released (from 1993-2010) and juvenile out-migrants being estimated has been observed (Pearson correlation coefficient r=0.879; M. Peterson, unpublished data). Based on the number of adults released for volitional spawning in Redfish Lake during 2010 (N = 1,576), a large increase in the number of natural out-migrants leaving the lake was expected to be seen in 2012. Bjornn et al. (1968) conducted smolt out-migration and adult return monitoring between 1954 and 1966; their work provides a detailed account of Sockeye Salmon life history in Redfish Lake. Sockeye Salmon smolt out-migration from Redfish Lake typically begins in early April, peaks in mid-May, and concludes by mid-June. Smolts out-migrate at either age-1 or age-2 and the proportions vary every year. During their 11-year study, Bjornn et al. (1968) noted a dominance of age-1 smolts for six of the 11 years. The dominance of age 1+ smolts observed during 2012 followed the same pattern observed by Bjornn et al. (1968). We also expect a boost in naturally produced adult returns resulting from this production (primarily during the 2014 return).

While the program produced a dramatic increase in natural origin smolts during 2012, overwinter out-migration success decreased in the hatchery presmolts. A total of 50,054 presmolts were released in July of 2011 into Redfish Lake and the expectation was to see overwinter out-migration success similar to that observed from 2000-2011 (26.5%). The estimate of 4% was drastically lower than expected. This was the second release of summer direct presmolts into Redfish Lake since 2000, and the only release that occurred in July. Similar overwinter out-migration success was observed resulting from a summer direct release of presmolts within Alturas Lake in 2010 (6%; Table 11). However, in Alturas Lake, only age-1+ smolts could be estimated, therefore, this number should be seen as a minimum. These presmolts may have experienced poor survival to out-migration, opted to reside in the lake an additional year, or may have residualized within the lake. Continued monitoring of presmolt out-migration in 2013 to determine the proportion of age-2+ out-migrants and conducting spawner surveys in the fall of 2013 and 2014 may provide some explanation regarding the poor out-migration success to date.

During the out-migration of 2012, natural origin smolts began emigrating from Redfish Lake approximately one week prior to hatchery origin smolts. This pattern has been observed since 2006 (Peterson et al. 2007, 2008, 2011, 2012a, 2012b), with one exception in 2008 (Peterson et al. 2010) when both hatchery and natural origin smolts had similar migration timing. The reason for these differences remains unknown but may result in the development of different numbers of strata used to estimate out-migration. Biological strata used to develop out-migration estimates were explained in further detail within Steinhorst et al. (2004) and were developed using similar periods of discharge and trap efficiency data collected at the trap site. During 2012, one stratum was used to estimate presmolt emigration, whereas 3 strata were used to estimate the natural origin smolts based on observed differences in stream discharge and 5 day trap efficiency rates. The development of proper stratification is important for developing accurate out-migration estimates each season and may vary by release strategy depending on behavioral or migration timing differences.

Trap efficiency data was a very important component (as mentioned above) used to estimate out-migration each season and may impact the precision of our estimates. Trap efficiency decreased from a twelve-year average (2000-2011) of 35% to 25% during 2012. This was likely due to increased predation at the trap by small mammals, piscivorous birds, and Bull Trout. Predation of released smolts continued to be observed during 2012. Several personnel visually observed hooded mergansers and Bull Trout harassing juvenile Sockeye Salmon at the trap (also reported in Axel et al. 2013). Predation above the trap on released fish could cause an artificial decrease in trap efficiency that would cause us to overestimate the number of natural out-migrants. During 2012, the capture and haul program to remove Bull Trout from the juvenile trap site was continued to improve our estimates of trap efficiency and produce better out-migration estimates at the Redfish Lake Creek trap. Additional efforts to reduce predation at the trap site may be necessary and should include the investigation of hazing techniques for predatory birds or small mammals.

Flow may further impact our trap efficiency estimates. While the lake buffers the creek during snow runoff events (day temperatures exceeding 19°C), the creek may rise enough at night to cause the trap to overflow and potentially cause a loss of smolts targeted for recapture. This phenomenon was observed three days during 2012 and data was likely lost from the trap. Trap efficiencies were typically generated over a period of weeks instead of days; therefore, the effects of lost smolts over one evening likely has less of an impact then predation above the trap on our out-migration estimates (over the course of the season). However, to avoid any loss of data, resulting from increased flow, protocols to monitor daytime flows and to check the traps at night (approximately 2:00 am) when daytime flows increase have been developed.

Understanding differences between groups and factors that affect survival to LGR, continues to be an important component of the research program. Differences in out-migration survival have been observed between smolts leaving the lake (natural origin and presmolts) and full-term hatchery smolts released directly into the creek. One possible hypothesis for these observed survival differences could be that full-term smolts released all at once (high densities) survive better to LGR through "predator saturation" (Liermann and Hilborn 2001). Smolts emigrating from the lake were exposed to the same predators but tend to leave the lake in much lower densities per day and over a longer period of time. The peak number of natural smolts emigrating in one day during 2012 was estimated at 5,231 smolts, whereas the abundance of smolts in the system after full-term smolt releases was approximately 166,000 smolts, thus swamping predators and increasing survival. Additional data analysis should be completed to develop a better understanding of the factors that affect survival to LGR.

During 2012, an estimated 124,160 (61.8% survival) of the 200,846 smolts that left the Sawtooth Valley arrived at LGR. Sawtooth Valley emigration success for all juvenile SR Sockeye Salmon to LGR has averaged 50.8% (SE 0.056) since the initiation of consistent full-term smolt releases in 2005. It may be important to note that factors affecting survival within this section of the migration corridor may include competition with non-native species, predation, environmental conditions, rearing and release strategies, or residualization (Axel et al. 2013). The variability observed between years and across release strategies continue to be investigated (Figure 12). Beginning in 2011, another project utilizing PIT tag and radio telemetry was initiated to investigate the variability observed between years and to try to identify areas where mortality occurred that could be managed or reduced (Axel et al. 2013). Further research is warranted to identify whether smolt size at release impacts survival in the migration corridor between the Sawtooth Valley and LGR for Snake River Sockeye Salmon. In addition, generation of models, which include environment factors such as discharge and water temperature to explain some of the variability observed between groups and across years should be explored.

Table 10. Out-migration estimate for natural and hatchery origin Sockeye Salmon smolts captured at the Redfish Lake Creek trap from April 8 to June 8, 2012.

Natural Origin smolts (three interval estimate)				
	Interval 1	Interval 2	Interval 3	Total
Dates	4/8-4/25/12	4/26-5/14/12	5/15-6/08/12	4/8-6/08/12
Trap efficiency	0.18	0.24	0.27	
Marked	228	794	250	1,272
Recaptured	41	187	68	296
Total handled	714	6,250	268	7,232
Estimated total	3,893	26,430	975	31,297
95% CI upper bound	5,131	30,090	1,241	35,131
95% CI lower bound	2,951	23,372	780	28,090

Hatchery origin smolts (one interval estimate)		
	Interval 1	Total
Dates	4/08-6/08/12	4/08-6/08/12
Trap efficiency	0.37	0.37
Marked	432	432
Recaptured	160	160
Total handled	821	821
Estimated total	2,208	2,208
95% CI upper bound	2,504	2,504
95% CI lower bound	1,942	1,942

Table 11. Estimated overwinter out-migration success for Sawtooth Fish Hatchery-reared presmolts released in the summer or fall to Redfish, Alturas, and Pettit lakes. These estimates only account for Age-1+ out-migrants from each release.

Out-migration Year	Redfish Lake	Alturas Lake	Pettit Lake
2000	29%	34%	46%
2001	20%	75%*	29%*
2002	40%	30%*	29%*
2003	15%*	NA*	59%*
2004	27%	54%	35%
2005	35%	82%	56%
2006	43%	38%	64%
2007	23%	26%	25%
2008	27%	53%	59%
2009	25%	31%	54%
2010	17%	9%	24%
2011	17%	6%*	15%
2012	4%*	NA	NA

*Indicates summer releases (July).

Table 12. Snake River Sockeye Salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR) for 2012. Eagle Fish Hatchery (EFH) reared the summer direct presmolt (SDR) release group. Sawtooth Fish Hatchery (SFH) reared the fall direct presmolt (FDR) release group. SFH, Oxbow Fish Hatchery (OFH), and the Manchester Research Station (NOAA) were the rearing locations for full-term smolt releases.

Release strategy (rearing location)	Total released[a]	Number tagged prior to release	PIT tags detected at trap	Smolt out-migration estimate	Number tagged at trap	Estimated SURPH survival at LGR	SURPH[c] 95% CI (±)	Estimated no. at LGR	Estimated travel time (days)
Redfish Lake									
Natural origin smolt	NA	NA	NA	31,297	1,607	50.90%	4.31%	15,930	9.0
SDR presmolt (EFH)	50,054	1,994	19	2,208	432	43.40%	7.88%	958	8.3
Alturas Lake[b]									
Natural origin smolt	NA	NA	NA	22	7	NA	NA	1	21
FDR presmolt (SFH)	0	NA	NA	2	2	NA	NA	0	NA
Pettit Lake[b]									
Natural origin smolt	NA	NA	NA	502	225	22.15%	12.40%	111	9.8
FDR presmolt (SFH)	0	NA	0	163	86	6.98%	9.56%	11	10.7
Redfish Lake Creek									
Hatchery origin smolt (OFH)	85,161	9,971	NA	85,161	NA	69.40%	10.39%	59,102	7.9
Hatchery origin smolt (SFH)	79,673	51,710	NA	79,673	NA	59.30%	1.37%	47,246	11.9
Radio-telemetry project (OFH)	395	395	NA	395	NA	45.80%	13.72%	181	8.1
Radio-telemetry project (SFH)	398	398	NA	398	NA	51.80%	23.32%	206	8.1
RT (leftover smolts) (OFH)	185	185	NA	185	NA	50.50%	38.02%	93	8.6
RT (leftover smolts) (SFH)	59	59	NA	59	NA	0.00%	0.00%	0	7.9
Hatchery origin smolt (NOAA)	781	781	NA	781	NA	41.10%	14.29%	321	11.0

[a] Total released from hatchery; presmolts = 2011, smolts = 2012.
[b] Data from Alturas and Pettit lake trap obtained from Shoshone-Bannock Tribes biologists.
[c] 95% CIs are two standard errors.

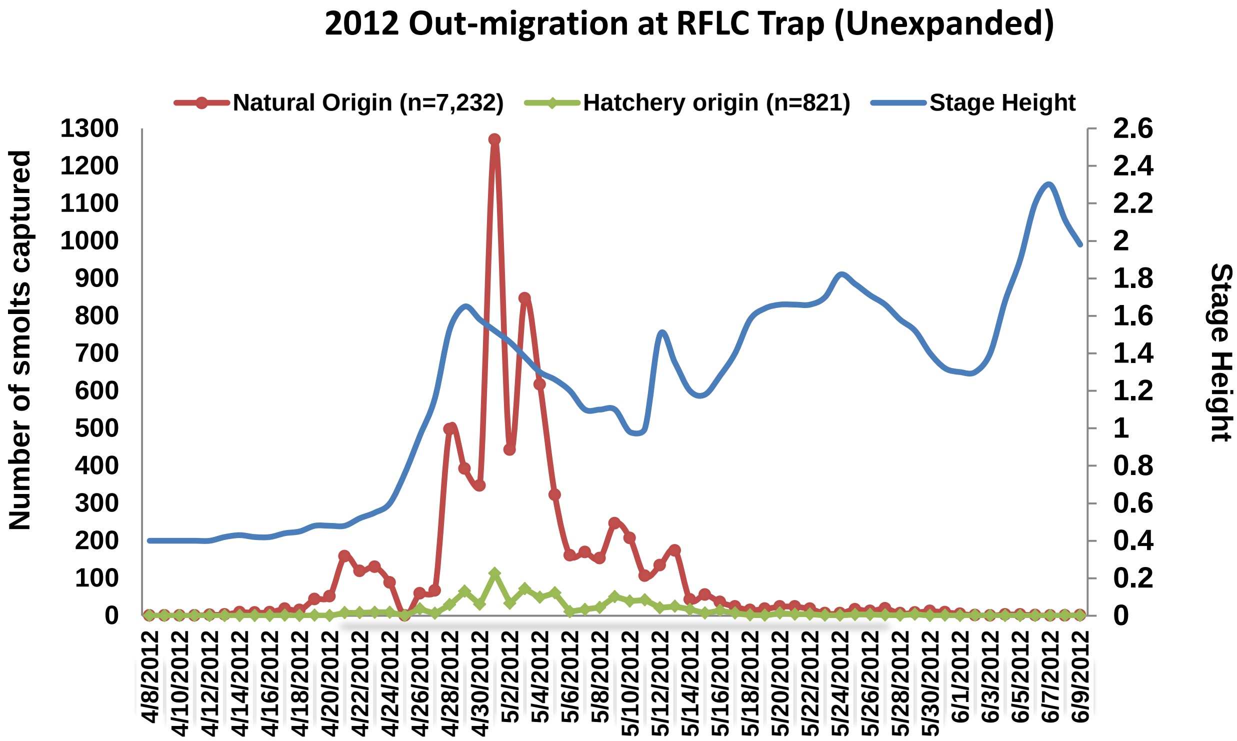


Figure 9. Daily capture of natural origin and hatchery origin Sockeye Salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2012 out-migration.

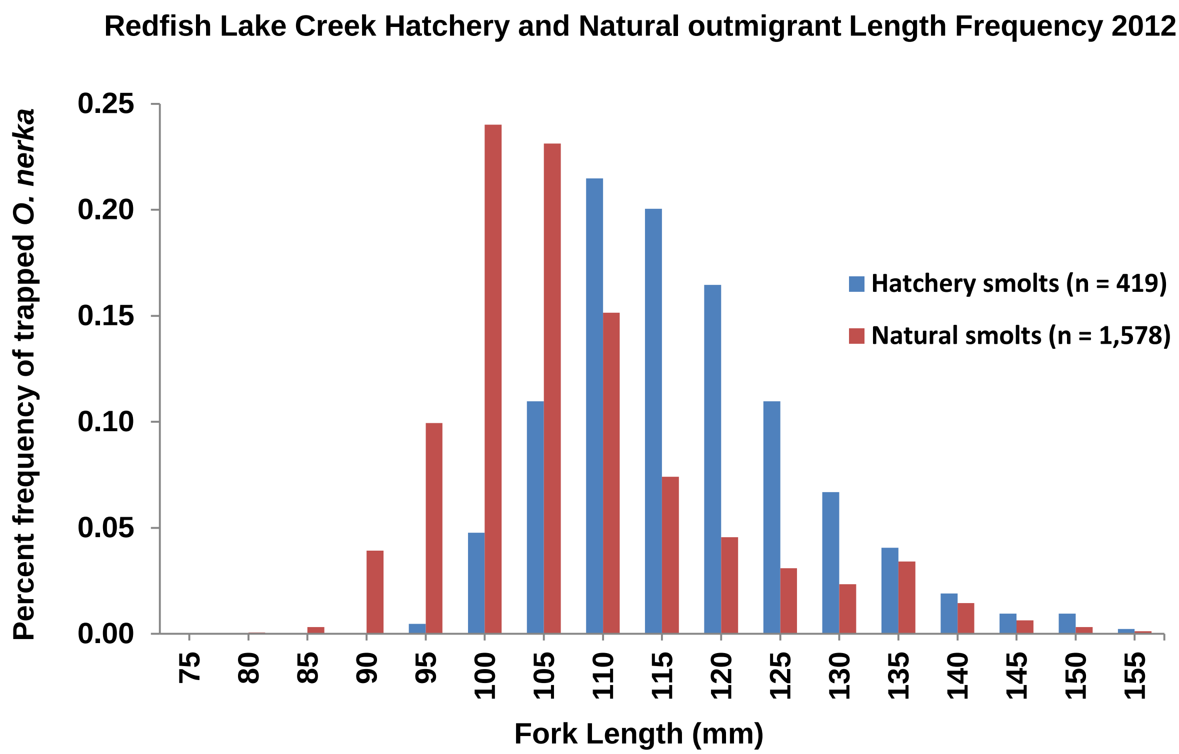


Figure 10. Length frequency of natural (n = 1,578) and hatchery origin (n = 419) Sockeye Salmon smolts collected at Redfish Lake Creek trap in 2012.

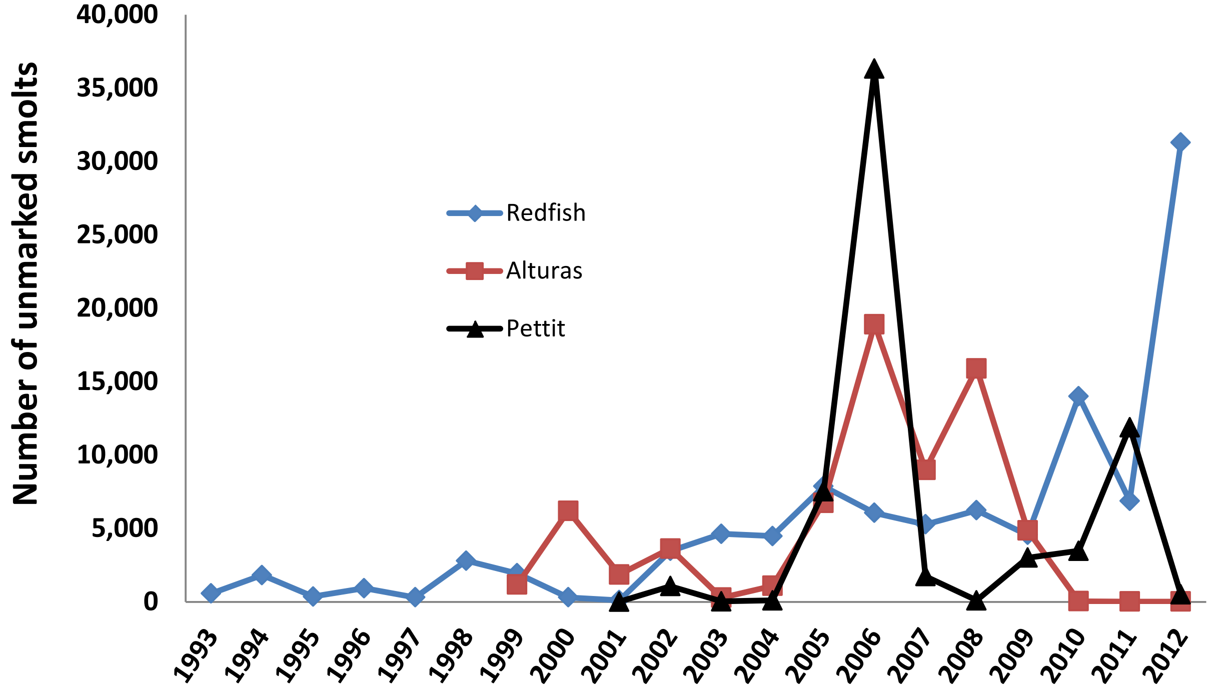


Figure 11. Numbers of natural origin Sockeye Salmon smolts emigrating from Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps by out-migration year. (juvenile out-migrant trap on Pettit Lake Creek has not been operated every year).

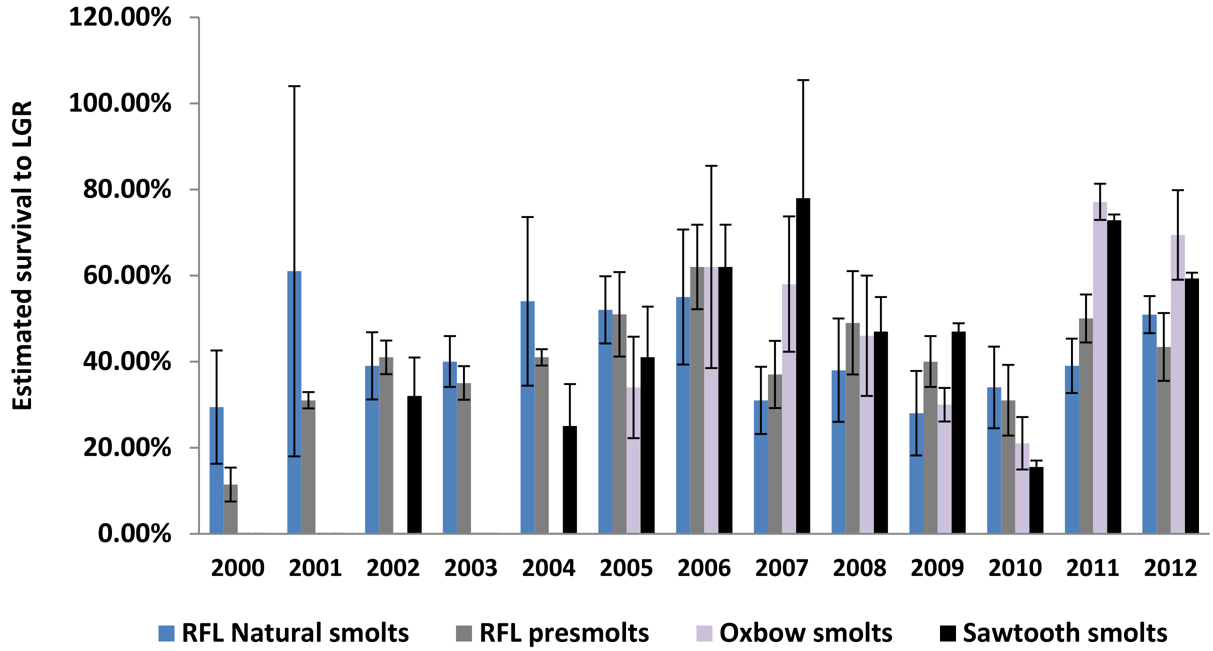


Figure 12. Estimated survival to Lower Granite Dam for Redfish Lake natural smolts, presmolt out-migrants, Oxbow full-term hatchery smolts (main production release group only), and Sawtooth full-term hatchery smolts (main production release group only) from 2000-2012. Error bars represent 95% CIs (1.96 * SE from the estimate).

PART 4—ANADROMOUS TRAPPING AND NATURAL PRODUCTION MONITORING AND EVALUATIONS

INTRODUCTION

Currently, research on adult Snake River Sockeye Salmon focuses on collecting data to generate three of the four viable salmonid population (VSP) parameters: abundance, productivity or population growth rate, and diversity. The fourth parameter, spatial structure, has been monitored by releasing fish at various life stages into all three recovery lakes and documenting survival (currently covered in Part 3 of this report) and will become more important in the recolonization phase of the program as adults are released into multiple lakes for natural spawning. A viable salmonid population is defined as a population that has a negligible risk of extinction due to threats from demographic, environmental, or genetic variation over a 100-year time period (McElhany et al. 2000). The recovery plan for Snake River Sockeye Salmon has been completed (NMFS 2014) and this information will be vital for future status assessments and the delisting or reclassification (e.g. from endangered to threatened) of this ESU. In order to meet biological and broad sense recovery goals, a minimum abundance threshold of 1,000 natural-origin spawners are needed for Redfish and Alturas lakes, while 500 natural-origin spawners are needed for Pettit Lake. In addition, the population growth rate must be stable or increasing and there must be a moderate risk rating for spatial structure and diversity for a viable population.

These parameters were measured by collecting information across a variety of life stages. Abundance of adults was measured as the number of returning anadromous adults trapped at each of the Sawtooth Valley weirs as well as the number of natural-origin and hatchery-origin adults released into Redfish Lake for natural spawning. Collections of returning adults provide the program with basic biological metrics such as run timing, length, weight, sex ratios, and age structure as well as estimates of adult survival from LGR to the Sawtooth Valley for the anadromous component. Parentage based tagging (PBT) evaluations determine if adults (full-term captive, hatchery-origin anadromous returns, and natural-origin anadromous returns) successfully spawn within the habitat and produce progeny that contribute to future generations. Evaluations of adult spawning (within the habitat) were measured by identifying the spatial distribution and quantifying redd production, as well as estimating migration timing of radio-tagged adults to known spawning locations within Redfish Lake. Productivity was measured as the smolt-to-adult return ratio (SAR) and adult-to-adult recruits-per-spawner (R/S) and recruits-per-female ratio (R/F). Diversity was measured using neutral microsatellite loci to track changes in heterozygosity and allelic diversity through time.

In this report, we describe the trapping activities that occurred in 2012. Information regarding trapping activities and adult releases were also presented in Baker et al. 2013. We also present the results of the genetic analyses and aging for the 2011 trapping season that were completed in 2012. Once these analyses were completed, we were able to finalize productivity metrics for brood year 2006 (with the age-5 adults returning in 2011) for natural and hatchery origin fish. Natural out-migration was estimated each year using juvenile weirs and traps (as described in Part 3). Juvenile abundance estimates related to brood year 2006 (BY06) productivity metrics were presented in earlier annual reports (out-migrants in 2008, Peterson et al. 2010; and out-migrants in 2009, Peterson et al. 2012a) and briefly summarized here to develop an SAR. Estimates of total egg deposition, egg-to-smolt survival, smolts per female, recruits-per-spawner and recruits-per-female were also generated to monitor and evaluate the success of BY06 released adults. Monitoring different life-stage survivals allows us to adaptively manage the captive broodstock program.

METHODS

Trapping of Anadromous Adult Returns

Two adult collection facilities were used to capture anadromous returning adult Snake River Sockeye Salmon. The first trap was located on Redfish Lake Creek approximately 1.0 km downstream from the lake outlet. This trap also serves as our juvenile out-migration trap and with minor modifications was converted to a picket weir trap (Craddock 1958). The second trap was located at the Sawtooth Fish Hatchery on the upper Salmon River approximately 10.1 river km upstream from the town of Stanley, Idaho. The traps were placed into operation on the descending limb of the hydrograph and were operated until no adults had been trapped for 7 consecutive days or until weather prohibited trap operation. The dates of operation during 2012 for Sawtooth Fish Hatchery and Redfish Lake Creek were June 21-September 14 and July 12-October 17, respectively, (Table 13).

Both trap locations were checked upon arrival each morning. During 2012, all adults collected at trap locations were either transported from the Sawtooth Valley to EFH for collection of biological data or direct released after data collection at the Redfish Lake Creek trap. Adults collected in the SFH weir during 2012 received a caudal fin punch. The caudal punch allows fish from both trap locations to be identified during the collection of biological data at EFH. Collected adults were loaded by net into a transport truck. During 2012, 186 adults were transported to the Eagle Fish Hatchery and 56 adults were “direct released” back into Redfish Lake Creek or directly into Redfish Lake.

Once trapped adults returned to EFH or prior to being directly released at Redfish Lake Creek, an adult workup station was set up to generate a daily PIT tag file. The software program used to develop the daily tag file was P3 (PSMFC 2013). Adults were individually removed from the transport truck using a dip net and taken to the anesthetic tank (MS-222; 50 mg/L). After fish were unconscious, personnel passed each anadromous adult over a PIT tag antenna and checked for the presence of CWT with the CWT detector. Adults that were PIT tagged as juveniles were displayed (if detected) on the computer screen. If no PIT tag was detected, personnel assigned a PIT tag (shrink wrapped to a cable zip tie) to the adult so individuals could be tracked to release for volitional spawning or incorporated into the captive broodstock (pending the genetic analysis results). Fork length (mm), sex, differential marks (such as adipose clips), genetic sample identification, and body injuries (if present) were recorded. Genetic samples were collected using a paper hole punch in the dorsal fin (or another fin) and placed in 100% ethanol filled vials for genetic analysis.

Scales were collected (approximately 4-5) immediately above the lateral line and slightly posterior to the dorsal fin (as identified in Devries and Frie 1996). The scales were transferred to a paper insert and placed in a scale envelope. Project personnel mounted the scales between two glass microscope slides. Scales were examined on a microfiche reader. The best scales for aging returning adults were selected based on the presence of a complete focus and minimal or no scale regeneration. The entire scale was imaged using 24 x magnifications. In addition, the freshwater portion was imaged using 48 x magnifications to determine when the fish out-migrated as a juvenile (after one or two years). Two technicians independently viewed each image to assign ages without reference to fish length. If there was no age consensus among the readers, a third reader viewed the image and all readers collectively examined the image to resolve their differences before a final age was assigned. If a consensus age was not attained, the sample was excluded from further analysis (Schrader et al. 2011). These data were then compared to the genetically derived ages (methods below). Scales were collected from 182 adult returns in 2012. Scales were not collected from adults that were directly released at Redfish Lake Creek due to scale re-absorption into the skin.

Adults that were directly released to Redfish Lake Creek (in high abundance years or later-returning adults) were processed for biological data (similar to the methods above) prior to being allowed to migrate into the lake. When all biological data had been collected, trapped adults were placed into one of the recovery holding boxes within Redfish Lake Creek. Once the fish had regained equilibrium, it was released or transported to the appropriate release location.

Utilizing the data collected from trap locations and EFH, upriver conversion (e.g. survival) rates were estimated from LGR back to the Sawtooth Valley employing three different methods to account for the degree of fallback and determine if window counts needed to be adjusted for fallback rates. Window count data generated at LGR and queried through the Columbia River DART website (http://www.cbr.washington.edu/dart/query/adult_daily) (Dart 2014) were divided by the total number of adults trapped to generate conversion rates (of trapped adults only) from LGR back to the Sawtooth Valley. Estimated conversion rates using only PIT-tagged adults, which were calculated by dividing the number of PIT-tagged adults observed at LGR by the number of PIT-tagged adults collected at the Sawtooth Valley traps, were also calculated (similar to Crozier et al. 2014). Finally, the conversion rate was estimated after adjusting adult numbers at LGR using PIT tag fallback percentage (the proportion of PIT-tagged individuals that were detected passing LGR more than once) data queried from the DART website (methods for these calculations can be found at http://www.cbr.washington.edu/fallback/). This was estimated by dividing the final trapped number by the adjusted passage counts at LGR. For years when fallback data was available (2008-2012), window counts were adjusted by the percentage of fallback to represent the number of adults crossing the dam.

Not all anadromous adult Sockeye Salmon that returned to the Sawtooth Valley were trapped and fish have been observed straying into other tributaries. Tributary spawning ground surveys were conducted on Stanley Lake Creek (to the confluence with Valley Creek), Valley Creek (from the confluence of Stanley Lake Creek to the confluence with the main Salmon River), Redfish Lake Creek (below the trap to the confluence with the main Salmon River), and the Salmon River (from SFH to the mouth of Redfish Lake Creek) weekly starting with the last week of August and continuing until the second week of October. If Sockeye Salmon were observed, the number was recorded in a field notebook for each week. The peak counts for each section (regardless of date) were summed together to estimate the number of adults present in the basin that were not trapped. These fish were reported in Baker et al. (2013).

Adult Spawning in Redfish Lake

Between September 14 and October 03, 2012, adult Sockeye Salmon were released to Redfish Lake for volitional spawning. Adult releases included 173 (79 female and 94 males) anadromous adults and 622 (268 female and 354 males) captive reared adults from NOAA Burley Creek Hatchery (BCH) and EFH (Table 14). Sex was determined by ultrasound for hatchery reared adults and the use of phenotypic secondary sex characteristics for the anadromous returns (Burgner 1991).

In order to assist in identifying spawning locations, six male and six female (three of each sex for anadromous and full-term hatchery) Sockeye Salmon were fitted with gastric implant radio transmitters prior to release (Eiler 1990). Radio transmitters were purchased from Advanced Telemetry Systems (ATS) and weighed approximately 14 g each. Telemetry investigations of adult locations began September 12, 2012 and continued weekly through November 6, 2012. Fish locations were recorded weekly by tracking movements via powerboat. Approximate migration timing to spawn locations within the lake was generated by estimating the dates that 25%, 50%, and 100% of the tagged adults migrated to known spawning locations. The movements of captive and anadromous radio tagged adults were compared to spawn timing observed at the EFH for both groups.

Redd construction observations were made while radio tracking adults near spawning locations beginning on September 18, 2012 and continued until November 6, 2012. Once adult spawning activity ceased within Redfish Lake, a final redd count was conducted on November 6, 2012. On the final count date, three observers were used to quantify redds. Areas of excavation (possible redds) were generally 3 m x 3 m in size and likely represented spawning events by multiple parents. The number of parents that contributed to the production of natural progeny in spawn year 2012 was unknown. The number of redds produced per female released was estimated by dividing the total number of redds by the number of females released. This metric assumes that all released females were capable of producing a redd within the lake and that all redds produced were visible and counted during the final count. During redd count surveys; any observed carcasses that could be retrieved were collected to facilitate the collection of biological information (e.g., fish sex and spawning status). Redd counts were also conducted on Fishhook Creek, Redfish Lake Creek, the Salmon River between Sawtooth Fish Hatchery and the mouth of Redfish Lake Creek, Valley Creek, and Little Redfish Lake in 2012.

Genetic Parentage Based Tagging Method

Genetic PBT is a relatively new technique but it is based upon a widely accepted and applied technique (e.g. parentage analyses, Steele et al. 2013). The principle of this technique involves genotyping a set of parents (that were spawned in the hatchery or released into the wild for volitionally spawning), genotyping offspring (at either the juvenile or adult stage), and assigning the offspring to the parent groups (Steele et al. 2013). A tagging rate calculated as the proportion of fish with complete genotypes out of the total number spawned or released was also applied to compensate for missing parents. The genetic analyses that were completed in 2012 for the 2011 return year are reported here. Genetic analyses were used to determine the origin of fish (release strategy) and age of each returning fish, and refine VSP metrics.

In 2011, 1,099 fish were trapped at the Redfish Lake Creek or Sawtooth Fish Hatchery weirs. A tissue sample was taken from all trapped fish for genetic analyses. The fish returning in 2011 were offspring of fish that spawned (either in the hatchery or natural environment) in 2006, 2007, and 2008 and were reared and released at various life stages. All potential parents of these returns were genetically sampled in the hatchery prior to spawning or release into the natural environment (for released adults). Genomic DNA extractions were carried out using a Nexttec DNA isolation kit according to the manufacturer's instructions (http://www.nexttec.biz). Samples were genotyped with a panel of 16 microsatellite loci (see Chapter 2 and contact authors for loci and genotyping protocols). A minimum of 9 loci per individual was needed for inclusion in the parentage analyses. Tagging rates were generated for each release strategy and brood year as the number of successfully genotyped parents (greater than 9 loci) out of the total number of parents:

Tagging Rate = proportion of genotyped males * proportion of genotyped females within each release strategy

The parentage software, Cervus V. X (Kalinowski et al. 2007) was used to perform the parentage analyses using parents with known sex. Up to one mismatch was allowed and only two parentage-assignments were accepted. Additionally, cross information and release year was used to validate assignments. Based upon this analysis, the release strategies and ages of the returning adults in 2012 were generated. While parentage based tagging essentially tags 100% of the offspring, not every offspring will be assigned to two parents due to missing parents in the sample, genotyping error rates, and mutation or recording errors. Ages for the un-assigned fish were generated in multiple ways to determine the best way to apply an age to an unassigned fish for productivity metrics: 1) extrapolations based upon tagging rates, 2) with scale ages or other ageing structures, or 3) all unknown fish were given an age via an age-length key. Program R code developed by Derek Ogle (fishR Vignette-Age-Length keys to assign age from lengths) was used to assign an age to unaged (e.g. unassigned) fish using genetic age and length keys with the semirandom method (Ogle 2013). The ages and lengths of the hatchery and natural production groups (separately) were used to develop age-length keys. An age was generated for each fish with known length (and unknown age). The trapping location of the fish was used to determine which release strategy unassigned adults should be categorized for additional productivity metric development (discussed later).

By combining the trap and PBT genetic data; an adult return timing figure was generated by release strategy. The total number of adults returned (by release strategy) to both trap locations per day was divided by the total run size (by release strategy) to generate a daily proportion during the return. The daily proportions were progressively summed until the proportion equaled one (or the total run size by release strategy). Adults that were captured during the net capture event (known as the “sockeye roundup”) below the SFH weir were not included in the run timing data because these individuals were not trapped and return timing was not available. This information was used to evaluate differences between hatchery and natural production. Median return date for all adult returns in 2011 was also calculated.

Brood Year 2006 Productivity Metrics

Smolt-to-Adult Survival

With the completion of genetic analyses for the 2011 return year, we were able to finalize productivity metrics for the brood year 2006. In order to calculate SARs, both juvenile out-migration data and adult return data were needed. Here, synthesized data for both juveniles (emigrating in 2008 [Peterson et al. 2010] and 2009 [Peterson et al. 2012a]) and adults returning in 2009 (Baker et al. 2010), 2010 (Baker et al. 2011), or 2011 (Baker et al. 2012) were summarized for BY06.

Juvenile emigration methodologies were discussed in part 3 of this report. Individual brood year smolt production was summed using age-1+ and age-2+ smolt estimates emigrating from basin lakes for natural and presmolt production for Redfish, Alturas, and Pettit lakes and using age-1+ release numbers for the full-term hatchery smolt components. Juvenile emigration data used to calculate SARs for brood year 2006 is presented in Table 15. For example, BY06 natural smolt production for Redfish Lake totaled 6,338 of which 4,927 were age-1+ smolts, which emigrated in 2008 and an additional 1,411 smolts that emigrated in 2009 as age-2+ smolts.

The adults used to calculate release strategy SARs were collected at the basin trap locations (described above) from 2009-2011. Two groups of adults returned to the Sawtooth

Valley: 1) a marked or tagged group of hatchery-origin fish, and 2) an unmarked group of natural-origin fish (which can also include eyed egg releases). In order to apply an age and origin to each returning adult, both scale aging and marks were used (return year 2009) or PBT assignments were used (return year 2010, 2011). The hatchery marks applied to different release strategies for BY06 can be found in the Snake River Sockeye Salmon Captive Broodstock Program hatchery element reports (Baker et al. 2009a and 2009b). Presmolt and natural production adults (originating from Alturas and Pettit Lake) collected at the SFH weir were summed together for both lakes in the SAR estimates because the lake of origin as emigrants was unknown when collected at the weir. Adults identified as natural origin (produced from captive adult releases, wild adults, or egg-box production) had an intact adipose fin and no CWT.

SAR estimates were generated by summing together age-3 (2009), age-4 (2010), and age-5 (2011) returns from the appropriate release strategy or group and divided by the estimated out-migration number from the appropriate BY for each release strategy or group.

Recruits-per-spawner and recruits-per-female

Returning adults that have been assigned to a specific brood year and release strategy were used to generate estimates of adult recruits-per-spawner and recruits-per-female. This was done by dividing the total number of returned adults (for the BY and release strategy) by the number of spawners (or females) that produced the group. For the hatchery production groups, the numbers of spawners was generated from spawning records at the EFH and BCH. For natural production within Redfish Lake, it was assumed that all adults released spawned and that either zero or negligible residual spawning occurred. The metrics identified above include all adult spawners, both successful and unsuccessful. R/S and R/F was also calculated using genetic data for successful spawners (removing unsuccessful spawners from the metrics) resulting from prespawn adult releases within Redfish Lake.

Natural Productivity within Redfish Lake

Natural productivity within Redfish Lake was estimated with the following metrics: total egg deposition within the lake, egg-to-smolt survival, number of smolts-per-female, and the recruits-per-spawner/female (as described above). Total egg deposition into the lake was estimated using weight/fecundity relationship data collected from hatchery spawned females (N = 1,678 females spawned at EFH between 2005 and 2013; Dan Baker unpublished data). Weights were collected from adults released into the lake during maturation sorts at the hatchery facilities (approximately 2 months prior to release). These weights were entered into a weight/fecundity relationship to develop the fecundity estimates. The calculated fecundities from all released females were summed to estimate total egg deposition. This estimate also assumed that all adults released to volitionally spawn deposited eggs into the gravel and that every female was productive. Egg-to-smolt survival was estimated by dividing the estimated BY natural smolt production estimate by the total egg deposition estimate. The numbers of smolts-per-female was estimated for natural production within Redfish Lake by dividing the number of female spawners released into the lake by the number of smolts produced for that corresponding BY.

RESULTS

Trapping Of Anadromous Adult Returns

A total of 242 anadromous adults were trapped during 2012, of which 107 and 135 were trapped at the RFLC trap and SFH weirs, respectively. The anadromous return in 2012 was the sixth highest return observed since the beginning of the captive broodstock program in 1991 (Table 1). A total of 130 males and 112 females were phenotypically identified for a ratio of 1.16 males per female for adults trapped during 2012. The average fork length and weight of all trapped males was 541 mm and 1,382 g, respectively. The average fork length and weight of all trapped females was 525 mm and 1,296 g, respectively. Personnel recaptured a total of 34 PIT-tagged adults that were tagged as juveniles prior to out-migration. Scales samples and genetic samples were collected from 184 and 242 returning anadromous Sockeye Salmon, respectively.

Window counts conducted by the US ACOE estimated 470 anadromous Sockeye Salmon passed LGR on their way back to the Sawtooth Valley. Using PIT tag data (N = 64), an estimated 24.4% or 115 adults were likely counted multiple times at the window. Therefore, adjusted passage was estimated at 355 adults. Estimated conversion rates using window count data, fallback adjusted counts, and PIT-tagged adult returns was 51.49%, 68.17%, and 53.10%, respectively (Table 16). Currently, conversion rates include only adults that were trapped at Sawtooth Valley trap sites. The estimated number of adults that returned to the Sawtooth Valley but were not trapped included 15 additional adults. This included five PIT-tagged adults interrogated within Valley Creek, four adults visually observed below SFH after the weir was removed, and six adults observed in Redfish Lake Creek spawning below the weir.

Adult Spawning

In 2012, a total of 795 prespawn adult Sockeye Salmon (622 full-term captive reared and 173 anadromous returns) were released into Redfish Lake. The first redds were observed near the "transfer dock" (see Figure 13) at Redfish Lake on September 25, 2012. Redd counts were finalized with three observers in one boat on November 06, 2012. During the final counts, 306 redds (areas of excavation) were identified (Table 14). Staff observed 56 redds located near the U.S. Forest Service Transfer dock, 64 redds located on the beach southeast of the Redfish Lake Creek inlet, 160 redds within the southern snorkel transect area, 24 redds at Sockeye Beach, and two redds along the west shore approximately halfway down the lake (Figure 13). This count was lower than the 2011 count of 385 redds (Table 14); however, approximately two times more females were released in 2011 than were released in 2012 (691 and 347, respectively). However, an increase in the number of redds per female was observed in 2012 over 2011 (0.88 redds/female in 2012 compared to 0.55 redds/female in 2011).

Radio-tagged fish moved to areas where redds were observed, and carcasses were recovered (when possible) to verify spawning. The migration timing to spawning locations of 25%, 50%, and 100% of tagged adults was estimated to be September 20, September 25, and October 2, 2012, respectively. Visual observations of captive and anadromous adults spawning within the lake matched those identified as peak dates at EFH of October 25 for anadromous adults and October 11 for captive adults. Radio telemetry data also assisted with collecting information on additional spawning locations during 2012. An adult implanted with a radio tag was observed within Fishhook Creek and an additional four Sockeye Salmon redds were counted in 2012. While conducting redd surveys, a total of 10 Sockeye Salmon redds were observed between Redfish Lake and the confluence of Redfish Lake creek and the Salmon River. No observations of redds being produced were made in Valley Creek from the mouth of the Salmon River to the confluence of Stanley Lake Creek during 2012; however, a spawned out carcass was retrieved indicating that spawning activity likely occurred.

Genetic Parentage Based Tagging

In 2012, parentage analysis of the 2011 return was completed. In total, 986 of the 1,099 (89.7) adults could be successfully assigned to two parents with 0 or 1 mismatch. Overall, 93% of the marked group could be assigned to two parents and 66% of the unmarked group could be assigned to two parents. In some cases, marks and tags were available so even if the fish could not be assigned to two parents, its origin was known. Using both mark information and assignment data, the composition of the 2011 returning adults was: 8% presmolts, 49% Sawtooth Fish Hatchery smolt releases, 30% Oxbow Fish Hatchery smolt releases, 7% offspring of adult releases, 2% from egg-box releases, and 5% unassigned to a group (Table 17). Using PBT analyses, ages were generated for 986 of the assigned adults: 70 age-3, 799 age-4, and 117 as age-5.

As described in the methods, the ages for the unassigned fish can be generated in three ways: 1) extrapolations based upon tagging rates, 2) with scale ages or other ageing structures, or 3) all unknown fish were given an age using age-length data. The use of these different methods for assigning ages to unassigned fish was investigated. In the first method, the tagging rates were used to expand assignments. Tagging rates for all release strategies was higher (greater than 89%) and led to the assignment of an additional 26 fish; however, there were still a number of fish that were not assigned an age or release strategy (N = 88). In this case, the tagging rates were able to account for 96% of the marked fish but only 68% of the unmarked fish. The second method involved comparisons between scale (total) ages and genetic ages to see if scale ages could be used for unassigned fish. In 2011, 197 scales were collected for aging. The overall concordance between PBT assignment and scale aging methods was 68% with an error rate of 32% (N = 63 adults) and a coefficient of variation (CV) of 5.8%. The overall comparison between scale and genetic ages can be seen in Figure 14. The age determined from scales was lower than the genetic age in 50 of the adults (25% error rate) and higher than the true age in 13 of the adults (7% error rate). Scale aging appears to underestimate the number of age-5 adult returns and over-estimate age-3 and age-4 adults. However, the overall age proportion of the total run did not change with the different aging methods.

The proportions based on scale aging analysis for adults returning in 2011 (only those comparable to PBT analyzed adults) were 8.6% age-3 (N = 17; 95% CIs range from 5.5% to 13.4%), 77.2% age-4 (N = 152; 95% CIs range from 70.8% to 82.5%), and 14.2% age-5 (N = 28; 95% CIs range from 10.0% to 19.8%; Table 18). The proportions based on PBT analysis (only those comparable to scale analyzed adults) were 5.1% age-3 (N = 10; 95% CIs range from 2.8% to 9.1%), 63.5% age-4 (N = 125; 95% CIs range from 56.5% to 69.9%), and 31.5% age-5 (N = 62; 95% CIs range from 25.4% to 38.5%; Table 18). The final method used the age-length keys, which was able to provide an age for each returning adult. Each of these methods has different pros and cons that are discussed in greater detail in the discussion.

Adult return timing in 2011 varied between release strategies. The median return date to Sawtooth Valley trap locations for naturally produced adults was August 19, 2011. Presmolt and Sawtooth smolt production had similar return timing with a median return date of August 25, 2011. Oxbow smolts median return date was August 24, 2011. The overall median trap date for all adult returns was August 24, 2011. The cumulative return timing for all anadromous adult returns in 2011 (by group) was presented in Figure 15.

Productivity Estimates Per Release Strategy (BY06)

A total of 200,024 smolts were estimated as emigrants resulting from production generated from spawned adults during the fall of 2006 (Table 19). SARs ranged from 0.33% for natural-origin production from Alturas and Pettit Lakes to 3.19% for natural-origin production from Redfish Lake (Table 19). Sawtooth-reared and Oxbow-reared full-term smolts had intermediate SARs of 0.57% and 0.89%, respectively. The average SAR for all production emigrating from the Sawtooth Valley as a result of production from BY06 adults was 0.72%. An estimated range of 0.13 to 5.19 recruits were produced per spawner during BY06 (Table 20). The OFH production group returned the highest number of recruits-per-spawner and natural production resulting from the combined emigration from Alturas and Pettit Lake produced the least number of recruits-per-spawner. SFH smolts produced the second highest R/S (1.60) followed by natural production from Redfish and the presmolt release strategy. The average R/S for the program for BY06 was 1.18 (1,449 recruits and 1,233 spawners; Table 20). The number of recruits-per-female ranged from 0.22 to 10.79 for the Alturas and Pettit lake presmolts and Oxbow reared full-term smolts, respectively. The average R/F for all release groups combined was estimated at 2.17 (1,449 recruits and 669 females; Table 20).

Natural Productivity within Redfish Lake

In 2006, a total of 247 females and 218 males were released in the fall (unpublished program data) to spawn naturally within Redfish Lake. The estimated egg deposition within the lake was 517,621 eggs (Table 21). The total estimated BY natural smolt production was 6,338 out-migrants (4,927 age-1+ and 1,411 age-2+ smolts), which resulted in a smolts-per-female metric of 26 smolts. Based on the number of smolts leaving the lake, egg-to-smolt survival was estimated at 1.22% for BY06 (Table 21). Genetic assignment data was also able to provide information regarding the reproductive success of captive released fish. Of the 247 females released, 56 (23%) produced at least one returning adult. Of the 218 males released, 70 (32%) produced at least one returning adult. Of the successful fish, the average number of recruits-per-spawner was 2.07 fish (or 3.61 R/F) and ranged from 1 to 8 returning adults. While not every fish spawned successfully, the fish that did spawn successfully were able to meet replacement levels.

DISCUSSION

2012 Anadromous Return

In 2012, 242 adults were trapped and 59 were used for broodstock purposes (30 females and 29 males; Dan Baker personal communication). While the number of trapped adults was a decline from numbers observed from 2008-2011, the 2012 return still represents the 6th highest return since the initiation of the program (Table 1). The incorporation of anadromous adults continues to be an important part of our program as these adults have been exposed to natural selective processes.

Not only were we able to get a census of the number of adults that returned to the Sawtooth Valley, but using PIT tag data, estimates of the numbers of adults passing Lower Granite Dam and the overall survival rate (e.g. conversion rate) between LGR and the Sawtooth Valley were developed. Window counts conducted at LGR provide an estimate of adults that migrate above the dam; however, using PIT tag data, observations have been made that some fish fallback and re-ascend as many as nine times (unpublished program data, M. Peterson), which likely inflates the number of adults observed in window counts. Furthermore, fish that fallback multiple times may be associated with migration delays or less likely to return to their natal locations than those that do not (Boggs et al. 2004). Therefore, fallback percentages were estimated and used to adjust window counts to develop conversion rates. In 2012, the fallback percentage was estimated at 24% percent and applied to the total window count. Overall, adjusting the window counts with fallback percentage data led to a higher conversion rate (by 15-16%) than by just using window counts or PIT tag data. The fallback percentage estimate was significantly higher than the estimate derived from window count data (not the PIT tag estimate) and could potentially lead to different interpretations regarding survival and the effects of dam operations so identifying the most accurate estimate of conversion remains an important program priority. Additional investigations should be conducted to determine whether COE window count data needs to be adjusted or if the counts represent a true estimate of adults passing LGR. During 2013, an investigation using a PBT mark–recapture analysis will be conducted to estimate conversion rates of adults trapped at LGR back to the Sawtooth Valley. This will be an independent measure of conversion rate that can be used to validate the estimates based upon PIT tags. Currently, conversion estimates do not include adults observed within the Sawtooth Valley that were not trapped; however, inclusion of these adults results in minimum increases to conversion rates (ranging from 3.2-7.8%; depending on the method used). Monitoring of untrapped adults will continue to be important to quantify straying from trap location and pioneering of adults into additional habitats within the Sawtooth Valley. This estimate also does not include nighttime passage through LGR.

Fallback percentage for Sockeye Salmon appears to be higher than levels observed for Spring/Summer Chinook Salmon (24.4% for Sockeye Salmon vs. 8.75% for Spring/Summer Chinook Salmon; Cassinelli et al. 2013). Additionally, Boggs et al. 2004 reported mean fall Chinook Salmon fallback percentage as 23.2%, steelhead as 4.1%, and spring-summer Chinook Salmon as 3.4% at LGR from 1997–2001. Clearly, there are behavioral and migratory differences between species, which lead to differences in fallback rates. Currently, the total escapement at LGR is calculated differently for different programs and agencies. Cassinelli et al. (2013) used PIT tags to adjust window counts for fallback and re-ascension as well as after-hours passage and found that the combined effect of these overestimates (fallback/reascension) and underestimates (after-hours passage) resulted in a net 3.3% overestimate based on window counts. The LSRCP hatchery Chinook Salmon program also uses straight PIT tag data to calculate conversion rates back to trap locations from LGR; however, sport harvest adds additional uncertainty to these estimates (Chris Sullivan, personal communication). In addition, the IDFG wild adult Steelhead and Chinook Salmon program uses unadjusted window counts or video count data and LGR trap sampling rates to estimate escapement weekly at LGR (Schrader et al. 2013) but do not directly measure conversion or survival to terminal areas. Identifying the correct methodology to use for Sockeye Salmon will be important for calculating life-stage specific survival measurement.

Natural Spawning

The numbers of adults released into Redfish Lake (both anadromous and captive releases) have increased corresponding with the increase of anadromous adult returns beginning in 2008. However, the number of adults released (N = 795) in Redfish Lake during 2012 represented a 33% decrease from the five-year average as a result of the smaller anadromous return. Using radio telemetry, migration timing to spawning locations and additional spawning locations were similar to past years'. We were also able to identify that redd construction timing was similar to observations made in previous years (Plaster et al. 2007; Peterson et al. 2008, 2010, 2012a). The distribution of redds within the lake was similar to past years where the majority of redds counted occur in the south end of the lake near the southern snorkel transect (Figure 13; Peterson et al. 2008, 2010, 2012a). While the number of females released declined between 2012 and 2011 (Table 14), the number of redds per female increased. Final redd counts were conducted in one day at the end of the season. There may be a variety of factors that affect our ability to accurately count redds during the final count and may include water clarity, viewing conditions (weather related issues such as storms vs. sunny), and adult densities released into the lake. The number of residual adults present on the spawning grounds may also skew our estimates because residual production was not estimated within Redfish Lake. The Shoshone-Bannock Tribe conducts night snorkeling surveys to monitor trends within the residual population but we have not attempted to use these data to differentiate between program spawning adults and residual redd production. Another factor was that some Sockeye Salmon redds averaged approximately 2 m^2 and may have represented multiple parents. Burgner (1991) suggests that mass spawning events within lakes may lead to multiple nests, or egg pockets, per female. Therefore, the number of redds and females per redd may be difficult to quantify.

Parentage Based Tagging – 2011 Return

PBT analysis has provided greater resolution in assigning ages and origin to returning adults, which can be beneficial for understanding the success of the different release strategies. Prior to using PBT analyses, the effectiveness of the adult release and egg-box strategies could not be quantified. The PBT analysis was able to assign fish to each of these release strategies and compare the return rates among these release strategies. PBT analysis also enabled the program to accurately estimate survival and productivity rates for each strategy as described below for the BY06 group.

Overall, the PBT analysis was able to generate ages for 89.7% of the 2011 return and provide information regarding the most successful release strategy, which was the Sawtooth Hatchery smolt release group followed by the Oxbow Hatchery smolt release group. Additionally, adult return age structure resulting from each release strategy was generated. Smolt production resulting from OFH was identified to have a higher proportion of age-3 adult returns compared to egg-box, presmolt, and natural production. The latter release strategies typically have a higher proportion of age-5 adult returns. Overall, in 2011, 79.3% of the adults that returned were age-4. The age-structure proportions observed for egg-boxes, presmolts, SFH smolt production, and natural production within Redfish Lake appear to be similar to data presented in Bjornn et al. (1968). Our results differed from the age structure observed overall at Bonneville Dam (representing upper Columbia and Snake river stocks) during 2011 return. Differences in overall proportions of age-3, age-4, and age-5 returns were observed, indicating that Snake River Sockeye Salmon may have a different age structure than that observed within the upper Columbia stocks (Williams et al. 2014).

In order to apply an age for all returning fish for productivity metrics, additional analyses were performed to generate ages for the un-assigned fish. Generating accurate ages for adult returns was important to assigning fish back to a specific BY for SAR estimation. PBT assignments produce the accurate ages needed to estimate SARs for the release strategies but cannot account for all fish. While the tagging rate method can assign some of the un-assigned fish to ages, it led to a sizeable percentage of unmarked fish with unknown ages. The results of the genetic and scale comparison indicated that 32% of the scale ages were incorrect. In general (using scales), younger adult returns (age-3) were overestimated and older aged adult returns (age-5) were underestimated. Similar patterns were observed in a steelhead study that validated the use of scale ages using PBT analysis (Seamons et al. 2009); however, the degree of error was lower. Overall, the age key was able to provide an age for each returning adult based upon a distribution of PBT ages and lengths and appears to be the best method available. The age key relies on having good age-length data and if data gaps exist in the known distribution, a fish was assigned to the age associated with the closest length. Since we have a relatively small number of unmarked fish returning, the distribution of known ages and lengths has gaps that may lead to some biases. As the program increases in size, we hope to improve our sample sizes for this analysis. Errors associated with aging can lead to differences in productivity metrics and potentially lead to inflations of weak cohorts or decreases of strong cohorts (Campana 2001; Copeland et al. 2007); therefore it is important to attain accurate ages.

Brood Year 2006 Productivity Metrics

Smolt-to-adult return rates suggest that volitional spawning within Redfish Lake appears to be an important release strategy to the success of the Snake River Sockeye Salmon Captive Broodstock Program. Natural production (primarily resulting from adult releases) occurring within Redfish Lake had the highest overall survival rates from the smolt-to-adult life stage for BY06. The use of full-term hatchery smolt production (both the OFH and SFH) follows natural production as the second best release strategy. Others have observed a similar survival pattern at the same life stage among natural and hatchery Chinook Salmon within the Snake River Basin (Buchanan et al. 2010; Cleary and Edwards 2011). In terms of smolt-to-adult return rates, egg-box and presmolt production do not appear to be very successful release strategies for producing anadromous adult returns. Based in part on this information, both egg-boxes and presmolt releases have been discontinued from the program and future releases will focus on full-term hatchery smolt and adult releases.

Full-term smolt production was observed to produce the highest number of R/S among the “spread-the-risk” release strategies for BY06. We see a 9-fold advantage using full-term hatchery smolt production over natural production within Redfish Lake. Our R/S results were similar to those observed by others investigating differences between hatchery and natural Chinook Salmon production. The Lostine River, Oregon Chinook Salmon supplementation program reported differences in recruits-per-spawner ratios of 8-16 times higher for hatchery production compared to natural Chinook Salmon (Cleary and Edwards 2011). Rabe and Nelson (2009) also observed R/S ratios approximately 8 times higher in Chinook Salmon hatchery production over natural production for BY 2003 data in the Johnson Creek, Idaho supplementation program. When our R/S data from BY06 was compared (ranging from 0.13-5.19) to data from a couple of Bristol Bay natural Sockeye Salmon populations, the estimates fall within ranges observed from 1952-1999. The Kvichak stock, averaged 2.2 R/S, followed by the Togiak (3.0 R/S) and Egegik (5.1 R/S), during that period (Ruggerone and Link 2006).

Natural productivity metrics provide the captive broodstock program with additional information to monitor the success of volitional spawning within the natural environment. Metrics were generated to compare levels of natural production produced currently (BY06) with that observed from 1954-1963 (Bjornn et al. 1968). The estimates of egg deposition were slightly lower than those provided by Bjornn et al. (1968). These differences could be attributed to fecundity differences between captive reared and anadromous adult returns. Captive reared fish released to spawn in 2006 averaged 2,096 eggs-per-female, whereas fecundity presented in Bjornn et al. (1968) was estimated at 2,900 eggs-per-female. The estimate of egg deposition based from the weight/fecundity data likely provides a reliable estimate and was derived using 1,678 females spawned within the captive broodstock. If the data produced for 1960-1962 from the Bjornn et al. (1968) data set were removed, because he speculated the erroneous values produced were a result of kokanee releases into Redfish Lake or residual production, our current estimates are lower for egg-to-smolt survival and for the number of smolts-per-female emigrating from BY06. However, when comparing the data estimated from 2004-2006 (for methods and results for 2004 and 2005, see Appendix C and D, respectively; Table 21) the estimates of egg-to-smolt survival and smolts-per-female were not statistically different. In years when fewer females were released, higher production of smolts-per-female was observed, which may indicate some residual production occurring within the lake. These natural productivity data suggest that the habitat within the lake produced Sockeye Salmon at a similar rate to that observed in the 1950s and 1960s. When comparing these metrics to more recent Sockeye Salmon productivity estimates, we see that the BY04-06 data falls within ranges observed for stocks in Bristol Bay, Alaska (Kvichak watershed; Ruggerone and Link 2006) and the Fraser River, BC (Chilko and Cultus watersheds; Peterman and Dorner 2011); however, the estimates were on the lower end of the observed range. This may be due to the extreme population bottleneck the Snake River Sockeye Salmon stock has endured and/or that the population exists on the extreme southern portion of the species range. The development of these data will serve as baseline information to monitor potential changes in productivity as the program continues to re-establish this at-risk population within the natural environment.

Learned differences observed between SARs and R/S metrics highlighted important information to the program. Understanding that juvenile Snake River Sockeye Salmon produced from natural spawning events have been observed to survive better to the adult life stage (higher SARs) and utilizing full-term smolt production to provide the largest component of our anadromous adult returns (R/S benefits) has increased the overall abundance of anadromous adults. This has also provided increased population stability and security within the ESU. Monitoring these VSP metrics should continue and should be investigated further.

Table 13. Trap operation dates at Sawtooth Valley collection sites for anadromous Snake River Sockeye Salmon returns since 2007.

Adult Return Year	**Sawtooth Fish Hatchery Weir**	**Redfish Lake Creek Trap**
	Dates of Operation	
2007	June 3 - September 15	July 7 - October 30
2008	June 3 - September 18	July 3 - October 21
2009	June 3 - September 20	July 3 - October 21
2010	June 3 - September 20	July 10 - October 12
2011	July 10 - September 9	July 22 - October 14
2012	June 21 - September 14	July 12 - October 17

Table 14. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history.

Lake	Rearing Origin	Date Released	Number Released	Number of Suspected Redds
Redfish	Full-term hatchery	1993	24	Unknown
Redfish	Full-term hatchery	1994	63	One behavioral observation
Redfish	Full-term hatchery	1996	120	30 suspected redds
Redfish	Full-term hatchery	1997	80	30 suspected redds
Pettit	Full-term hatchery	1997	20	1 suspected redd
Alturas	Full-term hatchery	1997	20	Test digs only
Redfish	Full-term hatchery	1999	18	
Redfish	Hatchery-produced anadromous	1999	3	8 suspected redds
Redfish	Full-term hatchery	2000	46	
Redfish	Hatchery-produced anadromous	2000	120	20 to 30 suspected redds
Pettit	Hatchery-produced anadromous	2000	28	none confirmed
Alturas	Full-term hatchery	2000	25	
Alturas	Hatchery-produced anadromous	2000	52	14 to 19 suspected redds
Redfish	Full-term hatchery	2001	65	12 to 15 suspected redds
Redfish	Hatchery-produced anadromous	2001	14	
Redfish	Full-term hatchery	2002	177	10 to 12 suspected redds
Redfish	Hatchery-produced anadromous	2002	12	
Redfish	Full-term hatchery	2003	309	42 suspected redds
Redfish	Full-term hatchery	2004	244	127 suspected redds
Redfish	Full-term hatchery	2005	176	78 suspected redds
Redfish	Full-term hatchery	2006	465	172 suspected redds
Redfish	Full-term hatchery	2007	498	195 suspected redds
Redfish	Full-term hatchery	2008	396	
Redfish	Hatchery-produced anadromous	2008	570	338 suspected redds
Redfish	Full-term hatchery	2009	680	
	Hatchery-produced anadromous	2009	651	201 suspected redds
Redfish	Full-term hatchery	2010	367	155 suspected redds + 39
	Hatchery-produced anadromous	2010	1,209	additional redds within tribs.
Redfish	Full-term hatchery	2011	558	385 suspected redds +
	Hatchery-produced anadromous	2011	990	31 additional redds within Stanley Basin tributaries
Redfish	Full-term hatchery	2012	622	306 suspected redds +
	Hatchery-produced anadromous	2012	173	14 additional redds within Stanley Basin tributaries
		TOTAL	**8,795**	

Table 15. Juvenile emigrations data collected in 2008 and 2009 used to calculate smolt-to-adult return rates for BY 2006.

Release Strategy	Age 1+ smolt (2008)	Age 2+ smolt (2009)	Total
Total smolts produced in BY 2006	196,181	3,843	200,024
Natural Origin (Redfish)	4,927	1,411	6,338
Presmolts (Redfish)	16,012	845	16,857
Sawtooth Smolts	73,808		73,808
Oxbow smolts	76,587		76,587
Natural Origin (Pettit and Alturas)	14,075	882	14,957
Presmolts (Pettit and Alturas)	10,772	705	11,477

Table 16. Adult Snake River Sockeye Salmon counted at Lower Granite Dam from 1991 to 2012, fallback percentage (DART queried data), adjusted count at Lower Granite Dam, and conversion rates from Lower Granite Dam to the Sawtooth Valley using window counts, adjusted counts, and PIT-tagged returns. Prior to 2008, few numbers of fish were PIT-tagged, few numbers of tagged fish returned, and fallback rates could not be calculated.

Year	Adult Sockeye Salmon @ LGR	# of PIT tags at LGR	# of fallback PIT tags at LGR	% Fallback (based off PIT tag data)	Adjusted passage @ LGR	# of adults trapped in	# of PIT tags trapped Valley	Conversion Rate (Window Count)	Conversion rate (fallback adjusted)	Conversion rate (PIT tag)
1991	8	NA	NA	NA	8	4	NA	50.00%	NA	NA
1992	15	NA	NA	NA	15	1	NA	6.67%	NA	NA
1993	12	NA	NA	NA	12	8	NA	66.67%	NA	NA
1994	5	NA	NA	NA	5	1	NA	20.00%	NA	NA
1995	3	NA	NA	NA	3	0	NA	0.00%	NA	NA
1996	3	1	NA	NA	3	1	NA	33.33%	NA	NA
1997	11	NA	NA	NA	11	0	NA	0.00%	NA	NA
1998	2	NA	NA	NA	2	1	NA	50.00%	NA	NA
1999	14	NA	NA	NA	14	7	NA	50.00%	NA	NA
2000	299	4	NA	NA	299	243	3	81.27%	NA	75.00%
2001	36	1	NA	NA	36	23	1	63.89%	NA	100.00%
2002	55	1	NA	NA	55	15	0	27.27%	NA	NA
2003	11	1	NA	NA	11	2	0	18.18%	NA	NA
2004	113	2	0	0.00%	113	24	0	21.24%	21.24%	NA
2005	18	NA	NA	NA	18	6	0	33.33%	NA	NA
2006	17	1	0	0.00%	17	3	0	17.65%	17.65%	NA
2007	52	1	0	0.00%	52	4	0	7.69%	7.69%	NA
2008	909	10	1	9.10%	826	599	3	65.90%	72.52%	30.00%
2009	1,219	17	1	5.60%	1,151	817	11	67.02%	70.98%	64.70%
2010	2,201	31	4	11.80%	1,941	1,322	19	60.06%	68.10%	61.30%
2011	1,502	332	47	13.40%	1,301	1,100	231	73.24%	84.50%	69.60%
2012	470	64	14	24.40%	355	242	34	51.49%	68.17%	53.10%

Table 17. Age Structure by release strategy for all genetically assigned anadromous adult returns in 2011.

Group	Smolt Release (Oxbow)	Smolt Release (SFH)	Adult Release	Presmolt Release	Egg-box Release	All
Age 3	63	3	0	4	0	70
Age 4	246	467	19	60	7	799
Age 5	0	33	54	17	13	117

Table 18. Ages generated for 2011 anadromous adults for comparisons using scale and PBT data.

Age	Scale age	Genetic age
3	17	10
4	152	125
5	28	62
Total	197	197

Table 19. Basin-to-basin estimates of smolt-to-adult return survival rates BY 2006. These estimates should be considered minimum estimates of survival for the different production strategies identified and do not include fish observed within the Sawtooth Valley that were not trapped.

Release Strategies and Brood Year		Adult returns by year and age			SAR
BY 2006	**smolts**	**2009 (age 3)**	**2010 (age 4)**	**2011 (age 5)**	
Estimated total smolt emigration for SY 2006	200,024	97	1,198	154	0.72%
Redfish Lake presmolt releases	16,857	0	44	13	0.34%
Alturas and Pettit presmolt releases (combined)	11,477	1	35	4	0.35%
Sawtooth-reared full-term smolts	73,808	5	382	34	0.57%
ODFW-reared full-term smolts	76,587	90	589	1	0.89%
Natural origin production from Redfish Lake	6,338	1	124	77	3.19%
Natural origin production from Alturas and Pettit lake	14,957	0	24	25	0.33%

Table 20. Adult productivity estimates of recruits-per-spawner and recruits-per-female for BY 2006. These estimates should be considered minimum estimates and do not include fish observed within the Sawtooth Valley that were not trapped.

Release Strategies					
BY 2006	**Recruits**	**Spawners**	**Females**	**R/S**	**R/F**
Estimated total adult recruits	1,449	1,322	669	1.10	2.17
Redfish Lake presmolt releases	57	263	178	0.22	0.32
Alturas and Pettit presmolt releases (combined)	40	263	178	0.15	0.22
Sawtooth-reared full-term smolts	421	263	178	1.60	2.37
ODFW-reared full-term smolts	680	131	63	5.19	10.79
Natural origin production from Redfish Lake	202	465	247	0.43	0.82
Natural origin production from Alturas and Pettit lake	49	375	181	0.13	0.27

Table 21. Estimates of natural productivity within Redfish Lake from BY 2004 through BY 2006 are presented below. These data consist of captively reared adults that were released to volitionally spawn within Redfish Lake during the BY identified.

BY	Female Spawners	Estimated Egg Deposition	Total Smolts	Egg-to-Smolt Survival	Smolts/Female
2004	135	260,262	5,609	2.16%	42
2005	50	101,680	6,088	5.99%	122
2006	247	517,621	6,338	1.22%	26

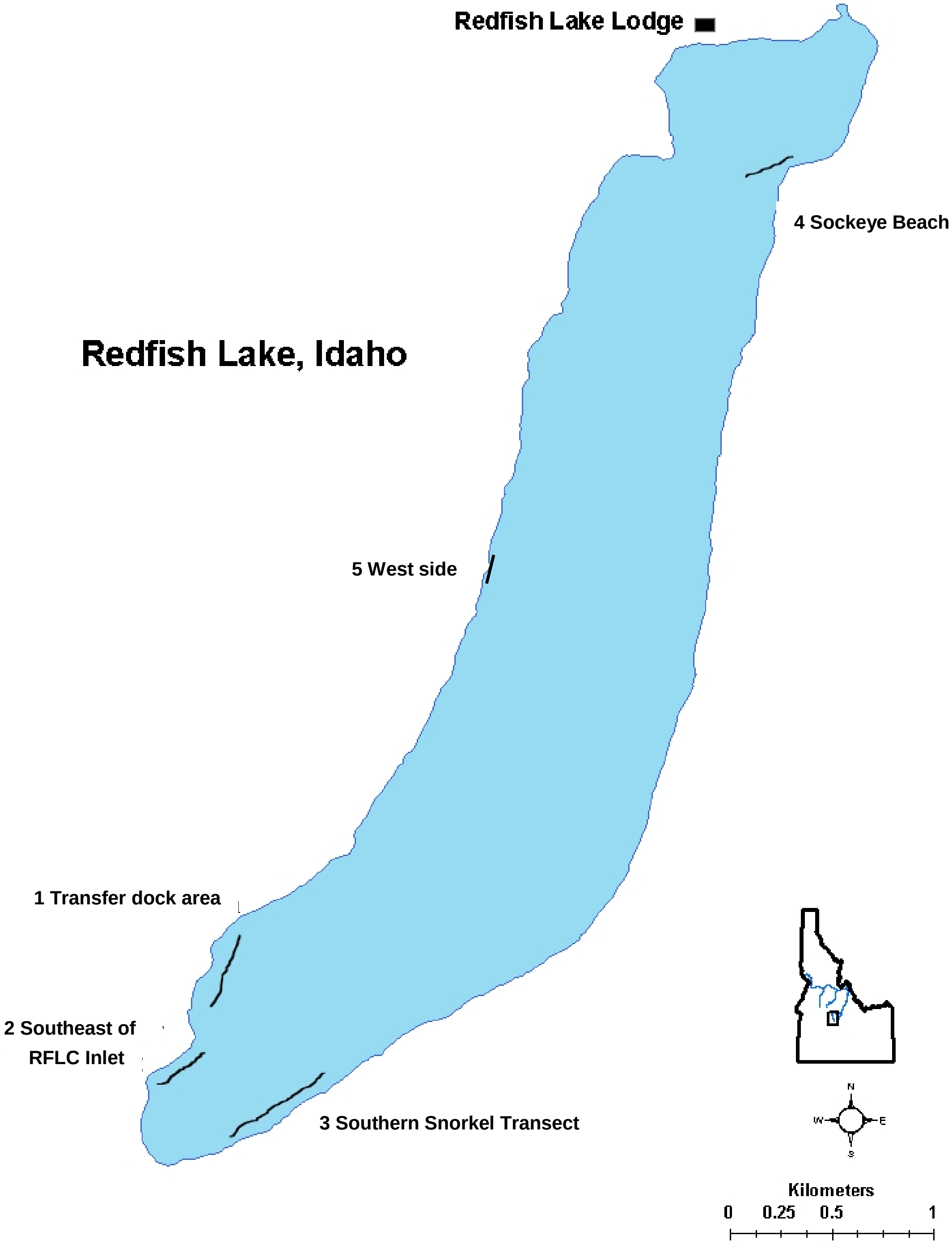


Figure 13. Spawning locations for Sockeye Salmon in Redfish Lake: 1) area near the U.S. Forest Service transfer camp dock, 2), area southeast of RFLC inlet, 3) southern snorkel transect area, 4) Sockeye Beach, and 5) west shoreline.

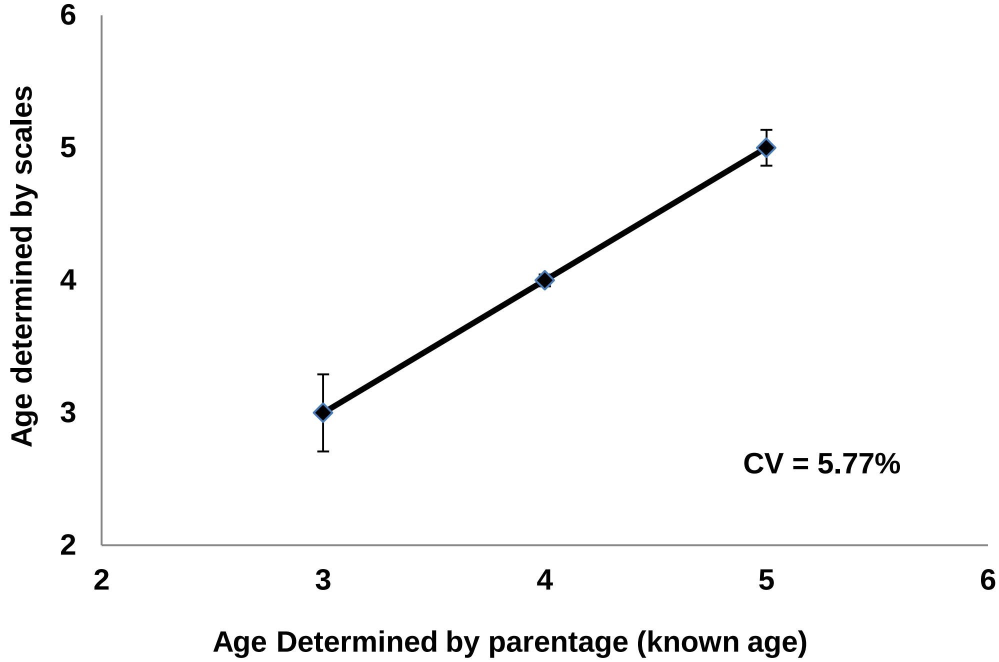


Figure 14. Calculated CV for the comparison of aging methods (scale vs genetic) for adults returning in 2011. The error bars represent 95% CIs (1.96 * SE) and illustrate the difficulties observed with aging age-3 (over-aged) and age-5 (under-aged) adults using scales.

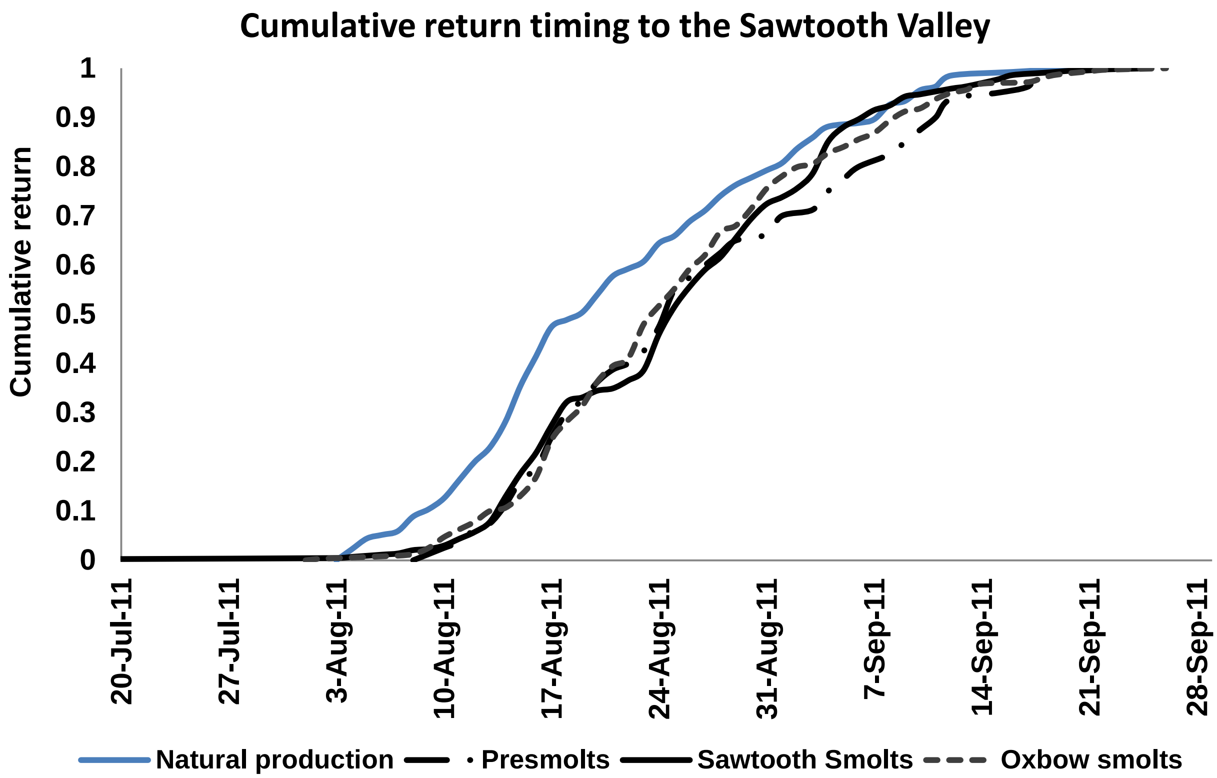


Figure 15. The cumulative return timing for 2011 adults (trapped) to the Sawtooth Valley (both trap locations) is illustrated in the figure above. Adults collected during the "Sockeye round-up" were not included in this figure.

PART 5—PREDATOR SURVEYS

INTRODUCTION

Declines in Bull Trout populations throughout the Pacific Northwest led to their listing as threatened under the Endangered Species Act in 1998. Prior to listing, IDFG implemented no-harvest fishing regulations to help protect the remaining populations in the State of Idaho. Because Bull Trout readily consume kokanee and other salmonids (Bjornn 1961; Beauchamp and Van Tassell 2001), a large increase in the number of adult Bull Trout in the Sawtooth Valley lakes could affect the recovery of Sockeye Salmon and kokanee populations in the lakes. Bull Trout spawner investigations were initiated in 1995 to monitor Redfish and Alturas lakes' Bull Trout populations. Index sections were established on Fishhook and Alpine creeks (tributaries to Redfish Lake and Alturas Lake, respectively) in 1998. Information collected in 2012 represented the 15-year data were collected in these index reaches.

METHODS

In 2012, a survey of the index reaches of Fishhook Creek and Alpine Creek were conducted on August 26 and September 12, 2012 to enumerate Bull Trout spawners and redds (Figure 16 and 17, respectively). These dates typically correspond with the initiation of spawning (first survey) and the completion of spawning activities and redd construction (second survey). No suitable tributary streams feed Pettit Lake and, as such, Bull Trout spawner surveys were not conducted on this system. Index sections were established with global positioning satellite (GPS) equipment. Two observers walked from the lower boundary of the index section upstream and recorded visual observations of Bull Trout and known or suspected Bull Trout redds. Coordinates of redd locations were recorded with a handheld GPS unit. In order to avoid omission of completed redds during the final count, completed redds identified during the first count were flagged. Flagging prevents omitting redds from the final count that were obscured over time.

In 2007, an additional area was surveyed for Bull Trout redds in Fishhook Creek (identified as Fishhook Creek lower site). The new section includes the lower portion of Fishhook Creek upstream of the first gradient gain above Redfish Lake and ends at the wilderness boundary located between GPS waypoints 44° 08.889N 114.55.660W, and 44°08.639N 114°57.384W (Figure 16).

<u>Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek</u>

As mentioned previously in this report (Part 3, page 31), during the out-migration season of 2012, trap efficiency at the juvenile out-migrant Sockeye Salmon trap on Redfish Lake Creek dropped from a twelve-year season average of 35% to 25%. The marked decrease in trap efficiency was attributed to avian, mammalian, and fish predation observed by trap tenders. Fish predation was attributed primarily to Bull Trout keying in on the release of marked Sockeye Salmon used to measure the trap efficiency. In an attempt to develop accurate juvenile Sockeye Salmon out-migration estimates with reliable trap efficiencies, IDFG attempted to capture Bull Trout at Redfish Lake Creek trap using angling methods. Each captured Bull Trout was scanned prior to tagging for juvenile Sockeye Salmon PIT tags. If smolt tags were identified, they were recorded and the Bull Trout received a PIT tag (cheek implants) and were transported four miles downstream from the confluence of Redfish Lake Creek and the Salmon River and released.

The adult Sockeye Salmon weir on Redfish Lake Creek captures all upstream migrating Sockeye Salmon and Bull Trout. Trapping in Redfish Lake Creek for adult migrants started on July 12 and continued until October 17, 2012.

RESULTS

Fishhook Creek

In the upper trend section of Fishhook Creek, observations of 9 adult Bull Trout and 7 redds were made on August 26, 2012. During our second survey on September 12, observations of 17 adult Bull Trout and 14 new redds (Figure 18) were made for a total of 21 completed redds and 26 adult Bull Trout counted. Observations of 3 adult Bull Trout and 3 redds on August 26, 2012 were made in the lower trend count area on Fishhook Creek. During our second survey on September 18, staff observed 6 adult Bull Trout and an additional 8 completed redds for a total of 11 redds, and 9 adult Bull Trout counted (Figure 19).

Alpine Creek

Staff observed no adult Bull Trout and no completed redds on either our August 27, 2012 or September 12, 2012 surveys (Figure 20). No blockage to upstream migration was observed before the count in 2012. This was the fifth year in a row we observed no Bull Trout utilizing the original trend area. Therefore, in addition to the original trend area, a second index site was established below the original area (starting point 43’53.792N 114’54.342W and ending at 43’53.824N 114’54.792W). On August 27, 2012 one adult Bull Trout was observed, and one redd was counted. On September 13, 2012 three adult Bull Trout were observed and 3 additional redds were counted for a total of four adults observed and four redds counted.

Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek

During spring juvenile trapping, staff captured five adult Bull Trout at the Redfish Lake Creek trap using hook and line that were PIT tagged and transported to the release location on the main Salmon River. No juvenile Sockeye Salmon smolt PIT tags were detected in the stomachs of the captured Bull Trout (Table 22).

During the operation of the adult Sockeye Salmon weir on Redfish Lake Creek in 2012, 83 adult Bull Trout were handled. A portion of the Bull Trout that were captured and passed received PIT tags (n = 49; Figure 21). One Bull Trout mortality was collected on the upstream side of the weir and attributed to either angling or post spawn events. Two adult Bull Trout were recaptures from previous years trapping events (2010, 2011 adult trap recaptures).

DISCUSSION

During the 15 years of data collection, fluctuating population trends have been observed in the data. The cyclic appearance in the data suggests normal variation within this population. Copeland and Meyer (2011) identified similar patterns within multiple salmonid populations in Idaho during the same period. Redd counts in Fishhook Creek had been stable or slightly increasing since 1998. Our findings were consistent with results from statewide monitoring efforts, which indicate that Bull Trout were increasing or at least stable across most of their range in Idaho (High et al. 2005). Because Bull Trout may spawn in alternating or consecutive years (Fraley and Shepard 1989), year-to-year variation would be expected.

The Alpine Creek population had increased steadily between 1998 and 2001, followed by a stabilizing period between 2002 and 2007 based on redd counts and fish observation data. Currently, no evidence exists to suggest that the population collapsed (staff observed adults spawning below the original trend area). It was suspected that upstream passage was halting the use of the original trend site spawning habitat within Alpine Creek. By establishing the second trend area below the original trend site, additional information about the population can be collected to identify whether population changes occur. Documentation of significant population changes have been identified from redd count data (Rieman and Meyers 1997).

Counts of redds in the trend sections were assumed to be an accurate reflection of the numbers of redds present. The streams in our surveys were much smaller than those used by Dunham et al. (2001), which indicated that redds could be missed in larger systems. For example, in the systems studied by Dunham et al. (2001), deepwater cover was defined as water greater than 1 m deep. In Fishhook and Alpine creeks, water depth rarely approached 1 m deep.

Work done by Schoby (2006) suggests that Bull Trout in the upper Salmon River migrate from spawning tributaries in early October and that some individuals migrate to Redfish Lake to overwinter. Since 2008, our adult Sockeye Salmon weir has been operated until mid- to late October, enabling us to collect data on Bull Trout moving into Redfish Lake to overwinter. The collection of these data should provide us with additional information on how Bull Trout populations fluctuate in the upper Salmon River drainage and whether predation issues within Redfish Lake may arise that are not detected by using redd data alone. If increasing numbers of Bull Trout are migrating into the system to overwinter, predation on *O. nerka* may increase resulting in decreased egg-to-smolt survival and lower migration success (due to increased presence in the spring at the juvenile trap). With the increase in adult Sockeye Salmon returns during 2008-2011, natural productivity monitoring has been established, which may also provide some information regarding trends related to change in predation within the lake.

Table 22. Bull Trout relocation effort juvenile out-migrant trapping at Redfish Lake Creek, 2012.

Year	Bull Trout Captured, PIT Tagged, Relocated	Bull Trout Recaptured At Trap Site	Bull Trout With *O. Nerka* PIT Tags Detected In Stomach	Bull Trout Mortalities Associated With Transport Activities
2008	18	4	4	0
2009	11	1	0	0
2010	3	0	0	0
2011	11	0	0	0
2012	5	0	0	0

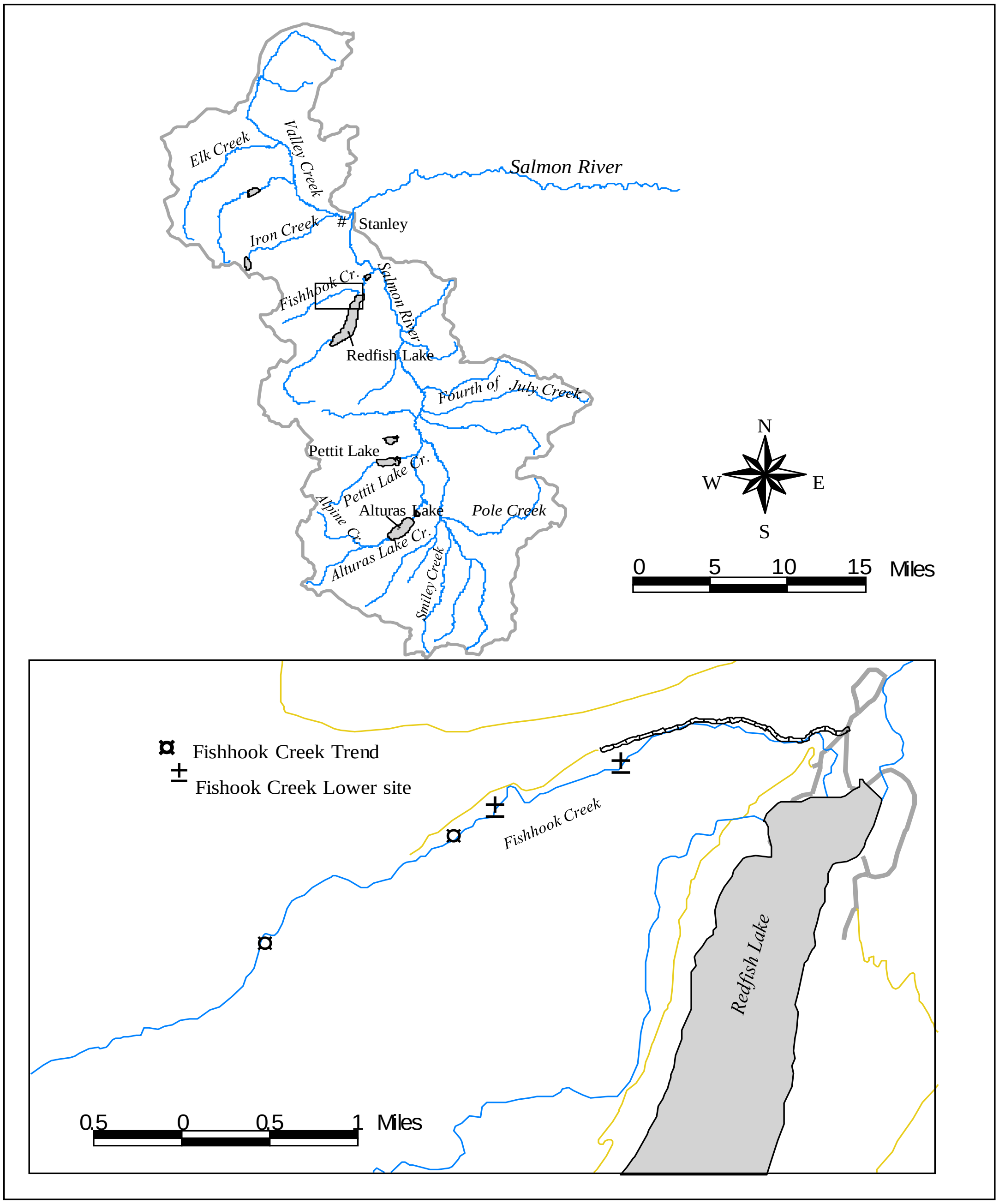


Figure 16. Location of Bull Trout redd index sections in Fishhook Creek in 2012.

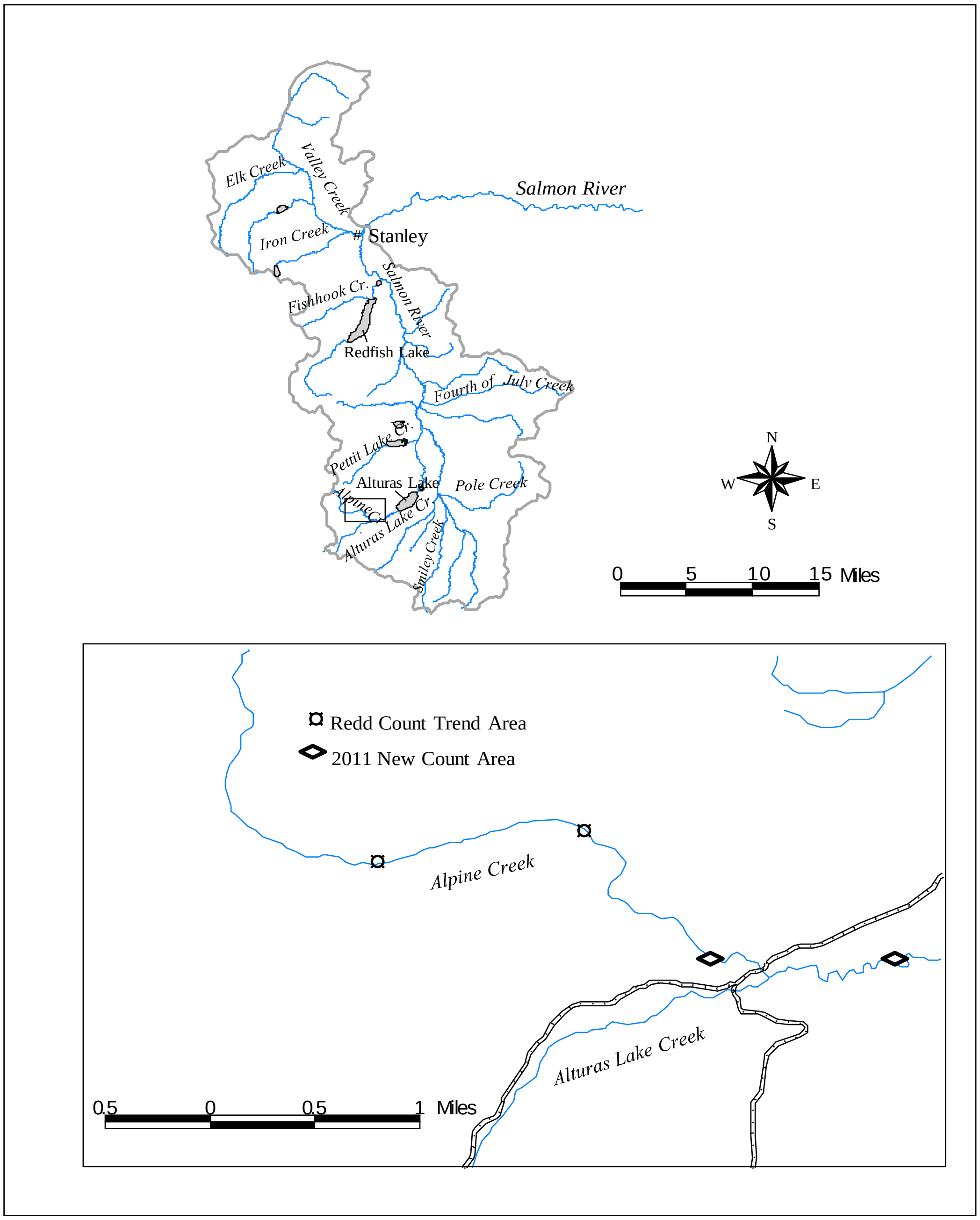


Figure 17. Location of Bull Trout redd index sections in Alpine Creek in 2012.

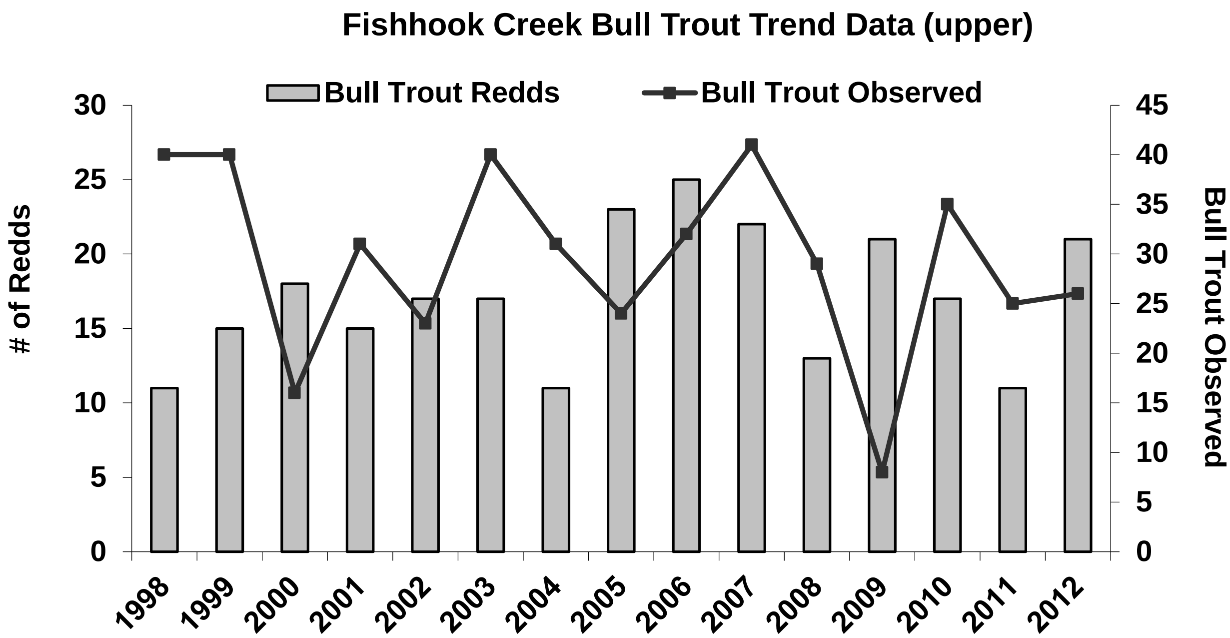


Figure 18. Total estimated Bull Trout redd counts and peak numbers of Bull Trout observed from 1998-2012 within Fishhook Creek (upper site).

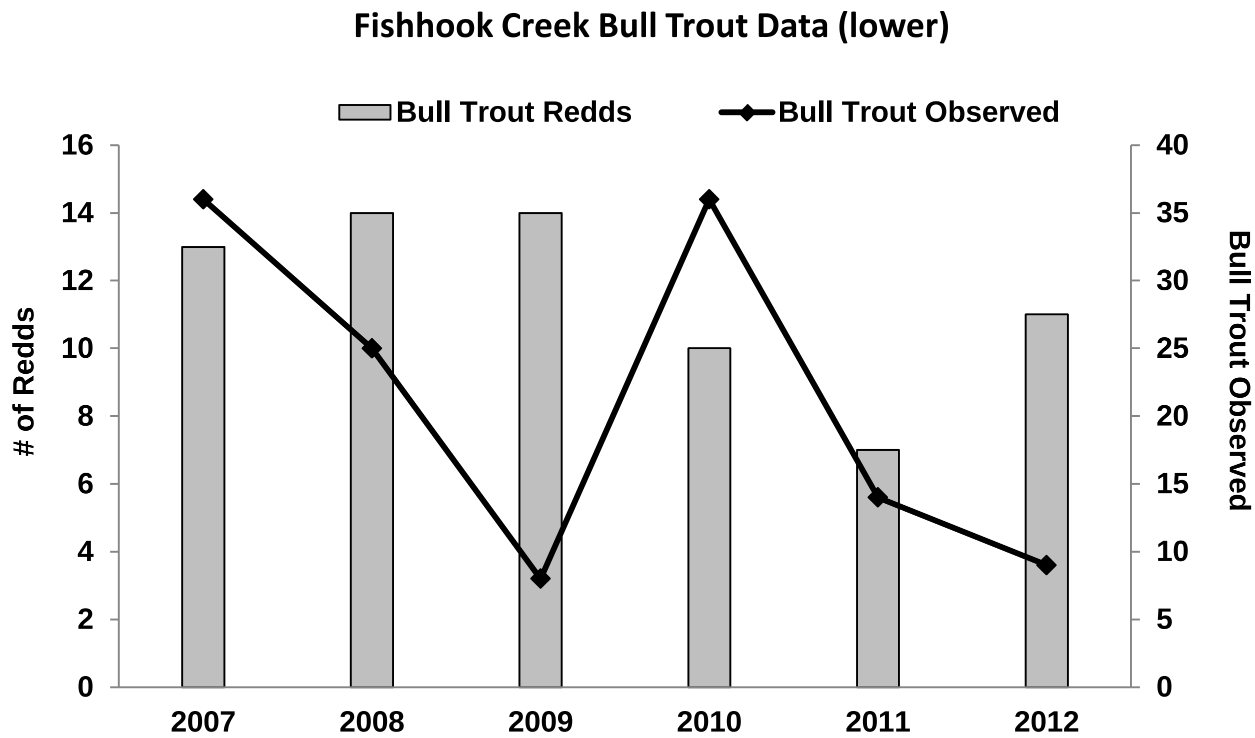


Figure 19. Total estimated Bull Trout redd counts and peak numbers of Bull Trout observed from 2007-2012 within Fishhook Creek (lower site).

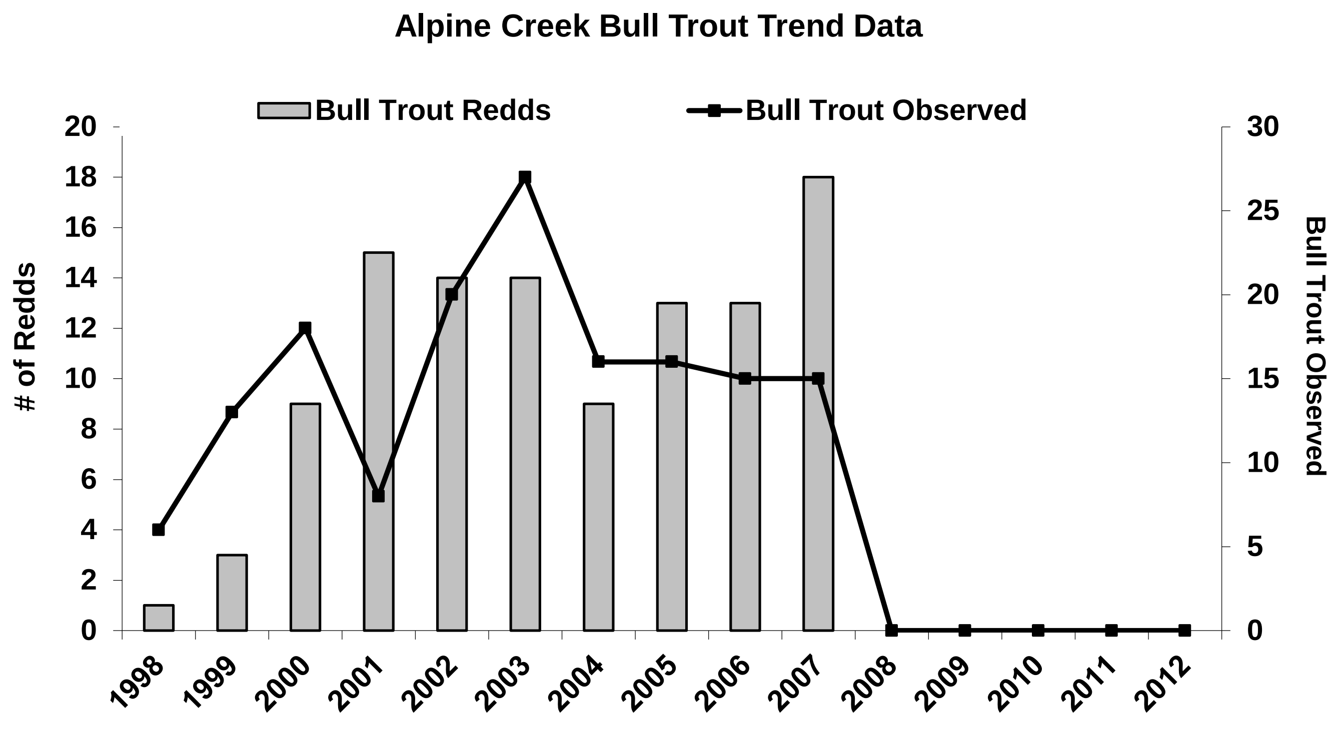


Figure 20. Total estimated Bull Trout redd counts and peak numbers of Bull Trout observed from 1998-2012 within Alpine Creek.

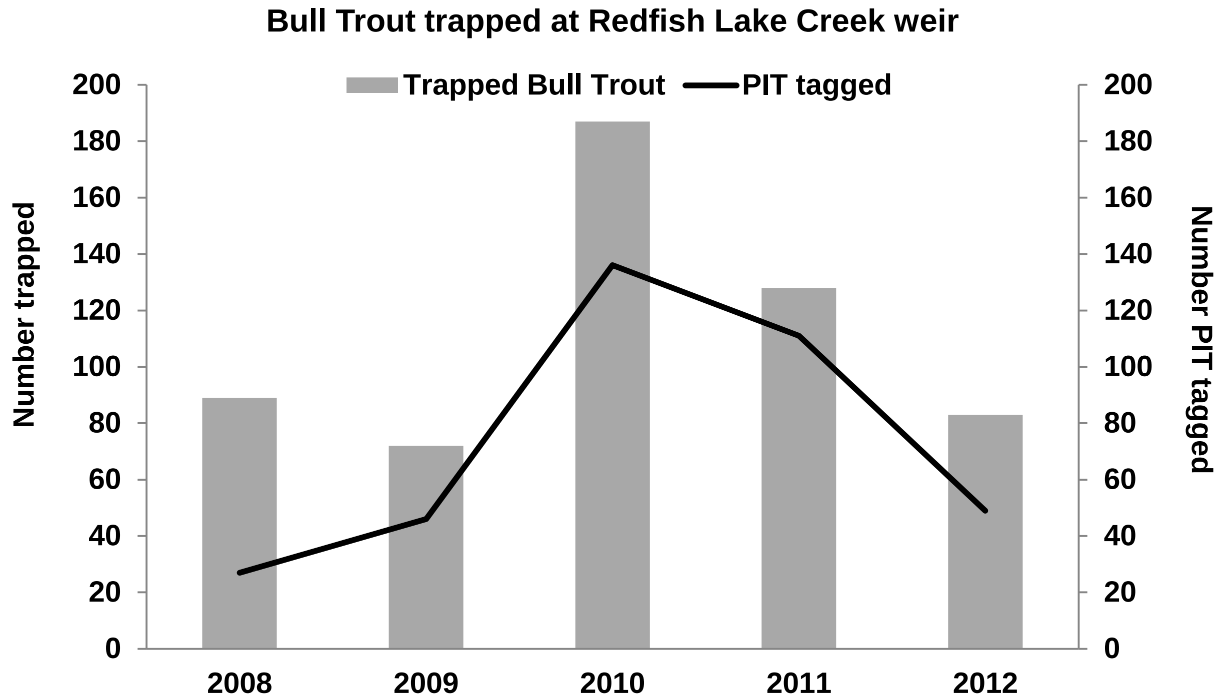


Figure 21. Total Bull Trout trapped at the adult Sockeye Salmon weir on Redfish Lake Creek from 2008-2012.

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APPENDICES

Appendix A. Fork length, weight (g), and age of *O. nerka* captured during midwater trawls conducted during August 2012 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age	Genetic Sample	Genetic Species ID
Redfish Lake					
1	33	0.3		RFLL12CTR0003	Sockeye
1	34	0.2		RFLL12CTR0002	Sockeye
1	51	1.2		RFLL12CTR0005	Sockeye
1	52	1.4		RFLL12CTR0004	Kokanee
1	57	1.5		RFLL12CTR0006	Kokanee
1	60	2.1	0	RFLL12CTR0007	Sockeye
1	65	2.6	0	RFLL12CTR0008	Sockeye
1	97	8.5	1	RFLL12CTR0001	Kokanee
2	37	0.4		RFLL12CTR0011	Sockeye
2	38	0.5		RFLL12CTR0010	Kokanee
2	40	0.5		RFLL12CTR0021	Sockeye
2	41	0.7		RFLL12CTR0019	Kokanee
2	42	0.6		RFLL12CTR0022	Kokanee
2	43	0.5		RFLL12CTR0020	Kokanee
2	44	0.7		RFLL12CTR0009	Kokanee
2	45	0.8		RFLL12CTR0016	Kokanee
2	47	0.9		RFLL12CTR0018	Sockeye
2	48	1.0		RFLL12CTR0017	Sockeye
2	50	1.0		RFLL12CTR0015	Kokanee
2	52	1.2		RFLL12CTR0012	Kokanee
2	52	1.1		RFLL12CTR0013	Kokanee
2	52	1.2		RFLL12CTR0014	Kokanee
2	65	2.5		RFLL12CTR0024	Kokanee
2	67	2.7	0	RFLL12CTR0023	Sockeye
3	42	0.6		RFLL12CTR0025	Kokanee
3	45	0.8		RFLL12CTR0026	No Genotype
3	46	0.8		RFLL12CTR0027	Kokanee
3	48	0.9		RFLL12CTR0031	Kokanee
3	50	1.1		RFLL12CTR0028	Sockeye
3	52	1.1		RFLL12CTR0030	Kokanee
3	55	1.6		RFLL12CTR0029	Sockeye
4	43	0.7		RFLL12CTR0032	Sockeye
4	45	0.8		RFLL12CTR0033	Kokanee
4	55	1.6		RFLL12CTR0034	Sockeye
5	37	0.4		RFLL12CTR0035	Kokanee
6	36	0.4		RFLL12CTR0036	Kokanee
6	40	0.6		RFLL12CTR0040	Kokanee
6	44	0.8		RFLL12CTR0039	Sockeye
6	50	1.1		RFLL12CTR0037	Kokanee
6	52	1.1		RFLL12CTR0038	Kokanee
7	48	1.0		RFLL12CTR0041	Kokanee
7	53	1.3		RFLL12CTR0042	Kokanee
7	100	9.2	1	RFLL12CTR0043	Kokanee
7	111	13.3	1	RFLL12CTR0044	Kokanee
8	46	0.8		RFLL12CTR0045	Kokanee
8	75	3.8	1	RFLL12CTR0046	Kokanee
9	37	0.5		RFLL12CTR0054	Kokanee
9	38	0.5		RFLL12CTR0056	Unknown <90%
9	44	0.7		RFLL12CTR0052	Kokanee
9	45	0.8		RFLL12CTR0057	Kokanee
9	46	0.9		RFLL12CTR0053	Kokanee

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age	Genetic Sample	Genetic Species ID
Redfish Lake					
9	46	0.9		RFLL12CTR0055	Kokanee
9	46	0.8		RFLL12CTR0047	Kokanee
9	47	0.9		RFLL12CTR0058	Kokanee
9	50	1.1		RFLL12CTR0050	Sockeye
9	52	1.2		RFLL12CTR0048	Kokanee
9	53	1.2		RFLL12CTR0051	Sockeye
9	58	1.8		RFLL12CTR0049	Sockeye
10	34	0.1		RFLL12CTR0059	Sockeye
10	43	0.6		RFLL12CTR0061	Kokanee
10	46	0.9		RFLL12CTR0062	Kokanee
10	47	1.0		RFLL12CTR0063	Kokanee
10	52	1.2		RFLL12CTR0060	Kokanee
10	55	1.5		RFLL12CTR0064	Kokanee
10	57	1.9	0	RFLL12CTR0065	Sockeye
10	64	2.4		RFLL12CTR0066	Sockeye
10	71	3.4		RFLL12CTR0067	Sockeye
10	97	11.8	1	RFLL12CTR0068	Kokanee
11	38	0.4		RFLL12CTR0070	Sockeye
11	43	0.7		RFLL12CTR0069	Kokanee
11	100	9.6	1	RFLL12CTR0071	Sockeye
12	42	0.6		RFLL12CTR0073	Kokanee
12	43	0.6		RFLL12CTR0072	Kokanee
12	52	1.3		RFLL12CTR0074	Kokanee
12	60	2.1		RFLL12CTR0075	Sockeye
12	77	3.8		RFLL12CTR0077	Sockeye
12	82	5.2	1	RFLL12CTR0076	Kokanee
12	125	18.2	2	RFLL12CTR0078	Kokanee
13	43	0.6	0	RFLL12CTR0082	Kokanee
13	45	0.8		RFLL12CTR0080	Kokanee
13	47	1.0		RFLL12CTR0079	Kokanee
13	50	1.1		RFLL12CTR0081	Kokanee
13	52	1.2		RFLL12CTR0083	Sockeye
13	55	1.6		RFLL12CTR0084	Sockeye
13	60	2.1	0	RFLL12CTR0085	No Genotype
13	62	2.4		RFLL12CTR0086	Sockeye
13	76	4.0	1	RFLL12CTR0087	Kokanee
14	36	0.4		RFLL12CTR0097	Sockeye
14	38	0.6		RFLL12CTR0088	Kokanee
14	41	0.5		RFLL12CTR0090	Kokanee
14	41	0.6		RFLL12CTR0091	Kokanee
14	41	0.6		RFLL12CTR0098	Unknown <90%
14	45	0.7		RFLL12CTR0096	Kokanee
14	46	0.9		RFLL12CTR0093	Kokanee
14	53	1.2		RFLL12CTR0089	Kokanee
14	53	1.1		RFLL12CTR0092	Kokanee
14	53	1.4		RFLL12CTR0095	Sockeye
14	58	1.7		RFLL12CTR0099	Kokanee
14	59	1.9	0	RFLL12CTR0094	Sockeye
14	80	4.7	1	RFLL12CTR0100	Sockeye
14	87	5.8	1	RFLL12CTR0101	Kokanee
14	98	8.4	1	RFLL12CTR0102	Kokanee
14	98	8.5		RFLL12CTR0103	Kokanee
15	31	0.6		RFLL12CTR0104	Kokanee

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age	Genetic Sample	Genetic Species ID
Redfish Lake					
15	38	0.5		RFLL12CTR0106	Kokanee
15	45	0.8		RFLL12CTR0105	Kokanee
15	81	4.6		RFLL12CTR0107	Kokanee
15	88	6.0	1	RFLL12CTR0108	Kokanee
15	93	7.2	1	RFLL12CTR0109	Kokanee
16	40	0.4		RFLL12CTR0113	Sockeye
16	41	0.6		RFLL12CTR0110	Kokanee
16	45	0.7		RFLL12CTR0111	Kokanee
16	50	1.2		RFLL12CTR0112	Kokanee
16	93	7.5	1	RFLL12CTR0114	Sockeye
16	114	12.7	1	RFLL12CTR0115	Kokanee
17	41	0.6		RFLL12CTR0116	Kokanee
17	63	2.4		RFLL12CTR0117	Kokanee
17	78	4.0		RFLL12CTR0118	Kokanee
18	37	0.5		RFLL12CTR0119	Kokanee
18	41	0.6		RFLL12CTR0120	Kokanee
18	57	1.7		RFLL12CTR0121	Sockeye
18	68	3.1		RFLL12CTR0122	Sockeye
Alturas Lake					
1	41	0.6		ALTL12CTR0005	Kokanee
1	43	0.6		ALTL12CTR0002	Kokanee
1	43	0.8		ALTL12CTR0004	Kokanee
1	45	0.8		ALTL12CTR0003	Kokanee
1	46	0.8		ALTL12CTR0006	Kokanee
1	46	0.9		ALTL12CTR0008	Kokanee
1	47	0.9	0	ALTL12CTR0001	Kokanee
1	47	0.9		ALTL12CTR0009	Kokanee
1	53	1.3		ALTL12CTR0013	Unknown <90%
1	54	1.4		ALTL12CTR0012	Kokanee
1	55	1.2	0	ALTL12CTR0010	Kokanee
1	56	1.6	0	ALTL12CTR0007	Kokanee
1	57	1.7	0	ALTL12CTR0011	Kokanee
1	70	3.2	0	ALTL12CTR0016	Kokanee
1	82	5.3	1	ALTL12CTR0014	Kokanee
1	83	5.5	1	ALTL12CTR0015	Kokanee
2	41	0.5		ALTL12CTR0017	Kokanee
2	43	0.7		ALTL12CTR0018	Kokanee
2	47	1.0		ALTL12CTR0020	Kokanee
2	53	1.5		ALTL12CTR0019	Kokanee
2	55	1.3	0	ALTL12CTR0021	Kokanee
2	57	1.7		ALTL12CTR0022	No Genotype
2	78	4.6	1	ALTL12CTR0026	Kokanee
2	83	4.9	1	ALTL12CTR0023	Kokanee
2	85	5.8	1	ALTL12CTR0024	Kokanee
2	85	6.5	1	ALTL12CTR0025	Kokanee
2	87	6.6	1	ALTL12CTR0028	Kokanee
2	87	6.8	1	ALTL12CTR0034	Kokanee
2	90	7.3		ALTL12CTR0032	Kokanee
2	90	7.4		ALTL12CTR0033	Kokanee
2	90	7.5		ALTL12CTR0036	Kokanee
2	91	8.4	1	ALTL12CTR0031	Kokanee
2	91	7.7		ALTL12CTR0027	Kokanee

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age	Genetic Sample	Genetic Species ID
Alturas Lake					
2	94	8.3	1	ALTL12CTR0029	Kokanee
2	97	9.1	1	ALTL12CTR0030	Kokanee
2	105	12.8	1	ALTL12CTR0037	Kokanee
2	107	11.9	1	ALTL12CTR0035	Kokanee
2	108	13.8	1	ALTL12CTR0038	Unknown <90%
2	117	17.7	1	ALTL12CTR0039	Kokanee
3	35	0.3		ALTL12CTR0041	Kokanee
3	38	0.4		ALTL12CTR0040	Kokanee
3	45	0.7		ALTL12CTR0042	Kokanee
3	46	0.8		ALTL12CTR0043	Kokanee
3	55	1.4		ALTL12CTR0046	Kokanee
3	55	1.5		ALTL12CTR0047	Kokanee
3	55	1.4		ALTL12CTR0048	Kokanee
3	56	1.4		ALTL12CTR0044	Kokanee
3	58	1.5		ALTL12CTR0045	Kokanee
3	74	3.7		ALTL12CTR0049	Kokanee
3	98	9.9	1	ALTL12CTR0050	Kokanee
4	34	0.3		ALTL12CTR0051	Kokanee
4	38	0.5		ALTL12CTR0058	Kokanee
4	40	0.6		ALTL12CTR0053	Kokanee
4	42	0.5		ALTL12CTR0052	Kokanee
4	43	0.5		ALTL12CTR0056	Kokanee
4	43	0.9		ALTL12CTR0060	Kokanee
4	44	0.8		ALTL12CTR0054	Kokanee
4	45	0.8		ALTL12CTR0057	Kokanee
4	45	0.9		ALTL12CTR0063	Kokanee
4	46	0.7		ALTL12CTR0055	Kokanee
4	47	0.9		ALTL12CTR0059	Kokanee
4	48	1.0		ALTL12CTR0061	Kokanee
4	50	1.0		ALTL12CTR0062	Kokanee
4	53	1.4		ALTL12CTR0064	Kokanee
4	55	1.4		ALTL12CTR0065	Kokanee
4	55	1.3		ALTL12CTR0066	Kokanee
4	56	1.5		ALTL12CTR0067	Kokanee
4	74	3.7	0	ALTL12CTR0068	Kokanee
4	83	5.9	0	ALTL12CTR0069	Kokanee
4	95	7.7	1	ALTL12CTR0070	Kokanee
4	93	7.4	1	ALTL12CTR0072	Kokanee
4	98	10.1	1	ALTL12CTR0071	Kokanee
4	98	12.0		ALTL12CTR0073	Kokanee
4	104	11.6	1	ALTL12CTR0074	Kokanee
4	115	15.6		ALTL12CTR0075	Kokanee
5	33	0.3		ALTL12CTR0076	Kokanee
5	39	0.5		ALTL12CTR0077	Kokanee
5	45	0.8		ALTL12CTR0078	Kokanee
5	45	0.8		ALTL12CTR0079	Kokanee
5	46	0.9		ALTL12CTR0082	Unknown <90%
5	47	0.9		ALTL12CTR0080	Kokanee
5	48	1.0		ALTL12CTR0100	Kokanee
5	49	1.2		ALTL12CTR0097	Kokanee
5	50	0.9		ALTL12CTR0081	Kokanee

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age	Genetic Sample	Genetic Species ID
Alturas Lake					
5	50	1.0		ALTL12CTR0090	Kokanee
5	50	1.2		ALTL12CTR0098	Kokanee
5	51	1.3.		ALTL12CTR0099	Kokanee
5	52	1.1		ALTL12CTR0092	Kokanee
5	52	1.3		ALTL12CTR0093	Kokanee
5	53	1.1		ALTL12CTR0083	Kokanee
5	53	1.3		ALTL12CTR0086	Kokanee
5	53	1.3		ALTL12CTR0091	Kokanee
5	53	1.3		ALTL12CTR0094	Kokanee
5	53	1.2		ALTL12CTR0095	Kokanee
5	53	1.3		ALTL12CTR0101	Kokanee
5	54	1.4		ALTL12CTR0088	Kokanee
5	54	1.4		ALTL12CTR0089	Kokanee
5	55	1.5		ALTL12CTR0085	Kokanee
5	55	1.5		ALTL12CTR0087	Kokanee
5	55	1.7		ALTL12CTR0096	Kokanee
5	55	1.5		ALTL12CTR0102	Kokanee
5	57	1.5		ALTL12CTR0084	Kokanee
6	32	0.3		ALTL12CTR0103	Kokanee
6	35	0.3		ALTL12CTR0105	Kokanee
6	39	0.5		ALTL12CTR0104	Kokanee
6	50	0.9		ALTL12CTR0108	Kokanee
6	50	0.8		ALTL12CTR0109	Kokanee
6	51	1.3		ALTL12CTR0107	Kokanee
6	52	1.2		ALTL12CTR0106	Kokanee
6	61	2.2		ALTL12CTR0110	Kokanee
6	65	2.4		ALTL12CTR0111	Kokanee
6	76	4.7		ALTL12CTR0113	Kokanee
6	81	4.5		ALTL12CTR0112	Kokanee
6	86	5.9		ALTL12CTR0114	Kokanee
6	90	8.1		ALTL12CTR0115	Kokanee
6	95	9.4		ALTL12CTR0116	Unknown <90%
6	97	9.7		ALTL12CTR0117	Kokanee
6	102	10.9		ALTL12CTR0118	Kokanee
6	105	13.4		ALTL12CTR0119	Kokanee
6	118	17.2	2	ALTL12CTR0120	Kokanee
Pettit Lake					
1	95	7.8	1	PETL12CTR0001	Sockeye
2	130	25.6	1	PETL12CTR0002	Unknown <90%
3	128	24.7	1	PETL12CTR0003	Sockeye
4	134	26.9	2	PETL12CTR0004	Unknown <90%
4	150	35.2	2	PETL12CTR0005	Unknown <90%
5	127	22.9	1	PETL12CTR0007	Unknown <90%
5	130	25.2	1	PETL12CTR0006	Unknown <90%
5	151	35.4	2	PETL12CTR0008	Unknown <90%
5	155	38.6	2	PETL12CTR0009	Sockeye
6	114	17.3	1	PETL12CTR0010	Unknown <90%
6	128	23.4	1	PETL12CTR0011	Unknown <90%
6	150	35.4	2	PETL12CTR0012	Sockeye

Appendix B. Arrival dates at Lower Granite Dam for PIT-tagged Sockeye Salmon smolts during the 2012 migration year.

	Redfish Lake					Pettit Lake			Alturas Lake		
Date	Natural Origin	Fall Direct	Hatchery Smolts	Oxbow Smolts	Sawtooth Smolts	Natural Origin	Fall Direct	Hatchery Smolts	Natural Origin	Fall Direct	Hatchery Smolts
4/25/2012	1										
4/29/2012			1								
4/30/2012	4		1								
5/1/2012	4		1								
5/2/2012	8		2								
5/3/2012	4	1	2								
5/4/2012	1		1								
5/5/2012	1		1								
5/6/2012	5	2	5								
5/7/2012	4										
5/8/2012	5	1	1			1					
5/9/2012	1	2	1			1		1			
5/10/2012	7		1								
5/11/2012	7		4								
5/12/2012	6		1			5					
5/13/2012	5					4					
5/14/2012	11					1		1			
5/15/2012	8		1								
5/16/2012	13	1	4	14	247				1		
5/17/2012	10		3	345	1,281						
5/18/2012	2			304	1,015						
5/19/2012	5		3	79	726						
5/20/2012	5		2	52	760						
5/21/2012	5			27	923						
5/22/2012	10		3	14	807						
5/23/2012	2			11	457						
5/24/2012	5			4	258						
5/25/2012	3		1		219						
5/26/2012	9			1	296						
5/27/2012	5			1	313						
5/28/2012	1		1	1	211						
5/29/2012				1	216						
5/30/2012	1			1	169						
5/31/2012					112						
6/1/2012	2				63						
6/2/2012			1		82						
6/3/2012	5				66						
6/4/2012	1				41						
6/5/2012	4			1	37						
6/6/2012	1				59						
6/7/2012				1	29						
6/8/2012					42						
6/9/2012	1				11						
6/10/2012					12						
6/11/2012					4						
6/12/2012					2						
6/13/2012					3						
6/14/2012					4						
6/15/2012					2						
6/16/2012					3						
6/17/2012											
6/18/2012					1						
6/19/2012					2						
6/20/2012					1						
6/21/2012					2						
6/22/2012					1						
7/5/2012					1						
7/11/2012					1						
Total	**172**	**7**	**40**	**857**	**8,480**	**12**		**2**	**1**		

Appendix C. Methods used to derive the adult productivity estimates (metrics) for Brood Year 2004.

METHODS

BROOD YEAR 2004 PRODUCTIVITY METRICS

Smolt-to-Adult Survival

In order to calculate SARs, both juvenile out-migration data is needed as well as adult return data. Here, synthesized data for both juveniles (emigrating in 2006 [Peterson et al. 2007] and 2007 [Peterson et al. 2008]) and adults returning in 2007 (Baker et al. 2009a), 2008 (Baker et al. 2009b), or 2009 (Baker et al. 2010) are presented to generate BY04 SARs.

Juvenile emigration methodologies are identified in part 3 of this report and apply to BY04 as well. Individual brood year smolt production is summed using age-1+ and age-2+ smolt estimates emigrating from basin lakes for natural and presmolt production for Redfish Lake and using age-1+ release numbers for the full-term hatchery smolt components. Juvenile emigration data used to calculate SARs for brood year 2004 is presented in Table 23 (below). For example, BY04 natural smolt production totaled 5,609 of which 5,107 were age-1+ smolts, which emigrated in 2006 and an additional 502 smolts that emigrated in 2007 as age-2+ smolts. Alturas and Pettit Lake data assumes that all out-migrants were age-1 at out-migration because age-specific data are missing during some out-migration seasons.

The adults used to calculate release strategy SARs were collected at the basin trap locations (described in Part 4 of this report) from 2007-2009. A total of 4 anadromous adults were trapped in 2007, 598 in 2008, and 817 in 2009. Trap operation dates are listed in Table 13 (Part 4 of this report). Two groups of adults return to the Sawtooth Valley: 1) a marked or tagged group of hatchery-origin fish, and 2) an unmarked group of natural-origin fish (which can also include eyed egg releases). In order to apply an age and origin to each returning adult, scale aging (2007, N = 4; 2008, N = 546; 2009, N = 719), a combination of differential marks, or tags and trapping location were used for BY04. The hatchery marks applied to different release strategies for BY04 can be found in the Snake River Sockeye Salmon Captive Broodstock Program hatchery element reports (Baker et al. 2006 and 2007). All hatchery origin adults were assigned to release strategies based on differential marking and trap return location. For example, a returning adult with an adipose clip and no CWT that returned to Redfish Lake Creek trap was assigned to presmolt production resulting from emigrants leaving Redfish Lake. Adults identified as natural origin (produced from captive adult releases, wild adults, or egg-box production) had an intact adipose fin and no CWT. Natural origin adults were assigned to release strategies based on trap return location. For example, if an adult was trapped that had an intact adipose fin, no CWT, and returned to the Sawtooth weir, it was assigned to the natural origin production group resulting from Alturas or Pettit lake. Data for BY04 assumes that adults did not stray between trap locations. Presmolt and natural production adults (originating from Alturas and Pettit lake) collected at the SFH weir were summed together for both lakes in the SAR estimates because the lake of origin as emigrants is unknown when collected at the weir.

Ages for adults that had scales with blown focus' or were not collected during 2008 (N = 52) and 2009 (N = 94) were generated using Program R and code developed by Derek Ogle (2013). This (fishR Vignette-Age-Length keys to assign age from lengths) was used to assign an age to unaged fish using scale age and length keys with the semirandom method (Ogle 2013).

The ages and lengths of the marked and unmarked groups were used to develop age-length keys. An age was generated for each fish with known length (and unknown age).

SAR estimates were generated by summing together age-3 (2007), age-4 (2008), and age-5 (2009) from the appropriate release strategy or group and divided by the estimated out-migration number from the appropriate BY for each release strategy or group.

Recruits-per-spawner and recruits-per-female

Returning adults that have been assigned to a specific brood year and release strategy were used to generate estimates of adult recruits-per-spawner and recruits-per-female. This was done by dividing the total number of returned adults (for the BY and release strategy) by the number of spawners (or females) that produced the group. For the hatchery production groups, the numbers of spawners was generated from spawning records at the EFH and BCH. For natural production within Redfish Lake, it was assumed that all adults released spawned and that either zero or negligible residual spawning occurred.

Natural Productivity within Redfish Lake

Natural productivity within Redfish Lake was estimated with the following metrics: total egg deposition within the lake, egg-to-smolt survival, smolts-per-female, and the recruits-per-spawner/female (as described above). Total egg deposition into the lake was estimated using weight/fecundity relationship data collected from hatchery spawned females (N = 1,678 females spawned at EFH between 2005 and 2013; Dan Baker unpublished data). Weights were collected from adults released into the lake during maturation sorts at the hatchery facilities (approximately 2 months prior to release). These weights were entered into the equation developed from the weight/fecundity relationship to develop the fecundity estimates. The calculated fecundities from all released females were summed to estimate total egg deposition. This estimate also assumed that all adults released to volitionally spawn deposited eggs into the gravel and that every female was productive. Egg-to-smolt survival was derived by dividing the estimated BY natural smolt production by the total egg deposition estimate. The numbers of smolts-per-female was estimated for natural production within Redfish Lake by dividing the number of female spawners released into the lake by the number of smolts produced for that corresponding BY.

RESULTS

Productivity Estimates per Release Strategy (BY04)

A total of 179,049 smolts were estimated as emigrants resulting from production generated from spawned adults during the fall of 2004 (Table 24). SARs ranged from 0.03% for presmolt production from Redfish Lake to 0.84% for natural-origin production from Redfish Lake (Table 24). Sawtooth reared and Oxbow reared full-term smolts had intermediate survivals of 0.22% and 0.44%, respectively. The resulting SAR for all production emigrating from the Sawtooth Valley as a result of production from BY04 adults was 0.24%.

An estimated range of 0.02 to 1.49 recruits were produced per spawner during BY04 (Table 25). The OFH production group returned the highest number of recruits-per-spawner and presmolt production from Redfish Lake produced the least number of recruits-per-spawner. Natural production resulting from Alturas and Pettit lakes produced the second highest R/S

(0.66) followed by Sawtooth reared full-term smolts and then natural production from Redfish Lake. The average R/S for the program for BY04 was 0.55 (437 recruits and 797 spawners; Table 25). The number of recruits-per-female ranged from 0.04 to 3.96 for the Redfish Lake presmolts and Oxbow reared full-term smolts, respectively. The average R/F for all release groups combined was estimated at 1.16 (437 recruits and 376 females; Table 25).

Natural Productivity within Redfish Lake

In 2004, a total of 135 females, 108 males and one adult, which the sex was unknown, were released in September (unpublished program data) to spawn naturally within Redfish Lake. The estimated egg deposition within the lake was 260,262 eggs (Table 21; Part 4 of this report). The total estimated BY natural smolt production was 5,609 out-migrants (5,107 age-1+ and 502 age-2+ smolts), which resulted in a smolts-per-female metric of 42 smolts. Based on the number of smolts leaving the lake, egg-to-smolt survival was estimated at 2.16% for BY04 (Table 21; Part 4 of this report).

Table 23. Juvenile emigrations data collected in 2006 and 2007 used to calculate smolt-to-adult return rates for BY 2004.

Release Strategy	Age 1+ smolt (2006)	Age 2+ smolt (2007)	Total
Total smolts produced in BY 2004	178,433	616	179,049
Natural Origin (Redfish)	5,107	502	5,609
Presmolts (Redfish)	16,498	114	16,612
Sawtooth Smolts	39,622		39,622
Oxbow smolts	46,430		46,430
Natural Origin (Pettit and Alturas)	55,247		55,247
Presmolts (Pettit and Alturas)	15,529		15,529

Table 24. Basin-to-basin estimates of smolt-to-adult return survival rates BY 2004. These estimates should be considered minimum estimates of survival for the different production strategies identified and do not include fish observed within the Sawtooth Valley that were not trapped.

Release Strategies and Brood Year		Adult returns by year and age			SAR
BY 2004	**smolts**	**2007 (age 3)**	**2008 (age 4)**	**2009 (age 5)**	
Estimated total smolt emigration for BY 2004	179,049	1	421	15	0.24%
Redfish Lake presmolt releases	16,612	0	5	0	0.03%
Alturas and Pettit presmolt releases (combined)	15,529	0	13	0	0.08%
Sawtooth-reared full-term smolts	39,622	0	85	2	0.22%
ODFW-reared full-term smolts	46,430	1	192	9	0.44%
Natural origin production from Redfish Lake	5,609	0	44	3	0.84%
Natural origin production from Alturas and Pettit lake	55,247	0	82	1	0.15%

Table 25. Adult productivity estimates of recruits-per-spawner and recruits-per-female for BY 2004. These estimates should be considered minimum estimates and do not include fish observed within the Sawtooth Valley that were not trapped.

Release Strategies and Brood Year					
BY 2004	**Recruits**	**Spawners**	**Females**	**R/S**	**R/F**
Estimated total adult recruits	437	797	376	0.55	1.16
Redfish Lake presmolt releases	5	291	138	0.02	0.04
Alturas and Pettit presmolt releases (combined)	13	291	138	0.04	0.09
Sawtooth-reared full-term smolts	87	291	138	0.30	0.63
ODFW-reared full-term smolts	202	136	51	1.49	3.96
Natural origin production from Redfish Lake	47	244	135	0.19	0.35
Natural origin production from Alturas and Pettit lake	83	126	52	0.66	1.60

Appendix D. Methods used to derive the adult productivity estimates (metrics) for Brood Year 2005.

METHODS

BROOD YEAR 2005 PRODUCTIVITY METRICS

Smolt-to-Adult Survival

In order to calculate SARs, both juvenile out-migration data is needed as well as adult return data. Here, synthesized data for both juveniles (emigrating in 2007 [Peterson et al. 2008] and 2008 [Peterson et al. 2010]) and adults returning in 2008 (Baker et al. 2009b), 2009 (Baker et al. 2010), or 2010 (Baker et al. 2011) are presented to generate BY05 SARs.

Juvenile emigration methodologies are identified in part 3 of this report and apply to BY05 as well. Individual brood year smolt production is summed using age-1+ and age-2+ smolt estimates emigrating from basin lakes for natural and presmolt production for Redfish Lake and using age-1+ release numbers for the full-term hatchery smolt components. Juvenile emigration data used to calculate SARs for BY05 is presented in Table 26 (below). For example, BY05 natural smolt production totaled 6,088 of which 4,778 were age-1+ smolts that emigrated in 2007 and an additional 1,310 smolts that emigrated in 2008 as age-2+ smolts. Alturas and Pettit lake data assumes that all out-migrants were age-1 at out-migration because age-specific data are missing during some out-migration seasons.

The adults used to calculate release strategy SARs were collected at the basin trap locations (described in Part 4 of this report) from 2008-2010. A total of 598 anadromous adults were trapped in 2008, 817 in 2009, and 1,322 in 2010. Trap operation dates are listed in Table 13 (Part 4 of this report). There are two groups of adults that return to the Sawtooth Valley: 1) a marked or tagged group of hatchery-origin fish, and 2) an unmarked group of natural-origin fish (which can also include eyed egg releases). In order to apply an age and origin to each returning adult, both scale aging, marks, and return location (return year 2008, N = 546; and in 2009, N = 719) or PBT assignments (described in Part 4 of this report) were used (return year 2010, N = 1,250) for BY05. The hatchery marks applied to different release strategies for BY05 can be found in the Snake River Sockeye Salmon Captive Broodstock Program hatchery element reports (Baker et al. 2007 and 2009a). Adults identified as natural origin (produced from captive adult releases, wild adults, or egg-box production) had an intact adipose fin and no CWT. Presmolt and natural production adults (originating from Alturas and Pettit lake) collected at the SFH weir were summed together for both lakes in the SAR estimates because the lake of origin as emigrants is unknown when collected at the weir.

Ages for adults that had scales with blown focus' or were not collected during 2008 (N = 52) and 2009 (N = 94) or were unassigned genetically using PBT methods (N = 30) were generated using Program R and code developed by Derek Ogle (2013). This (fishR Vignette-Age-Length keys to assign age from lengths) was used to assign an age to unaged fish using scale or genetic ages and length keys with the semirandom method (Ogle 2013). The ages and lengths of the marked and unmarked groups were used to develop age-length keys. An age was generated for each fish with known length (and unknown age).

SAR estimates were generated by summing together age-3 (2008), age-4 (2009), and age-5 (2010) from the appropriate release strategy or group and divided by the estimated out-migration number from the appropriate BY for each release strategy or group.

Recruits-per-spawner and recruits-per-female

Returning adults that have been assigned to a specific brood year and release strategy were used to generate estimates of adult recruits-per-spawner and recruits-per-female. This was done by dividing the total number of returned adults (for the BY and release strategy) by the number of spawners (or females) that produced the group. For the hatchery production groups, the numbers of spawners was generated from spawning records at the EFH and BCH. For natural production within Redfish Lake, it was assumed that all adults released spawned and that either zero or negligible residual spawning occurred.

Natural Productivity within Redfish Lake

Natural productivity within Redfish Lake was estimated with the following metrics: total egg deposition within the lake, egg-to-smolt survival, smolts-per-female, and the recruits-per-spawner/female (as described above). Total egg deposition into the lake was estimated using weight/fecundity relationship data collected from hatchery spawned females (N = 1,678 females spawned at EFH between 2005 and 2013; Dan Baker unpublished data). Weights were collected from adults released into the lake during maturation sorts at the hatchery facilities (approximately 2 months prior to release). These weights were entered into the equation developed from the weight/fecundity relationship to develop the fecundity estimates. The calculated fecundities from all released females were summed to estimate total egg deposition. This estimate also assumed that all adults released to volitionally spawn deposited eggs into the gravel and that every female was productive. Egg-to-smolt survival was derived by dividing the estimated BY natural smolt production by the total egg deposition estimate. The numbers of smolts-per-female was estimated for natural production within Redfish Lake by dividing the number of female spawners released into the lake by the number of smolts produced for that corresponding BY.

RESULTS

Productivity Estimates per Release Strategy (BY05)

A total of 145,263 smolts were estimated as emigrants resulting from production generated from spawned adults during the fall of 2005 (Table 27). SARs ranged from 0.08% for natural-origin production resulting from Alturas and Pettit lakes to 1.43% for natural-origin production from Redfish Lake (Table 27). Sawtooth-reared and Oxbow-reared full-term smolts had intermediate survivals of 0.34% and 1.07%, respectively. The resulting SAR for all production emigrating from the Sawtooth Valley as a result of production from BY05 adults was estimated at 0.61%.

An estimated range of 0.05 to 4.50 recruits were produced per spawner during BY05 (Table 28). The OFH production group returned the highest number of recruits-per-spawner and presmolt production produced the least number of recruits-per-spawner. Natural production resulting from Redfish Lake produced the second highest R/S (0.49) followed by Sawtooth reared full-term smolts and then natural production from Alturas and Pettit Lakes combined. The average R/S for the program for BY05 was 1.00 (889 recruits and 885 spawners; Table 28). The number of recruits-per-female ranged from 0.14 to 11.94 for the natural production from Alturas and Pettit Lake, as well as both presmolt groups and Oxbow reared full-term smolts, respectively. The average R/F for all release groups combined was estimated at 2.68 (889 recruits and 332 females; Table 28).

Natural Productivity within Redfish Lake

In 2005, a total of 50 females, 123 males, and three adults of which the sex was unknown were released in September (unpublished program data) to spawn naturally within Redfish Lake. The estimated egg deposition within the lake was 101,680 eggs (Table 21; Part 4 of this report). The total estimated BY natural smolt production was 6,088 out-migrants (4,778 age-1+ and 1,302 age-2+ smolts), which resulted in a smolts-per-female metric of 122 smolts. Based on the number of smolts leaving the lake, egg-to-smolt survival was estimated at 5.99% for BY05 (Table 21; Part 4 of this report).

Table 26. Juvenile emigrations data collected in 2007 and 2008 used to calculate smolt-to-adult return rates for BY 2005.

Release Strategy	Age 1+ smolt (2007)	Age 2+ smolt (2008)	Total
Total smolts produced in BY05	142,931	2,332	145,263
Natural Origin (Redfish)	4,778	1,310	6,088
Presmolts (Redfish)	14,142	1,022	15,164
Sawtooth Smolts	47,094		47,094
Oxbow smolts	54,582		54,582
Natural Origin (Pettit and Alturas)	10,743		10,743
Presmolts (Pettit and Alturas)	11,592		11,592

Table 27. Basin-to-basin estimates of smolt-to-adult return survival rates BY 2005. These estimates should be considered minimum estimates of survival for the different production strategies identified and do not include fish observed within the Sawtooth Valley that were not trapped.

Release Strategies and Brood Year		Adult returns by year and age			SAR
BY 2005	smolts	2008 (age 3)	2009 (age 4)	2010 (age 5)	
Estimated total smolt emigration for BY05	145,263	160	700	29	0.61%
Redfish Lake presmolt releases	15,164	1	11	12	0.16%
Alturas and Pettit presmolt releases (combined)	11,592	1	20	2	0.20%
Sawtooth-reared full-term smolts	47,094	29	132	0	0.34%
ODFW-reared full-term smolts	54,582	127	458	0	1.07%
Natural origin production from Redfish Lake	6,088	1	71	15	1.43%
Natural origin production Alturas and Pettit lake	10,743	1	8	0	0.08%

Table 28. Adult productivity estimates of recruits-per-spawner and recruits-per-female for BY 2005. These estimates should be considered minimum estimates and do not include fish observed within the Sawtooth Valley that were not trapped.

Release Strategies and Brood Year					
BY 2005	**Recruits**	**Spawners**	**Females**	**R/S**	**R/F**
Estimated total adult recruits	889	885	332	1.00	2.68
Redfish Lake presmolt releases	24	429	168	0.06	0.14
Alturas and Pettit presmolt releases (combined)	23	429	168	0.05	0.14
Sawtooth-reared full-term smolts	161	429	168	0.38	0.96
ODFW-reared full-term smolts	585	130	49	4.50	11.94
Natural origin production from Redfish Lake	87	176	50	0.49	1.74
Natural origin production from Alturas and Pettit lake	9	150	65	0.06	0.14

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