



**SNAKE RIVER SOCKEYE SALMON  
CAPTIVE BROODSTOCK PROGRAM  
RESEARCH ELEMENT**

**ANNUAL PROGRESS REPORT  
January 1, 2008—December 31, 2008**



**Prepared by:**

**Mike Peterson, Senior Fisheries Research Biologist  
Kurtis Plaster, Senior Fisheries Technician  
Laura Redfield, Fisheries Technician  
and  
Jeff Heindel, Conservation Hatcheries Supervisor**

**IDFG Report Number 10-09  
June 2010**

**SNAKE RIVER SOCKEYE SALMON  
CAPTIVE BROODSTOCK PROGRAM  
RESEARCH ELEMENT**

**2008 Annual Project Progress Report**

**Part 1—Project Overview**

**Part 2—*Oncorhynchus nerka* Population Monitoring and Redfish  
Lake Sport Fishery Investigations**

**Part 3— Sockeye Salmon Juvenile Out-migrant and Adult Spawning  
Monitoring and Evaluation**

**Part 4—Predator Surveys**

**By**

**Mike Peterson  
Kurtis Plaster  
Laura Redfield  
Jeff Heindel**

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

**To:**

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

**Project Number 2007-402-00  
Contract Number 33644 & 37981**

**IDFG Report Number 10-09  
June 2010**

## TABLE OF CONTENTS

	<u>Page</u>
PART 1—PROJECT OVERVIEW .....	1
BACKGROUND .....	1
SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM.....	2
PROJECT GOALS.....	3
PROJECT OBJECTIVES .....	3
STUDY AREA.....	4
2007 and 2008 Captive Broodstock Program Egg and Juvenile Supplementation .....	5
LITERATURE CITED.....	10
PART 2—ONCORHYNCHUS NERKA POPULATION MONITORING AND REDFISH LAKE SPORT FISHERY INVESTIGATIONS.....	15
INTRODUCTION .....	15
METHODS.....	15
<i>Oncorhynchus nerka</i> Population Monitoring.....	15
Redfish Lake Sport Fishery Investigations .....	16
RESULTS AND DISCUSSION.....	16
<i>Oncorhynchus nerka</i> Population Monitoring.....	16
Redfish Lake.....	16
Alturas Lake.....	17
Pettit Lake.....	17
Redfish Lake Sport Fishery Investigations .....	18
LITERATURE CITED.....	24
PART 3—SOCKEYE SALMON JUVENILE OUT-MIGRANT AND ADULT SPAWNING MONITORING AND EVALUATION.....	25
INTRODUCTION .....	25
SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION .....	25
ADULT SPAWNING MONITORING AND EVALUATION .....	25
METHODS.....	26
SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION .....	26
Redfish Lake Creek Trap .....	26
Alturas Lake Creek Trap .....	27
Pettit Lake Creek Trap .....	27
Salmon River and Redfish Lake Creek Smolt Groups.....	27
Mainstem Snake and Columbia River Dams .....	27
ADULT SPAWNING MONITORING AND EVALUATION .....	28
Sockeye Salmon Spawning Investigations.....	28
Unmarked Juvenile Out-migrant Monitoring .....	28
Adult Trapping on Redfish Lake Creek.....	29
RESULTS AND DISCUSSION.....	29
SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION .....	29
Redfish Lake Creek Trap .....	29
Alturas Lake Creek Trap .....	30

**Table of Contents, continued.**

	<b><u>Page</u></b>
Pettit Lake Creek Trap .....	30
Salmon River and Redfish Lake Creek Smolt Groups .....	30
Mainstem Snake and Columbia River Dams .....	31
SOCKEYE SALMON SPAWNING INVESTIGATIONS AND UNMARKED JUVENILE OUT-MIGRANT MONITORING .....	31
Sockeye Salmon Spawning Investigations .....	31
Unmarked Juvenile Out-migrant Monitoring .....	32
LITERATURE CITED .....	40
PART 4—PREDATOR SURVEYS .....	42
INTRODUCTION .....	42
METHODS .....	42
Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek.....	43
RESULTS AND DISCUSSION .....	43
Fishhook Creek.....	43
Alpine Creek .....	43
Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek.....	44
LITERATURE CITED .....	49
APPENDICES .....	50

## LIST OF TABLES

		<u>Page</u>
Table 1.	Eyed-egg production by IDFG and NOAA facilities for the Snake River sockeye salmon captive broodstock program 1991—2008. ....	6
Table 2.	Snake River sockeye salmon captive broodstock program egg and fish reintroduction history 1993—2008. ....	6
Table 3.	Physical and morphometric characteristics of three study lakes located in the Sawtooth Valley, Idaho. ....	7
Table 4.	Sockeye salmon releases to Sawtooth Valley waters in 2007. ....	7
Table 5.	Sockeye salmon releases to Sawtooth Valley waters in 2008. ....	8
Table 6.	Estimated <i>O. nerka</i> population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2008. ....	19
Table 7.	Estimated 2008 <i>O. nerka</i> abundance, density (fish/ha), and biomass (kg/ha) by age class in Redfish, Alturas, and Pettit lakes. ....	20
Table 8.	Estimated kokanee escapement to Fishhook Creek 1991 to 2008 and Alturas Lake Creek 1992 to 2007. Data obtained from the Shoshone-Bannock Tribes. ....	21
Table 9.	Estimated angler effort on Redfish Lake for the 2008 fishing season. ....	21
Table 10.	Historical kokanee catch rates, kokanee harvest estimates, bull trout catch rates, and angler effort for the Redfish Lake fishery. ....	21
Table 11.	Catch rates (fish/hour) for summer 2008 on Redfish Lake categorized by day type and species. ....	22
Table 12.	Estimated number of fish harvested and released on Redfish Lake during the summer 2008. ....	22
Table 13.	Summary of 2008 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Sawtooth Fish Hatchery (SFH) was the rearing location for the fall-direct released (FDR) presmolts and Salmon River smolt release group. Oxbow Fish Hatchery (OFH) was the rearing location for the Redfish Lake Creek smolt release. ....	33
Table 14.	Out-migration estimate for natural and hatchery origin sockeye salmon smolts captured at the Redfish Lake Creek trap from April 18 to June 17, 2008. ....	34
Table 15.	Estimated overwinter survival and out-migration for Sawtooth Fish Hatchery-reared presmolts released in the fall to Redfish, Alturas, and Pettit lakes (2000-Present). ....	34
Table 16.	Redfish Lake Sockeye Salmon Captive Broodstock Program prespawm adult release history (1993-Present). ....	35
Table 17.	Summary of sockeye salmon redd observations in Redfish Lake in 2008. ....	35
Table 18.	Bull trout adult fish counts and redd counts in index sections of Fishhook Creek from 1998 to 2008. ....	45
Table 19.	Bull trout adult fish counts and redd counts in index sections of Alpine Creek from 1998 to 2008. ....	45
Table 20.	Bull trout relocation effort; juvenile out-migrant trapping at Redfish Lake Creek, 2008. ....	46

## LIST OF FIGURES

		<u>Page</u>
Figure 1.	Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.....	9
Figure 2.	Estimated bull trout catch rates from 1996-2008 within Redfish Lake. The trend line is used to show the population increase within the lake. The equation for the trend line is $y = 0.0059x + 0.13$ with an $R^2$ of 0.05. ....	23
Figure 3.	Daily capture of natural origin and hatchery origin sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2008 out-migration.....	36
Figure 4.	Length frequency of natural (n = 486), and hatchery origin (n = 664) sockeye salmon smolts collected at Redfish Lake Creek trap in 2008.....	37
Figure 5.	Spawning locations for sockeye salmon in Redfish Lake: 1) Sockeye beach, 2) the south beach near the slide, 3) the area near the U.S. Forest Service transfer camp dock, and 4) west side spawning area used in 2008.....	38
Figure 6.	Natural origin sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2008 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).....	39
Figure 7.	Location bull trout redd index sections in Fishhook Creek in 2008. ....	47
Figure 8.	Location of bull trout redd index sections in Alpine Creek in 2008.....	48

## LIST OF APPENDICES

Appendix A.	Fork length (mm), weight (g) and age of <i>O. nerka</i> captured during midwater trawls conducted during September 2008 on Redfish, Pettit, and Alturas lakes. ....	51
Appendix B.	Arrival dates at Lower Granite Dam for PIT-tagged sockeye salmon smolts during the 2008 migration year. ....	54

## PART 1—PROJECT OVERVIEW

### BACKGROUND

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. Waples et al. (1991) described Snake River sockeye salmon as a species on the threshold of extinction, and it was listed as endangered under the Endangered Species Act (ESA) on November 20, 1991 (ESA; 16 U.S.C.A. §§1531 to 1544). Snake River sockeye salmon are one of 28 stocks of Pacific salmon and steelhead (*Genus: Oncorhynchus*) in the Columbia River basin currently listed as threatened or endangered under the Endangered Species Act (<http://www.nwr.noaa.gov/ESA-Salmon-Listings/upload/snapshot-7-09.pdf>).

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; actual adult escapement enumeration or estimations were not conducted. 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, 62 adults were estimated to have returned to the Sawtooth Valley. No redds or anadromous adults were identified 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 Snake River sockeye salmon's decline (Federal Register 1991).

The National Marine Fisheries Service (NMFS) listed Snake River sockeye salmon as an endangered species under the 1973 Endangered Species Act (as amended in 1978) in November of 1991 (Federal Register 1991). A population is considered a distinct population segment and, hence, a species for purposes of the Endangered Species Act if it represents an evolutionary significant unit of the biological species (Waples 1991). To be considered an evolutionary significant unit, 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 sockeye salmon population of the Snake River sockeye salmon stock. Snake River sockeye salmon are one of three remaining stocks of sockeye salmon in the Columbia River system; the other two stocks, Okanogan Lake sockeye salmon 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. Additionally, there has been no reported evidence of straying of sockeye salmon from the upper Columbia River into Redfish Lake (Waples et al. 1991; Winans et al. 1996). Mitochondrial DNA analyses completed in 2003 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 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).

Genetic investigations conducted during and after Snake River sockeye salmon were listed further refined genetic relationships between anadromous sockeye salmon, residual sockeye salmon, and resident kokanee present in Redfish Lake. The presence of all three of these life history strategies of *O. nerka* in Redfish Lake complicated the ESA listing. Anadromous *O. nerka* (sockeye salmon) 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* (sockeye salmon) spawn with anadromous sockeye salmon on the shoals of the lake in October and November. Residual sockeye salmon 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 lifecycle 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 nonindigenous to Redfish Lake and were periodically stocked from a range of hatchery sources beginning in 1930 and continuing through 1972 (Bowler 1990). Redfish Lake anadromous sockeye salmon, residual sockeye salmon, and out-migrants 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.

## **SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM**

The Snake River sockeye salmon captive broodstock program collected fish from the following sources for broodstock and reintroduction purposes: 1) anadromous adult returns that were trapped between 1990 and 1998 and retained for hatchery spawning, 2) residual adults that were trapped between 1992 and 1995 and retained for hatchery spawning, and 3) smolts that were trapped between 1991 and 1993, reared until maturity, and spawned in the hatchery. Sixth generation lineages of the founders are currently in captive broodstock culture. Both IDFG and National Oceanic and Atmospheric Administration (NOAA) Fisheries maintain Snake River sockeye salmon captive broodstocks. Groups of fish are 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 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. 2003a; Baker et al. 2005a, 2005b, 2006, 2007). Additionally, NOAA Fisheries rears annual captive broodstocks from the egg stage to maturity at the Manchester Research Station and Burley Creek Hatchery near Seattle, Washington (Flagg 1993; Flagg and McAuley 1994; Flagg et al. 1996, 2001; Frost et al. 2002, 2008).

The IDFG and NOAA Fisheries captive broodstock programs have produced approximately 4,201,412 eyed-eggs from 1991 through 2008 (Table 1). Each year approximately 1,200 eggs are selected to be reared in the hatchery as an annual captive broodstock; the remaining eggs are utilized for reintroduction into the habitat.

The development of captive broodstock program reintroduction plans follows a “spread-the-risk” philosophy incorporating multiple release strategies and multiple lakes (Hebdon et al.

2004). 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 November and December, 2) presmolt releases direct to lakes in October, 3) smolt releases to outlet streams in May, and 4) prespawn adult releases (hatchery-reared) direct to lakes in September. All hatchery-reared presmolt and smolt release groups are uniquely marked to identify release strategy and release origin. To date, approximately 2,927,671 sockeye salmon eggs and fish have been reintroduced to Sawtooth Valley waters (Table 2). Overall survival to release (over different strategies) from the eyed-egg stage of development has averaged just over 68% for the program.

Life history traits exhibited by wild sockeye salmon and habitat carrying capacity evaluations conducted by the Shoshone-Bannock Tribes (SBT) (Teuscher and Taki 1995, 1996; Taki and Mikkelsen 1997; Taki et al. 1999; Griswold et al. 2000; Lewis et al. 2000; Kohler et al. 2001, 2002, 2008) influence annual release plans. 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. Smolt out-migration from Redfish Lake begins in early April, peaks in mid-May, and is complete by mid-June. Smolts out-migrate at either age-1 or age-2; the proportion of age-1 and age-2 smolts varies every year. During their 11-year study, Bjornn et al. (1968) noted a dominance of age-1 smolts for six of the 11 years. Age-2 smolts ranged from 2% to 77% of the total out-migration over the course of the early monitoring effort. Age-2 smolts are common in many other sockeye salmon lakes. The reasons for the additional freshwater residence time are unclear (Burgner 1991). Smolt fork length ranges between 45 mm and 120 mm. Adult sockeye salmon begin arriving at Redfish Lake Creek in mid-July and continue escapement through early September. Sockeye salmon spawn over submerged beach substrate of the lake; spawning peaks in mid-October. Returning adults are primarily two-ocean fish (Bjornn et al. 1968).

Efforts to prevent extinction of the Snake River sockeye salmon are coordinated through the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), a team of biologists representing IDFG, the SBT, NOAA Fisheries, and the University of Idaho. The Bonneville Power Administration provides coordination for the SBSTOC process.

## **PROJECT GOALS**

The immediate goal of the program is to utilize captive broodstock technology to conserve the population's unique genetics. Long-term goals include increasing the number of individuals in the population to address NOAA's interim abundance guidelines and to provide sport and treaty harvest opportunity. Draft ESA delisting criteria for Snake River sockeye salmon includes the return of 1,000 adults to Redfish Lake, 500 adults to Pettit Lake, and 500 adults to Alturas Lake for two generations (NMFS 2002). Interim abundance targets must be met without relying on hatchery production (e.g., natural origin adults).

## **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 wild and broodstock 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 includes two areas of effort: 1) sockeye salmon captive broodstock culture, and 2) sockeye salmon research and evaluations. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to sockeye salmon captive broodstock culture appears under a separate cover (Baker et al. *in review*). Research and evaluation activities associated with Snake River sockeye salmon are permitted under the ESA (NOAA) Nos. 1120, 1124, and 1481 (for a review see Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000; Hebdon et al. 2002; Hebdon et al. 2003; Willard et al. 2003b; Willard et al. 2005). This report details fisheries research information collected between January 1 and December 31, 2008. Research information includes *O. nerka* population monitoring in Sawtooth Valley lakes, sport fishery evaluation on Redfish Lake, smolt out-migration monitoring and evaluation at lake outlets, telemetry studies of mature adult sockeye salmon released to Sawtooth Valley lakes for natural spawning, and predator investigations 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 under the ESA listing. 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 3). 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*, redbside 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 are released into Pettit, Alturas, and Stanley lakes in the summer to increase sportfishing opportunities. Sportfishing on Pettit, Alturas, and Stanley lakes is 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 15 kokanee per day with no seasonal closures. Sportfishing regulations on Redfish Lake restrict kokanee fishing/harvest to

January 1 through August 7 to protect residual sockeye salmon. No trout have been stocked in Redfish Lake since 1992.

### **2007 and 2008 Captive Broodstock Program Egg and Juvenile Supplementation**

All hatchery origin sockeye salmon released to Sawtooth Valley waters were adipose fin-clipped to distinguish hatchery rearing origin and/or release strategy. A subsample of some of the release groups was PIT tagged prior to release.

In 2007, 184,275 sockeye salmon and 51,008 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 4). All presmolts released in 2007 were brood year 2006 (BY06) age-0 fish reared at IDFG Sawtooth Fish Hatchery (SFH) and were adipose fin clipped (AD). Redfish Lake received 62,015 presmolts (988 PIT tagged), Alturas Lake received 9,977 presmolts (1,005 PIT tagged), and Pettit Lake received 10,113 presmolts (993 PIT tagged) in October by direct lake releases. Smolts were released to the Salmon River and Redfish Lake Creek on May 8, 2007. A total of 101,676 BY05 smolts were released at two separate release sites (47,094 below the river water intake to SFH and 54,582 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at three locations: IDFG Sawtooth Fish Hatchery (SFH), IDFG Eagle Fish Hatchery (EFH), and ODFW Oxbow Fish Hatchery (OFH). All sockeye released from SFH, and OFH were coded-wire tagged, differentially marked (Oxbow FH fish were AD/RV clipped; SFH and EFH fish were AD-clipped) and had representative groups PIT tagged (1,019 OFH, 1,025 SFH, and 329 EFH). Four hundred ninety-four hatchery-produced adult sockeye salmon (all reared at NOAA Burley Creek Hatchery) were released to Redfish Lake for volitional spawning in September. In November, 51,008 eyed-eggs (reared at NOAA Burley Creek Hatchery) were planted in Pettit Lake.

In 2008, 235,369 sockeye salmon and 67,984 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). All presmolts released in 2008 were age-0 fish from brood year 2007 (BY07) reared at SFH. Redfish Lake received 57,093 presmolts (1,006 PIT tagged), Alturas Lake received 16,864 presmolts (974 PIT tagged), and Pettit Lake received 10,048 presmolts (1,005 PIT tagged) in October by direct lake releases. Smolts were released to the Salmon River on May 7, 2008. A total of 150,395 BY06 smolts were released at two separate release sites (76,587 below the river water intake to SFH and 73,808 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at two locations: IDFG Sawtooth Fish Hatchery and ODFW Oxbow Fish Hatchery. All sockeye smolts released were coded-wire tagged, differentially marked (Oxbow FH fish were AD/LV clipped; SFH fish were AD-clipped), and had representative groups PIT tagged (988 OFH, 979 SFH). Three hundred ninety-eight hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September. A total of 571 anadromous return adult sockeye salmon were released into Redfish Lake between September 2 and September 16, 2008 for volitional spawning. In November and December, 67,984 eyed-eggs reared at NOAA Burley Creek Hatchery and Eagle Fish Hatchery were planted in Pettit Lake.

Table 1. Eyed-egg production by IDFG and NOAA facilities for the Snake River sockeye salmon captive broodstock program 1991—2008.

<b>Brood year</b>	<b>Eyed-eggs produced by IDFG</b>	<b>Eyed-eggs produced by NOAA</b>
1991	1,978	0
1992	36	0
1993	13,647	0
1994	259,536	48,000
1995	3,006	0
1996	110,756	381,500
1997	152,760	171,965
1998	15,580	47,533
1999	63,168	65,400
2000	253,047	94,500
2001	121,320	90,859
2002	66,324	60,516
2003	303,983	139,359
2004	140,823	135,699
2005	145,207	143,362
2006	258,342	190,603
2007	175,810	192,354
2008	220,334	134,105
<b>Total:</b>	<b>2,305,657</b>	<b>1,895,755</b>

Table 2. Snake River sockeye salmon captive broodstock program egg and fish reintroduction history 1993—2008.

<b>Year of reintroduction</b>	<b>Eyed-eggs</b>	<b>Presmolts</b>	<b>Smolts</b>	<b>Hatchery-reared adults</b>	<b>Anadromous Adults</b>
1993	0	0	0	20	0
1994	0	14,119	0	65	0
1995	0	91,572	3,794	0	0
1996	105,000	1,932	11,545	120	0
1997	105,767	255,711	0	120	0
1998	0	141,871	81,615	0	0
1999	20,311	40,271	9,718	21	3
2000	65,200	72,114	148	271	200
2001	0	106,166	13,915	79	14
2002	30,924	140,410	38,672	190	12
2003	199,666	76,788	0	315	0
2004	49,134	130,716	96	241	0
2005	51,239	72,108	78,330	173	0
2006	184,596	107,292	86,052	464	0
2007	51,008	82,105	101,676	494	0
2008	67,914	84,005	150,395	398	571
<b>Total</b>	<b>930,764</b>	<b>1,417,180</b>	<b>575,956</b>	<b>2,971</b>	<b>800</b>

Table 3. Physical and morphometric characteristics of three study lakes located in the Sawtooth Valley, Idaho.

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

Table 4. Sockeye salmon releases to Sawtooth Valley waters in 2007.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks <sup>a</sup>	Number PIT-tagged	Mean Release Weight (g)	Rearing Location
Salmon River (above SFH weir)	Smolt (2005)	05/08/2007	46,765	AD/CWT	1,025	21.7	SFH
			329	AD	329	69.0	EAG
Redfish Lake Creek (Below weir)	Smolt (2005)	05/08/2007	54,582	ADRV/CWT	1,019	51.6	OFH
Alturas Lake (direct lake)	Presmolt (2006)	10/02/2007	9,977	AD	1,005	7.1	SFH
Pettit Lake (direct lake)	Presmolt (2006)	10/03/2007	10,113	AD	993	7.0	SFH
Redfish Lake (direct lake)	Presmolt (2006)	10/03/2007	62,015	AD	988	6.7	SFH
Redfish Lake (direct lake)	Adult (2002)	09/05/2007	2	PIT	2	1,500.0	NOAA-BC
		09/05/2007	53	PIT	53	3,200.0	NOAA-BC
		09/05/2007	126	PIT	126	1,300.0	NOAA-BC
		09/05/2007	182	PIT	182	1,300.0	NOAA-BC
		09/06/2007	90	PIT/AD	90	1,126.0	EAG
		09/10/2007	41	PIT/AD	41	1,087.0	EAG
Pettit Lake (direct lake)	Eyed-egg (2007)	11/27/2007	51,008	NA	NA	NA	NOAA-BC

<sup>a</sup> AD = adipose fin-clip, ADRV/CWT = adipose fin, right ventral fin-clip, coded-wire tagged.

<sup>b</sup> SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EAG = Idaho Department of Fish and Game Eagle Fish Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery; NOAA-MML = National Oceanic Administration Manchester Marine Lab.

Table 5 Sockeye salmon releases to Sawtooth Valley waters in 2008.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks <sup>a</sup>	Number PIT-tagged	Mean Release Weight (g)	Rearing Location <sup>b</sup>
Salmon River (above SFH weir)	Smolt (2006)	05/07/2008	76,587	AD/LV/CWT	998	44.3	OFH
Redfish Lake Creek (Below weir)	Smolt (2006)	05/07/2008	73,808	AD/CWT	979	17.6	SFH
Alturas Lake (direct lake)	Presmolt (2007)	10/06/2008	16,864	AD	974	5.1	SFH
Pettit Lake (direct lake)	Presmolt (2007)	10/06/2008	10,048	AD	1,005	5.6	SFH
Redfish Lake (direct lake)	Presmolt (2007)	10/07/2008	57,093	AD	1,006	5.0	SFH
Redfish Lake (direct lake)	Adult Anadromous	09/02/2008	57	Mix		1,280.7	ANAD
	Anadromous	09/16/2008	413	Mix	2	1,279.5	ANAD
	Anadromous	09/16/2008	101	Mix	1	1,203.6	ANAD
	Captive	09/16/2008	253	AD	253	1,263.3	NOAA-BC
	Captive	09/17/2008	145	PIT	145	1,235.6	EAG
Pettit Lake (direct lake)	Eyed-egg (2008)	11/25/2008	24,678	NA	NA	NA	NOAA-BC
		12/3/2008	43,306	NA	NA	NA	EAG

<sup>a</sup> AD = adipose fin-clip, ADRV/CWT = adipose fin, right ventral fin-clip, coded-wire-tagged.

<sup>b</sup> ANAD= Anadromous adult return; SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EAG = Idaho Department of Fish and Game Eagle Fish Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

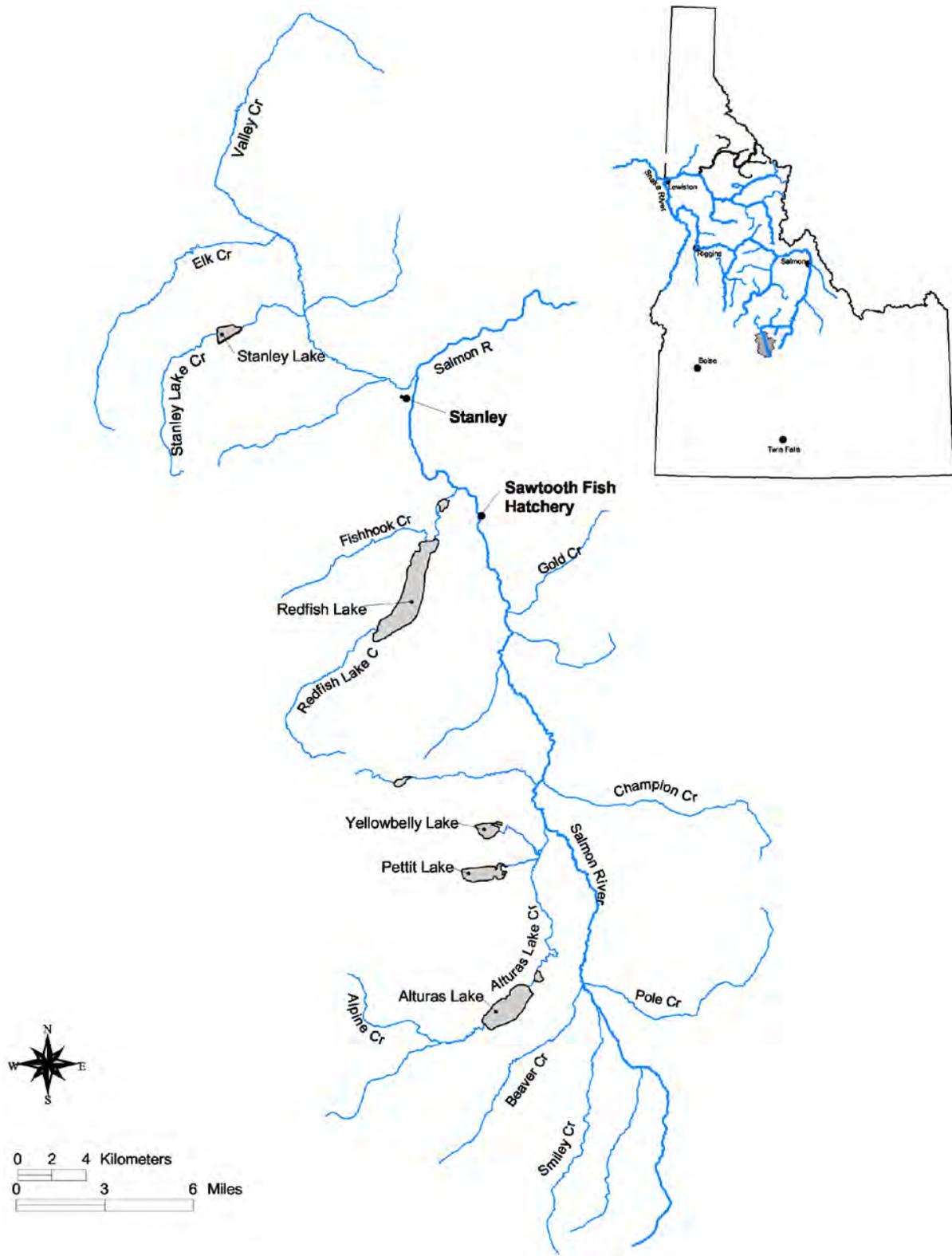


Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

## LITERATURE CITED

- Baker, D., J. Heindel, J. Redding, and P. A. Kline. In review. Snake River sockeye salmon captive broodstock program, hatchery element, 2007. Project no. 91-72. Portland, Oregon, Bonneville Power Administration, Annual Report.
- Baker, D., J. Heindel, J. Redding, and P. A. Kline. 2005a. Snake River sockeye salmon captive broodstock program, hatchery element, 2003. Project no. 91-72. Portland, Oregon, Bonneville Power Administration, Annual Report.
- Baker, D., J. Heindel, J. Redding, and P. A. Kline. 2005b. Snake River sockeye salmon captive broodstock program, hatchery element, 1999. Project no. 91-72. 2005. Portland, Oregon, Bonneville Power Administration, Annual Report.
- Baker, D. J., J. A. Heindel, J. J. Redding, and P. A. Kline. 2006. Snake River sockeye salmon captive broodstock program, hatchery element, 2005. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Baker, D. J., J. A. Heindel, J. J. Redding, and P. A. Kline. 2007. Snake River sockeye salmon captive broodstock program, hatchery element, 2006. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Bjornn, T. C., D. R. Craddock, and D. R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, sockeye salmon, *Oncorhynchus nerka*. Transactions of the American Fisheries Society 97:360-375.
- Bowler, B. 1990. Additional information on the status of Snake River sockeye salmon. Idaho Department of Fish and Game. Boise, Idaho.
- Brannon, E. L., A. L. Setter, T. L. Welsh, S. J. Rocklage, G. H. Thorgaard, and S. A. Cummings. 1992. Genetic analysis of *Oncorhynchus nerka*. Project no. 199009300. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Brannon, E. L., T. Welsh, R. Danner, K. Collins, M. Casten, G. H. Thorgaard, K. Adams, and S. Cummings. 1994. Genetic analysis of *Oncorhynchus nerka*: Life history and genetic analysis of Redfish Lake *Oncorhynchus nerka*. Project no. 199009300. Bonneville Power Administration, Completion Report. Portland, Oregon.
- Burgner, R. L. 1991. Life History of Sockeye Salmon. Pages 3-117 in C. Groot, and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press. Vancouver, British Columbia.
- Chapman, D. W., W. S. Platts, D. Park, and M. Hill. 1990. Status of Snake River sockeye salmon. Final report for Pacific Northwest Utilities Conference Committee. Don Chapman Consultants Inc. Boise, Idaho.
- Cummings, S. A., E. L. Brannon, K. J. Adams, and G. H. Thorgaard. 1997. Genetic analyses to establish captive breeding priorities for endangered Snake River sockeye salmon. Conservation Biology 11:662-669.

- Evermann, B. W. 1895. A preliminary report upon salmon investigations in Idaho in 1894. Bulletin of the United States Fish Commission 15:253-285.
- Evermann, B. W. 1896. A report upon salmon investigations in the headwaters of the Columbia River, in the state of Idaho, in 1895. U.S. Fish Commission Bulletin 16:151-202.
- Faler, J. C., and M. S. Powell. 2003. Genetic analysis of Snake River sockeye salmon (*Oncorhynchus nerka*). Bonneville Power Administration Annual Report. Portland, Oregon.
- Federal Register. 1991. Endangered and threatened species; endangered status for Snake River sockeye salmon-910379-1256. 91. Department of Commerce, National Oceanic and Atmospheric Administration, 50 CFR Part 222.
- Flagg, T. A. 1993. Redfish Lake sockeye salmon captive broodstock rearing and research, 1991-1992. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Flagg, T. A., and W. C. McAuley. 1994. Redfish Lake sockeye salmon captive broodstock rearing and research, 1991-1993. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Flagg, T. A., W. C. McAuley, M. R. Wastel, D. A. Frost, and C. V. W. Mahnken. 1996. Redfish Lake sockeye salmon captive broodstock rearing and research, 1994. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Flagg, T. A., W. C. McAuley, D. A. Frost, M. R. Wastel, W. T. Fairgrieve, and C. V. W. Mahnken. 2001. Redfish Lake sockeye salmon captive broodstock rearing and research, 1995-2000. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Frost, D. A., W. C. McAuley, D. J. Maynard, and T. A. Flagg. 2002. Redfish Lake sockeye salmon captive broodstock rearing and research, 2001. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Frost, D. A., W. C. McAuley, D. J. Maynard, M. R. Wastel, B. Kluver, and T. A. Flagg. 2008. Redfish Lake sockeye salmon captive broodstock rearing and research, 2007. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Griswold, R., A. Kohler, and D. Taki. 2000. Salmon River sockeye salmon habitat and limnological research: 1999 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Hebdon, J. L., M. Elmer, and P. Kline. 2000. Snake River sockeye salmon captive broodstock program, research element, 1999. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Hebdon, J. L., J. Castillo, and P. Kline. 2002. Snake River sockeye salmon captive broodstock program, research element, 2000. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

- Hebdon, J. L., J. Castillo, C. Willard, and P. Kline. 2003. Snake River sockeye salmon captive broodstock program, research element, 2001. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Hebdon, J. L., P. A. Kline, D. Taki, and T. A. Flagg. 2004. Evaluating reintroduction strategies for Redfish Lake sockeye salmon captive broodstock progeny. American Fisheries Society Symposium 44: 401-413.
- Johnson, K. 1993. Research and recovery of Snake River sockeye salmon, 1992. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Johnson, K., and J. Pravecsek. 1995. Research and recovery of Snake River sockeye salmon, 1993. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Johnson, K., and J. Pravecsek. 1996. Research and recovery of Snake River sockeye salmon, 1994-1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P. 1994. Research and recovery of Snake River sockeye salmon, 1993. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., and J. Younk. 1995. Research and recovery of Snake River sockeye salmon, 1994. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., and J. A. Lamansky. 1997. Research and recovery of Snake River sockeye salmon, 1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., and J. Heindel. 1999. Snake River sockeye salmon captive broodstock program, hatchery element, 1998. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., and C. Willard. 2001. Snake River sockeye salmon captive broodstock program, hatchery element, 2000. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., J. Heindel, and C. Willard. 2003a. Snake River sockeye salmon captive broodstock program, hatchery element, 1997. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., C. Willard, and D. Baker. 2003b. Snake River sockeye salmon captive broodstock program, hatchery element, 2001. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kohler A., B. Griswold, and D. Taki. 2001. Snake River sockeye salmon habitat and limnological research: 2000 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

- Kohler A., D. Taki, and B. Griswold. 2002. Snake River sockeye salmon habitat and limnological research: 2001 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kohler A., B. Griswold, D. Taki and S. Letzing. 2008. Snake River sockeye salmon habitat and limnological research: 2008 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Lewis, B., D. Taki, and R. Griswold. 2000. Snake River sockeye salmon habitat and limnological research: 2000 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- National Oceanic and Atmospheric Administration (NOAA). 2005. Endangered Species Act status review and listing information. (<http://www.nwr.noaa.gov/ESA-Salmon-Listings/upload/snapshot-7-09.pdf>).
- NMFS. 2002. Interim Abundance Targets. Seattle, Washington, National Oceanic and Atmospheric Administration.
- Pravecek, J., and K. Johnson. 1997. Research and recovery of Snake River sockeye salmon, 1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Pravecek, J., and P. Kline. 1998. Research and recovery of Snake River sockeye salmon, 1996. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Taki, D., and A. Mikkelsen. 1997. Salmon River sockeye salmon habitat and limnological research: 1996 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Taki, D., B. Lewis, and R. Griswold. 1999. Salmon River sockeye salmon habitat and limnological research: 1997 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Teuscher, D., and D. Taki. 1995. Salmon River sockeye salmon habitat and limnological research, In Teuscher, D., and D. Taki (ed). Snake River sockeye salmon habitat and limnological research: 1994 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Teuscher, D., and D. Taki. 1996. Salmon River sockeye salmon habitat and limnological research, In Teuscher, D., and D. Taki (ed). Snake River sockeye salmon habitat and limnological research: 1995 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Waples, R. S. 1991. Definition of a "species" under the Endangered Species Act: Application to Pacific Salmon. Seattle, Washington, U. S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-F/NWC 194.

- Waples, R. S., O. W. Johnson, and R. P. Jones Jr. 1991. Status review for Snake River sockeye salmon. Seattle, Washington, U. S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-F/NWC 195.
- Waples, R. S., P. B. Aebersold, and G. A. Winans. 1997. Population genetic structure and life history variability in *Oncorhynchus nerka* from the Snake River Basin. Project no. 93-068. Portland, Oregon, Bonneville Power Administration Annual Report.
- Willard, C., D. Baker, J. Heindel, J. Redding, and P. Kline. 2003a. Snake River sockeye salmon captive broodstock program, hatchery element, 2002. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Willard, C., J. L. Hebdon, J. Castillo, J. Gable, and P. Kline. 2003b. Snake River sockeye salmon captive broodstock program, research element, 2002. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Willard, C., K. Plaster, J. Castillo, and P. Kline. 2005. Snake River sockeye salmon captive broodstock program, research element 2003. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Winans, G. A., P. A. Aebersold, and R. S. Waples. 1996. Allozyme variability in selected populations of *Oncorhynchus nerka* in the Pacific Northwest, with special consideration of populations of Redfish Lake, Idaho. Transactions of the American Fisheries Society 205:645-663.

## **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 *O. nerka* abundance coupled with limnology data (collected and reported by the Shoshone-Bannock Tribes [SBT]) is necessary for making responsible decisions regarding the reintroduction of sockeye salmon juveniles from the captive broodstock program. Utilizing multiple release strategies at various life stages allows program managers to design reintroduction plans that take advantage of the nursery lakes' current carrying capacities, which are estimated by trawling, hydroacoustic surveys, and limnological surveys (hydroacoustic and limnological surveys conducted and reported by the SBT). Productivity in the lakes varies annually and the presence of kokanee in the nursery lakes creates increased competition for limited food sources between kokanee and sockeye salmon. During years in which a lake is experiencing low productivity and/or high kokanee abundance, the program limits reintroduction efforts of individuals that would spend more time in nursery lakes and diverts individuals to more productive lakes.

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 Permit 1481). 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. Permit 1481 (NOAA) 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 initiate spawning in Fishhook Creek, while residual sockeye salmon remain in the lake.

The roving creel survey conducted on Redfish Lake was designed to estimate total kokanee harvest and to collect tissue samples for genetic analysis from angler-harvested kokanee. The tissue samples were collected for genetic analysis to estimate the number of unmarked sockeye salmon harvested incidental to the kokanee fishery.

### **METHODS**

#### **Oncorhynchus nerka Population Monitoring**

To estimate *O. nerka* (kokanee and sockeye salmon) abundance, density, and biomass in Sawtooth Valley lakes, midwater trawling was conducted at night during the dark (new) phase of the moon in September. Spawning-age kokanee (>250 mm fork length) in Redfish and Alturas lakes migrate to tributaries to spawn in August; therefore, trawling is conducted in September to prevent the collection of biased trawl catch data and because juvenile *O. nerka* that remain in valley lakes are tightly stratified during this time of the year. Redfish, Pettit, and Alturas lakes were sampled September 29–October 1, 2008. Trawling was performed in a stepped-oblique fashion as described by Rieman (1992) and Kline (1994). A minimum of six trawl transects were conducted per lake. Total *O. nerka* abundance, density, and biomass were estimated using a program developed by Rieman (1992). Abundance estimates generated by this program are 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 are expressed in relation to lake surface area. Whenever possible, we estimated abundance, density, and biomass by

individual age class (assuming representation in the trawl). We calculated confidence intervals using the following formula of Scheaffer et al. (1990):

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

Fork length (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) and returned to the laboratory. Three program technicians aged scales to determine length ranges for age classification. Scales were mounted between microscope slides before aging and viewed with a microfiche. Complete fish carcasses were collected and sent to the University of Idaho's Center for Salmonid and Freshwater Species at Risk for proximate analysis (proximate analysis results are presented under a separate report cover produced by the University of Idaho). Stomachs were removed and preserved for diet analysis by SBT biologists. Heads were removed and submitted to IDFG's Eagle Fish Health Lab for whirling disease testing (results are covered under a separate cover; see Baker et al. *in review*) because the Myxosporean parasite, *Myxobolus cerebralis*, which can cause salmonid whirling disease, is present in the upper Salmon River. Fin clips were stored in 100% ethanol and delivered to the IDFG Genetics Laboratory for DNA analysis.

### **Redfish Lake Sport Fishery Investigations**

A roving creel survey was conducted from May 26 through August 6, 2008 (kokanee harvest closes on August 7 to protect residual sockeye salmon). 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 two 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. Fin clips were taken from harvested kokanee that were checked by creel survey personnel. Fin clips were stored in 100% ethanol and delivered to IDFG Genetics Laboratory personnel for DNA analysis. Creel data were analyzed using the Creel Census System computer program developed by McArthur (1992) and used to estimate angler effort, catch rates, and harvest.

## **RESULTS AND DISCUSSION**

### **Oncorhynchus nerka Population Monitoring**

#### **Redfish Lake**

October 1 trawl catch (six transects, Appendix A) included 20 natural origin *O. nerka* and zero hatchery origin sockeye salmon. *Oncorhynchus nerka* abundance was estimated at 26,284 fish (95% CI  $\pm$  13,226). The *O. nerka* population was 36% (within Redfish Lake) of the

estimated abundance in 2007 (73,702 fish) and 32% of the estimated abundance of *O. nerka* for 2006 (82,796; Table 6).

Density and biomass were estimated at 42.7 fish/ha and 0.29 kg/ha, respectively (Table 6). This represented decreases of 36% for densities and a 35% decrease in biomass from estimated levels in 2007 (Peterson et al. 2007). Age-0, age-1, and age-2 *O. nerka* were represented in the trawl sample from Redfish Lake. Age-0 fish had the highest density (25.4 fish/ha) and age-1 had the highest biomass (0.13 kg/ha; Table 7).

### **Alturas Lake**

September trawl catch on Alturas Lake (six transects, Appendix A) included 85 natural origin *O. nerka* and zero hatchery origin sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 71,088 fish (95% CI  $\pm$  34,189), 210.3 fish/ha, and 2.66 kg/ha, respectively (Table 6). Age-0, age-1, age-2, and age-3 *O. nerka* were represented in the trawl sample. Age-1 fish had the highest density (132.7 fish/ha) and contributed 46.2% of the biomass (Table 7). The estimates for abundance, density, and biomass represent decreases from 2007 estimates of 42.7%, 42.7%, and 22.2% respectively from 2007 (Table 6).

Kokanee control within the three nursery lakes has proven to be difficult because of many factors such as weir failure, otter damage to weirs and traps, and the lack of a permanent sill structure (A. Kohler, Shoshone Bannock Tribes, personal communication). Kokanee control should remain as a priority for the program to control zooplankton abundance and minimize *O. nerka* population fluctuations.

### **Pettit Lake**

September trawl catch on Pettit Lake (six transects, Appendix A) included 17 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 8,470 fish (95% CI  $\pm$  4,640), 52.9 fish/ha, and 1.28 kg/suitable ha, respectively (Table 6). Age-0, age-1, and age-2 fish were represented in the trawl sample. Age-0 fish had the highest density (37.4 fish/ha) and Age-2 fish had the highest biomass (1.00 kg/ha; Table 7). The estimates for abundance, density, and biomass represent decreases over 2007 estimates of 42.6%, 42.6%, and 66.7%, respectively.

With the additional knowledge we have gained by using the new trawling gear for three years, it appears we have also increased our ability to capture fish from the older age classes. Because these older age classes were missing from earlier datasets, it was difficult to accurately monitor a specific age class of kokanee through maturation. We are able to trawl 50% faster with the new gear, which may increase our capture efficiencies in the older age classes. We believe using the new trawling gear may provide us with more precise estimates of the older age classes of *O. nerka* found within Redfish, Alturas, and Pettit lakes. The estimates of older age (age-2 and older) *O. nerka* are likely the kokanee component of the population found within Redfish and Alturas and may be residual production within Pettit Lake.

It is possible that *O. nerka* populations within the basin lakes are expanding in response to fertilization (conducted by the SBT, reported under a separate cover), and sampling bias is not the cause of these rapid population fluctuations. Zooplankton abundance levels have remained high enough for *O. nerka* growth to occur within each lake (Robert Griswold, Bio-Lines, personal communication). We have also experienced high levels of adult escapement in

both Fishhook Creek and Alturas Lake Creek over the past couple of years (Table 8), which may have led to more recruitment into the systems.

Whether population fluctuations between 2006 and 2007 were a sampling response or a biological response, the estimates of these fish will help us to develop escapement goals, which are necessary to minimize kokanee and zooplankton population fluctuations. These goals should also provide a stable nursery habitat environment for sockeye salmon by reducing competition between kokanee and sockeye. Escapement goals will be established during the summer of 2009 (before kokanee enter the tributaries to spawn) and presented to the SBSTOC for discussion and modification.

Genetic samples collected from trawl-captured fish in 2008 have not been analyzed for any of the three basin lakes as of the completion of this report.

### **Redfish Lake Sport Fishery Investigations**

In 2008, we contacted 41 angler parties (95 individual anglers) on Redfish Lake. Idaho residents made up 97% of those interviewed. Most anglers used lures (87.3%), followed by bait (7.4%). Total angler effort was estimated at 2,424 hours (95% CI  $\pm$  452; Table 9). This effort estimate represents a 26% increase in fishing pressure between 2007 and 2008 (Table 10). Boat anglers expended more effort (77.1%) than bank anglers (22.9%), which was similar to results from 2007 (Peterson et al. 2007).

The season catch rate for all fish (harvested and released) was 0.26 fish/hour. Catch rates decreased 24% over the estimate from 2007 (Peterson et al. 2007). Kokanee catch rates (harvested and released) averaged 0.08 kokanee/hour for weekdays and 0.11 kokanee/hour for weekends (0.09 kokanee/hour for the season, Table 11). These estimates were also 25% lower than the estimate of 0.12 kokanee/hour for the season in 2007. Bull trout catch and release rates averaged 0.00 bull trout/hour for weekdays and 0.23 bull trout/hour for weekends (IDFG regulations prohibit harvesting bull trout; Table 11). We also estimated that 159 bull trout were caught and released from Redfish Lake during 2008 (Table 12). The season catch rate for bull trout is lower than observed rates from 2006 and 2007 (0.35 and 0.12 bull trout/hour respectively) and similar to catch rates observed in 2005 (0.09 bull trout/hour). We have seen a trend of overall increase in bull trout catch rates since the harvest closure in 1994 (Figure 2). This trend will be discussed further in Part 4 of this report under Predator Surveys. Other fish (cutthroat, northern pikeminnow, redband shiner, sucker *catostomus* spp.) accounted for a combined catch rate (harvested and released) of 0.08 fish/hour for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 508 fish (95% CI  $\pm$  154.8). This was an overall decrease of 19% from the 2007 estimate. The majority (71%) of all caught fish were released. Kokanee harvest was estimated at 106 fish (95% CI  $\pm$  92.4) and the number of kokanee released was estimated at 60 (95% CI  $\pm$  0.00) (Table 12). The harvest of kokanee increased an estimated 89.3%. In 2007, we observed the lowest harvest rate for kokanee since 2001 and the third lowest rate since the re-establishment of the kokanee fishery in 1995 (Table 10). Because of the low harvest rate and increased rate of released kokanee by anglers, we initiated an angler education program in the basin lakes to explain the importance of harvesting kokanee to reduce competition between the two forms of *O. nerka* found in the lakes (Peterson et al. 2007). This program began in the spring of 2007 and continued in 2008. We hope to determine if any additional fishing pressure is applied to Redfish Lake as a result of the program.

No hatchery-produced sockeye salmon (adipose-clipped) were observed by creel personnel during 2008. The direct impact of the kokanee fishery on residual sockeye salmon (through incidental harvest) is evaluated annually using genetic analysis of tissue samples collected from kokanee in the creel. Genetic analysis of fin clips obtained from harvested kokanee (n = 8) has not been completed for 2008.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2008.

Year	Population ( $\pm$ 95% CI)	Density (fish/ha)	Biomass (kg/ha)
<b>Redfish Lake (615 surface hectares)</b>			
2008	26,284 (13,226)	42.7	0.29
2007	73,702 (24,195)	119.8	0.84
2006	82,796 (47,407)	134.6	2.37
2005	56,220 (4,192)	91.4	0.3
2004	82,258 (3,486)	133.0	0.3
2003	81,727 (2,763)	132.9	1.6
2002	50,204 (4,085)	81.6	1.0
2001	12,980 (2,959)	21.1	<0.1
2000	10,268 (1,605)	16.7	<0.1
1999	42,916 (1,795)	69.7	0.9
1998	31,486 (1,716)	51.2	1.8
1997	55,762 (1,590)	90.7	2.5
1996	56,213 (3,526)	91.4	2.8
1995	61,646 (2,078)	100.2	4.4
1994	51,529 (4,902)	83.8	1.4
1993	49,628 <sup>a</sup>	80.7	1.6
1992	39,481 (2,498)	64.2	1.0
1990	24,431 (11,000)	39.7	0.8
<b>Alturas Lake (338 surface hectares)</b>			
2008	71,088 (34,189)	210.3	2.66
2007	124,073 (23,327)	367.1	3.43
2006	105,779 (50,702)	313.0	3.51
2005	20,956 (2,136)	98.8	0.3
2004	36,206 (2,579)	107.1	1.9
2003	46,234 (5,183)	136.8	5.5
2002	24,374 (2,328)	72.1	2.2
2001	70,159 (1,696)	207.6	2.4
2000	125,462 (1,572)	371.0	2.1
1999	56,675 (4,476)	167.7	0.4
1998	65,468 (2,860)	193.7	1.4
1997	9,761 (933)	28.9	2.1
1996	13,012 (691)	38.5	1.4
1995	23,061 (1,202)	68.2	1.7
1994	5,785 (1,957)	17.1	0.4
1993	49,037 (1,443)	145.1	2.6
1992	47,237 (3,782)	139.8	2.4
1991	125,045 (1,881)	370.0	3.9
1990	126,644 (1,690)	374.7	3.3

Table 6. Continued.

Year	Population ( $\pm$ 95% CI)	Density (fish/ha)	Biomass (kg/ha)
<b>Pettit Lake (160 surface hectares)</b>			
2008	8,470 (4,640)	52.9	1.28
2007	14,746 (7,099)	92.2	3.84
2006	33,246 (12,416)	207.8	7.4
2005	23,970 (2,136)	149.8	2.2
2004	46,065 (3,288)	287.9	9.8
2003	11,961 (626)	136.8	5.5
2002	18,328 (384)	114.5	12.1
2001	16,931 (1,311)	105.8	6.1
2000	40,559 (1,317)	253.5	10.2
1999	31,422 (2,515)	196.4	6.3
1998	27,654 (862)	172.8	9.7
1997	21,730 (1,462)	135.8	5.1
1996	71,654 (911)	447.8	15.3
1995	59,002 (1,653)	368.8	14.7
1994	14,743 (1,966)	92.1	3.1
1993	10,511 (640)	65.7	0.8
1992	3,009 (539)	18.8	2.5

<sup>a</sup> Confidence limits not calculated—single transect estimate.

Table 7. Estimated 2008 *O. nerka* abundance, density (fish/ha), and biomass (kg/ha) by age class in Redfish, Alturas, and Pettit lakes.

	Age-0	Age-1	Age-2	Age-3	Age-4	Total
<b>Redfish Lake (615 surface ha)</b>						
No. captured	12	7	1	0	0	20
Mean length (mm) ( $\pm$ 95 CI)	53.1	95.6	180.0	NA	NA	NA
Mean weight (g) ( $\pm$ 95 CI)	1.38	8.55	51.9	NA	NA	NA
Abundance	15,623	9,236	1,424	NA	NA	26,284
95% CI High	31,435	17,668	5,085	NA	NA	39,510
95% CI Low	0	804	0	NA	NA	13,058
Density (fish/ha)	25.4	15.0	2.3	NA	NA	42.7
Biomass (kg/ha)	0.04	0.13	0.12	NA	NA	0.29
<b>Alturas Lake (338 surface ha)</b>						
No. captured	15	53	21	4	0	85
Mean length (mm) ( $\pm$ 95 CI)	64.3	97.3	149.8	183.7	NA	NA
Mean weight (g) ( $\pm$ 95 CI)	2.35	9.22	37.19	65.75	NA	NA
Abundance	13,117	44,853	10,579	2,539	NA	71,088
95% CI High	30,390	69,416	18,345	5,456	NA	105,277
95% CI Low	0	20,290	2,813	0	NA	36,899
Density (fish/ha)	38.8	132.7	31.3	7.5	NA	210.3
Biomass (kg/ha)	0.09	1.23	0.96	0.38	NA	2.66
<b>Pettit Lake (160 surface ha)</b>						
No. captured	12	1	4	0	0	17
Mean length (mm) ( $\pm$ 95 CI)	64.0	165.0	190.5	NA	NA	NA
Mean weight (g) ( $\pm$ 95 CI)	2.92	55.00	80.0	NA	NA	NA
Abundance	5,989	490	1,991	NA	NA	8,470
95% CI High	10,430	1,749	3,608	NA	NA	13,110
95% CI Low	1,548	0	374	NA	NA	3,830
Density (fish/ha)	37.4	3.1	12.4	NA	NA	52.9
Biomass (kg/ha)	0.11	0.17	1.00	NA	NA	1.28

Table 8. Estimated kokanee escapement to Fishhook Creek 1991 to 2008 and Alturas Lake Creek 1992 to 2007. Data obtained from the Shoshone-Bannock Tribes.

<b>Year</b>	<b>Fishhook Creek</b>	<b>Alturas Lake Creek</b>
1991	7,200	No survey data
1992	9,600	60
1993	10,800	200
1994	9,200	3,200
1995	7,000	1,600
1996	10,662	744
1997	8,572	8,492
1998	6,149	15,237
1999	2,336	8,334
2000	60	827
2001	5,853	145
2002	8,626	99
2003	9,679	48
2004	1,508	7,101
2005	4,375	11,652
2006	14,021	2,276
2007	11,235	519
2008	4,908	10,312

Table 9. Estimated angler effort on Redfish Lake for the 2008 fishing season.

<b>Redfish Lake</b>	<b>Boat</b>	<b>Bank</b>	<b>Tube</b>	<b>Total</b>
Hours fished	1,870	554	0	2,424
±95% CI	423	91	0	452

Table 10. Historical kokanee catch rates, kokanee harvest estimates, bull trout catch rates, and angler effort for the Redfish Lake fishery.

	<b>Kokanee catch rates (fish/hour)</b>		<b>Kokanee harvested</b>	<b>Bull trout catch rate (fish/hr)</b>	<b>Angler parties interviewed</b>	<b>Estimated hours fished/season</b>
	<b>Harvested (fish/hour)</b>	<b>Released (fish/hour)</b>				
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

Table 11. Catch rates (fish/hour) for summer 2008 on Redfish Lake categorized by day type and species.

Day Type	Kokanee		Cutthroat Trout		Bull Trout		All Fish	
	Kept	Released	Kept	Released	Kept	Released	Kept	Released
Weekday	0.08	0.00	0.06	0.03	0.00	0.00	0.14	0.03
Weekend Day	0.00	0.11	0.00	0.03	0.00	0.23	0.00	0.40
Season Avg.	0.05	0.04	0.04	0.03	0.00	0.08	0.09	0.16

Table 12. Estimated number of fish harvested and released on Redfish Lake during the summer 2008.

Redfish Lake	Harvested				All Fish $\pm$ 95% CI
	Kokanee	Cutthroat Trout	Bull Trout	Other	
Harvested	106	42	0	0	148 $\pm$ 95.63
Released	60	126	159	15	360 $\pm$ 121.01

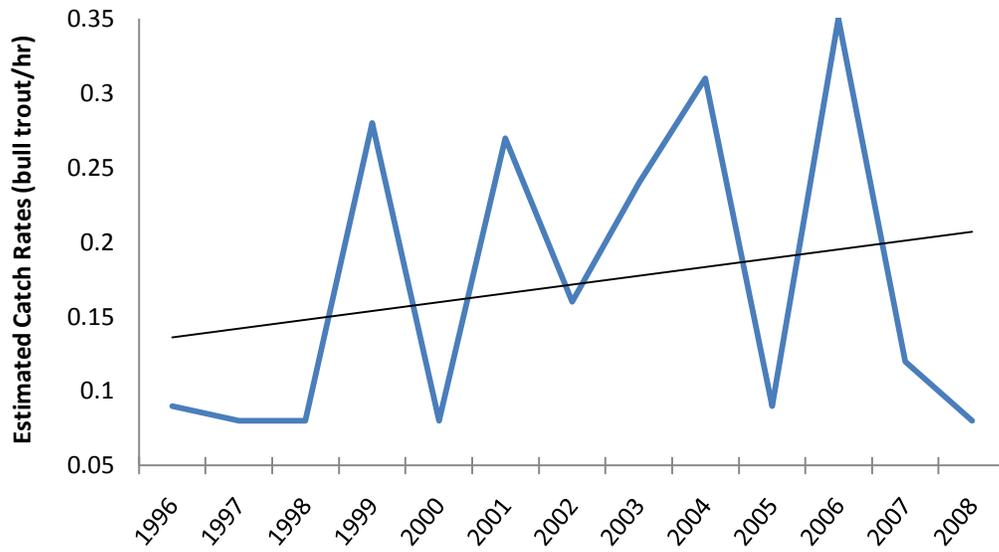


Figure 2. Estimated bull trout catch rates from 1996-2008 within Redfish Lake. The trend line is used to show the population increase within the lake. The equation for the trend line is  $y = 0.0059x + 0.13$  with an  $R^2$  of 0.05.

## LITERATURE CITED

- Baker, D., J. Heindel, D. Green, and P. Kline. *In review*. Snake River sockeye salmon captive broodstock program, hatchery element 2008. IDFG Draft Report. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P. A. 1994. Research and recovery of Snake River sockeye salmon. Idaho Department of Fish and Game. Annual Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-72, Contract No. DE-BI79-91BP21065. Portland, Oregon.
- McArthur, T. 1992. Statewide angler opinion and harvest surveys. Idaho Department of Fish and Game, Project No. F-71-R-14, Subproject I, Study I. Boise, Idaho.
- Peterson, M., B. Moore, K. Plaster and P. Kline. 2007. Snake River sockeye salmon captive broodstock program, research element 2006. IDFG Report no. 07-28. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Rieman, B. E. 1992. Kokanee salmon population dynamics—kokanee salmon monitoring guidelines. Idaho Department of Fish and Game, Project No. F-73-R-14, Subproject II, Study II. Boise, Idaho.
- Scheaffer, Mendenhall, and Ott. *Elementary Survey Sampling*. 1990. Duxbury Press.

## **PART 3—SOCKEYE SALMON JUVENILE OUT-MIGRANT AND ADULT SPAWNING MONITORING AND EVALUATION**

### **INTRODUCTION**

#### **SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION**

Monitoring overwinter survival and out-migration of sockeye salmon smolts plays an important role in restoration efforts. Trapping conducted on the lake outlet streams provides information on timing of out-migration and smolt sizes. Out-migrant monitoring provides an opportunity to monitor natural production of sockeye salmon in the lakes and to evaluate the success of different release strategies. This information allows us to make informed decisions regarding the placement of future captive broodstock progeny.

Out-migrant trapping also provides overwinter survival information for presmolts (fall direct-release) released into the nursery lakes in October the year prior to out-migrant trapping. Hatchery origin sockeye salmon smolts captured at lake out-migrant traps originated primarily from the October 2007 release of adipose fin-clipped presmolts numbering 62,015 sockeye, 9,977 sockeye, and 10,113 sockeye to Redfish, Alturas, and Pettit lakes, respectively (Table 13). All presmolts released in 2007 were reared at Sawtooth Fish Hatchery (SFH).

#### **ADULT SPAWNING MONITORING AND EVALUATION**

Releasing mature adult sockeye salmon into Sawtooth Valley lakes has been an important part of the "spread-the-risk" philosophy of the SBSTOC. Prespawn sockeye salmon adults were first released back to the wild in 1993. Adult sockeye salmon raised to maturity in the hatchery and released to valley lakes to spawn provide a "natural" or unmarked smolt component that is subject to natural selection. Beginning in 1999, hatchery origin anadromous sockeye salmon have been released into valley lakes (when available) along with adult sockeye salmon that were raised to maturity in a hatchery. Currently, prespawn adults are released only to Redfish Lake.

Success of releasing hatchery-produced adults to spawn naturally is evaluated by determining if there is a corresponding increase in production in the number of unmarked smolts out-migrating and observed egg-to-smolt survival. Unmarked out-migrants can be progeny of residual sockeye salmon adults that spawn in basin lakes, hatchery origin prespawn adults released to the lakes for natural spawning, anadromous adults released to the lakes for natural spawning, eyed-egg releases, or misclipped hatchery origin smolts. Juvenile kokanee (nonanadromous) could also "fall out" of nursery lakes and contribute to trap counts. The weirs on Redfish Lake Creek and Pettit Lake Creek and the screw trap on Alturas Lake Creek enable us to monitor and estimate unmarked out-migrating smolts and obtain genetic samples.

Current evaluations of adult sockeye salmon releases focus on the number of redds produced and estimations of unmarked juvenile out-migrants and collection of genetic material for future DNA parental exclusion analysis.

## METHODS

### SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

#### Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) is 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 only 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. 2007, 2008). The trap was operated from April 18 through June 17, 2008 and contains nine bays, five of which were fitted with incline bar traps. IDFG staff checked the trap at least twice daily in 2008. The trap is fished until high water forces us to remove it, until fish stop emigrating from the lake, or until mid-June (contract deadline for removal of trap and the placement of the adult trap).

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 fish from each 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 aged the discrepancies. 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 values (the scale ages in this case) and fits mixture distributions to grouped data by utilizing a maximum likelihood estimator. All captured nontarget species were counted and released immediately. Fin-clip samples were taken from all wild fish for future genetic analyses (Redfish Lake = 691, Alturas Lake = 318, Pettit Lake = 23). Tissue samples and complete fish carcasses were collected and sent to the University of Idaho's Center for Salmonid and Freshwater Species at Risk for proximate analysis (N = 58). These fish were measured for fork length (1 mm) and weighed to the nearest 0.1 g. Proximate sampled fish were sacrificed or were trap mortalities.

To estimate trapping efficiency, up to 20 natural origin sockeye salmon smolts (determined by presence of an adipose fin) and 20 hatchery origin sockeye salmon smolts were PIT tagged daily and released approximately 250 m upstream of the weir one-half hour after sunset. 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 fall direct-released sockeye salmon smolts. 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). Natural origin fish typically out-migrate earlier in the season than fall direct-release fish (Figure 3). 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). Smolt out-migration estimates were calculated separately for natural origin and fall direct-released hatchery origin sockeye salmon smolts. During the spring of 2008, we experienced normal flow conditions throughout the trapping season.

### **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 is located 13 km downstream from the Alturas Lake outlet and was operated from April 16 to June 10, 2008. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 9,977 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2007 (Table 13). The Alturas Lake out-migrant population estimate was derived using the same estimator described above (Steinhorst et al. 2004) except under extreme flow conditions when other methods are used to estimate out-migrant numbers, which would be presented under a separate cover provided by the SBT.

### **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 is located 1 km downstream from the Pettit Lake outlet at a permanent weir site and was operated from April 17–June 10, 2008. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 10,113 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2007 (Table 13). 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 is based on the actual number of smolts trapped. However, during normal to high flow years, the trap must be removed, and other means are used to estimate the number of out-migrants, which would be presented under a separate cover provided by the SBT.

### **Salmon River and Redfish Lake Creek Smolt Groups**

Seventy-six thousand five hundred eighty-seven (76,587) BY06 smolts were released near the river water intake of SFH (Table 13). This release included smolts reared at Oregon Department of Fish and Wildlife Oxbow Fish Hatchery (OFH). All fish released were adipose fin-clipped and coded-wire tagged with a representative group (n = 988) PIT tagged.

A total of 73,808 BY06 smolts were released into Redfish Lake Creek below the out-migrant weir (Table 13). This release group originated from smolts reared at SFH. All fish were adipose/right ventral fin-clipped and coded-wire-tagged with a representative group (n = 979) PIT tagged.

### **Mainstem Snake and Columbia River Dams**

In 2008, the majority of sockeye salmon smolts were transported and released below Bonneville Dam; this included PIT-tagged fish. As a result, mainstem survival evaluations were only conducted to Lower Granite Dam (LGR). Sockeye salmon smolt survival 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 to develop SURPH survival estimates to LGR. The SURPH model uses PIT tag detections at various dams to develop a Cormack/Jolly-Seber estimate of survival to LGR. Total natural origin and hatchery origin smolt out-migration (for each lake and different release strategy) 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 (Table 13).

## **ADULT SPAWNING MONITORING AND EVALUATION**

### **Sockeye Salmon Spawning Investigations**

Between September 2 and 17, 2008, 969 adult sockeye salmon were released to Redfish Lake (Table 16). Adult releases included 571 anadromous return adults, 253 adults raised at NOAA Burley Creek Hatchery, and 145 Eagle Fish Hatchery adult fish. Sex was determined by ultrasound on hatchery adults, and efforts were made to release fish of equal sex ratios.

In order to assist in identifying spawning locations, five male and five female hatchery-produced sockeye salmon were fitted with gastric implant radio transmitters prior to release. Telemetry investigations of adult locations began September 17, 2008 and continued weekly through November 7, 2008. Fish locations were recorded weekly by tracking movements via powerboat.

Redd counts were also conducted once a week (coinciding with radio telemetry events) beginning on October 29, 2008 and continuing until November 7, 2008. Suspected redds were generally enumerated by two observers on each count date. On the final count date, two boats with three observers each were used. Areas of excavation (possible redds) were generally 3 m x 3 m in size and likely represented spawning events by multiple parents. As such, we do not know how many parents contributed to the production of natural progeny in spawn year 2008. 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). We also performed redd counts on Little Redfish Lake in 2008.

### **Unmarked Juvenile Out-migrant Monitoring**

In 2008, unmarked out-migrants produced from program fish releases to Redfish Lake included age-1 out-migrants produced from 464 hatchery-origin adults released for volitional spawning in 2006 and age-2 out-migrants produced from 173 hatchery-origin adults released in 2005. Eyed egg releases (n = 104,688) to Alturas Lake and residual sockeye or kokanee spawning in 2006 would have produced age-2 unmarked out-migrants in 2008. Any age-1 unmarked out-migrants would have been produced by residual sockeye or kokanee found within Alturas Lake. Unmarked out-migrants produced from program fish releases to Pettit Lake included age-2 out-migrants produced from 79,908 eyed-eggs released in 2006. The proportions of age-1 and age-2 unmarked out-migration were determined for 2008 Redfish, Alturas, and Pettit lake out-migrants by aging scales. The methods for this analysis are discussed above.

## **Adult Trapping on Redfish Lake Creek**

The adult 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 3 and continued until October 20, 2008. During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2008, 381 adult anadromous sockeye and 89 adult bull trout were captured. An additional 50 sockeye were enumerated on August 14, 2008 and avoided capture in the adult weir, plus one anadromous sockeye was counted below the weir on October 20, 2008 when the weir was removed (total estimated escapement of anadromous sockeye to Redfish Lake Creek weir was 432).

## **RESULTS AND DISCUSSION**

### **SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION**

#### **Redfish Lake Creek Trap**

A total of 6,513 sockeye salmon smolts (1,274 natural origin and 5,239 hatchery origin) were trapped during the 2008 out-migration season (Figure 3). Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 105 mm (range 82 mm to 141 mm; Figure 4) and 104.6 mm (range 83 mm to 144 mm; Figure 4), respectively. Sockeye salmon smolt lengths were slightly shorter in 2008 than during the 2007 out-migration season.

Based on observed trapping efficiencies and discharge during out-migration monitoring, we determined that using three trapping intervals for the natural origin smolts was appropriate for estimating total natural origin sockeye salmon smolt out-migration. Of the 1,274 natural origin smolts handled in 2008, 504 were marked and released upstream of the weir to estimate trapping efficiency.

Trap efficiency decreased from a five-year average (2001-2005) of 42% to 25% during 2008. This was likely due to predation at the trap by small mammals, piscivorous birds, and bull trout and probably not due to the high flows observed. Several personnel visually observed hooded mergansers and bull trout harassing juvenile sockeye at the trap. The artificial decrease in trap efficiency would have caused us to overestimate the number of natural out-migrants. During 2008, we continued our capture and haul program to remove bull trout from the juvenile trap site so we can develop better out-migration estimates at the Redfish Lake Creek trap.

The 2008 total natural origin sockeye smolt out-migration was estimated at 6,237 fish (95% CI 5,210–7,624; Table 14). The proportion of age-1 natural origin smolts was estimated at 79%, which equals 4,927 smolts; the proportion of age-2 natural origin smolts was estimated at 21%, which equals 1,309 smolts. As referenced in the Methods section of this report, age proportions were estimated using the MIX software application.

Of the 5,239 fall direct-released smolts handled in 2008, 711 were marked and released upstream of the weir to estimate trap efficiency. Total fall direct-released smolt out-migration was estimated at 17,034 fish (95% CI 14,902–20,293; Table 14). Overwinter survival and out-migration for this group was 27% of the number of presmolts planted in 2007 (Table 15). The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated, using the MIX software application, at 94% (95% CI  $\pm$  0.7%), which equals 16,012 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 6% (95% CI  $\pm$  0.7%), which

equals 1,022 smolts. As mentioned above, these proportions are similar to those observed from past years.

### **Alturas Lake Creek Trap**

One thousand seven hundred fifty-one sockeye salmon smolts (1,354 natural origin and 397 hatchery origin) were trapped during the 2008 out-migration season. Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 89 mm (range 68 mm to 143 mm) and 94 mm (range 76 mm to 121 mm) respectively. The average size of out-migrating sockeye smolts was larger than in 2007 (Peterson et al. 2008).

Total natural origin sockeye smolt out-migration for Alturas Lake was estimated at 15,903 fish (95% CI 12,255–23,429; see SBT annual report to BPA for methods and calculations) and hatchery origin smolt out-migration was estimated at 5,273 fish (95% CI 3,947–6,265; see SBT annual report for methods and calculations; Table 13). Genetic samples were collected from out-migrating sockeye smolts to identify the source of out-migrants (whether these fish were produced by kokanee or residual sockeye). Overwinter survival and estimated out-migration for the fall direct-release group was 52.8% of the number of presmolts planted in 2007 (Table 15). Scales for aging were collected from natural origin smolts at the Alturas Lake Creek trap in 2008. The proportion of age-1 natural origin smolts was estimated, using the MIX software application, at 87.9% (95% CI 83.4%–92.4%), which equals 4,634 smolts, and the proportion of age-2 natural origin smolts was estimated at 12.1% (95% CI 7.6%–16.6%), which equals 638 smolts. We will continue to collect scales from these fish and monitor proportions for this population.

### **Pettit Lake Creek Trap**

Total natural origin sockeye smolt out-migration for Pettit Lake in 2008 was estimated at 100 fish (95% CI not calculated; see SBT annual report to BPA for methods and calculations) and hatchery origin smolt out-migration was estimated at 5,962 fish (95% CI not calculated; see SBT annual report for methods and calculations; Table 13). Overwinter survival and out-migration for fall 2007 direct-released presmolts was 58.9% (Table 15). Fork length of natural origin and fall direct-released sockeye salmon smolts captured averaged 129 mm (range 108 mm to 176 mm) and 125 mm (range 108 mm to 175 mm), respectively. Scales for aging were collected from natural origin smolts at the Pettit Lake Creek trap in 2008. The proportion of age-1 natural origin smolts was estimated using the MIX software application at 95.8% (95% CI 93.3%–98.3%), which equals 96 smolts; the proportion of age-2 natural origin smolts was estimated at 4.2% (95% CI 1.7%–6.7%), which equals four smolts. Age class proportions were similar for Pettit Lake as seen in 2006 and 2007 (Peterson et al. 2008).

### **Salmon River and Redfish Lake Creek Smolt Groups**

We released 73,808 BY06 smolts into Redfish Lake Creek below the out-migrant weir on May 7, 2008. This release group consisted of smolts reared at Sawtooth FH. All fish released were adipose fin-clipped and coded-wire-tagged with a representative group (n = 979) PIT tagged. Fork length of the Salmon River smolt group averaged 106.8 mm (range 82 mm to 140 mm), and these fish had an average weight of 12.9 g/fish.

A total of 76,587 BY06 smolts were released into the Salmon River above the Sawtooth FH river water intake upstream of the weir on May 7, 2008. This release included smolts reared at Oregon Department of Fish and Wildlife Oxbow FH. All fish were adipose/right ventral fin-

clipped and coded-wire-tagged with a representative group (n = 988) PIT tagged. The average length and weight of the Redfish Lake Creek smolt group was 144.9 mm (range 109 mm to 166 mm) and 33.1 g/fish (range 13.2 to 52.1 g/fish), respectively. Oxbow FH smolts are larger than Sawtooth FH smolts because of the warmer rearing water temperatures at Oxbow FH (spring water), and temperatures vary throughout the year at Sawtooth FH (Salmon River water).

### **Mainstem Snake and Columbia River Dams**

We estimated smolt out-migration success to LGR for natural origin and hatchery origin sockeye salmon smolt groups using PIT tag interrogation data (Table 13; Appendix B). Estimates reflect numbers of smolts that arrived at LGR based on results from data analyses using the SURPH model (Table 13). Survival among release groups ranged from 22% (Pettit Lake natural origin smolts) to 63% (Alturas Lake natural origin smolts). The average survival rate for all the release groups was 44.4% to LGR (down from 55% survival in 2007). An estimated 2,370 (38% survival) and 8,347 (49% survival) natural origin and fall direct-release sockeye smolts, respectively, survived to LGR from the Redfish Lake Creek trap. Survival from the Alturas Lake Creek trap to LGR was estimated at 10,018 (63% survival) for natural origin smolts and 3,111 (59% survival) for fall direct-release smolts. Survival from the Pettit Lake Creek trap to LGR was estimated at 22 (22% survival) for natural origin smolts and 1,848 (31% survival) for fall direct-release smolts. An estimated 34,690 (47% survival) sockeye smolts survived to LGR from the Salmon River smolt release group and 35,230 (46% survival) sockeye smolts survived from the Redfish Lake Creek smolt release. The total estimate for sockeye smolts that out-migrated from Stanley Basin waters and survived to LGR for 2008 was 95,637 (Table 13).

This was the third year we used the SURPH model to estimate survival and numbers of smolts to LGR. In the past, we had used daily collection efficiencies estimated for Chinook salmon smolts (Sandford and Smith 2002) and expanded PIT tag interrogation data to develop these estimates. The old methodology did not allow us to develop confidence intervals around the estimates, and annual out-migration estimates were generally not comparable due to variability in systems operations. We will continue to utilize the SURPH model to develop survival and total estimates to LGR and will run past program data through the model to enable us to make comparisons between years.

## **SOCKEYE SALMON SPAWNING INVESTIGATIONS AND UNMARKED JUVENILE OUT-MIGRANT MONITORING**

### **Sockeye Salmon Spawning Investigations**

The first redd was observed near Sockeye Beach at Redfish Lake on October 2, 2008. Redd counts were finalized with three observers each in two boats on November 7, 2008. This was the first year that we observed adults utilizing the area near Point Campground as a spawning location since the initiation of the project. Redd construction timing was similar to observations made in the past (Willard et al. 2005, Plaster et al. 2007). During the final counts, 338 redds (areas of excavation) were identified (Table 17). Seventy-nine redds were located near the Transfer Camp, 191 redds were located at the south beach area, 66 were located at Sockeye Beach, and two were counted on the west side of Redfish Lake near Point Campground (Table 17; Figure 5). This is the highest redd count since the project began and is likely the result of the largest adult release to date. Areas of excavation (possible redds) are typically large (~3 m x 3 m) and may represent multiple spawning events by multiple parents;

therefore, we do not know how many parents contributed to potential natural production in 2008. Radio-tagged fish moved to areas where redds were observed, and carcasses were recovered to verify spawning.

A total of nine areas of excavation were located in Little Redfish Lake in 2008.

### **Unmarked Juvenile Out-migrant Monitoring**

In 2008, 6,237 unmarked smolts (95% CI 5,210 to 7,624) were estimated to have out-migrated from Redfish Lake (Table 14), 15,903 unmarked smolts (95% CI 12,255 to 23,429) were estimated to have out-migrated from Alturas Lake, and 100 unmarked smolts were enumerated to have out-migrated from Pettit Lake (Table 13, Figure 6). The SBSTOC believes it is very important to utilize reintroduction strategies that produce natural origin smolts (e.g., prespawn adult releases and eyed-egg introductions). It is very difficult to evaluate the effectiveness of these release strategies while we have kokanee populations and potentially increasing residual populations within the basin lakes.

Since 2002, we have been working with the University of Idaho's Center for Salmonid and Freshwater Species at Risk and the Eagle Fish Genetics Laboratory to utilize DNA microsatellite methods to identify individual parental contribution to unmarked smolt production through parental exclusion analysis. Parental exclusion analysis allows assignment of an individual smolt to parents of a release strategy, allowing comparisons between the relative individual contribution of adults released to spawn volitionally and survival comparisons to certain life history stages (e.g., green-egg to smolt and/or fry to smolt survival) for various release strategies. Results would allow program managers to emphasize the release strategy with the highest reproduction potential. Additionally, parental exclusion analysis will allow for evaluation of the reproductive contribution of residuals and estimation of the number of kokanee that fall out. We are currently testing the assignments of juveniles from known adult crosses to see how well they assign and then we should be able to employ these techniques to samples collected in the field (C. Kozfkay, IDFG, personal communication).

Table 13. Summary of 2008 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Sawtooth Fish Hatchery (SFH) was the rearing location for the fall-direct released (FDR) presmolts and Salmon River smolt release group. Oxbow Fish Hatchery (OFH) was the rearing location for the Redfish Lake Creek smolt release.

Release strategy (rearing location)	Total released <sup>a</sup>	Number tagged prior to release	PIT tags detected at trap	Smolt out- migration estimate	Number tagged at trap	Estimated SURPH survival at LGR	SURPH <sup>c</sup> 95% CI (±)	Estimated no. at LGR
<u>Redfish Lake</u>								
Natural origin smolt	NA	NA	NA	6,237	504	38.00%	12.00%	2,370
FDR presmolt (SFH)	62,015	988	70	17,034	711	49.00%	12.00%	8,347
<u>Alturas Lake<sup>b</sup></u>								
Natural origin smolt	NA	NA	NA	15,903	427	63.00%	22.00%	10,019
FDR presmolt (SFH)	9,977	1,005	34	5,273	218	59.00%	16.00%	3,111
<u>Pettit Lake<sup>b</sup></u>								
Natural origin smolt	NA	NA	NA	100	23	22.00%	18.00%	22
FDR presmolt (SFH)	10,113	993	139	5,962	85	31.00%	6.00%	1,848
<u>Redfish Lake Creek</u>								
Hatchery origin smolt (SFH)	73,808	979	NA	73,808	NA	47.00%	8.00%	34,690
<u>Salmon River</u>								
Hatchery origin smolt (OFH)	76,587	988	NA	76,587	NA	46.00%	14.00%	35,230

<sup>a</sup> Total released from hatchery.

<sup>b</sup> Data from Alturas and Pettit lakes trap obtained from Shoshone-Bannock Tribes biologists.

<sup>c</sup> 95% CIs are two standard errors.

Table 14. Out-migration estimate for natural and hatchery origin sockeye salmon smolts captured at the Redfish Lake Creek trap from April 18 to June 17, 2008.

<b>Natural Origin smolts (three interval estimate)</b>				
	<u>Interval 1</u>	<u>Interval 2</u>	<u>Interval 3</u>	<u>Total</u>
Dates	4/18-5/8/08	5/9-6/6	6/7-6/17/08	4/18-6/17/08
Trap efficiency	0.29	0.20	0.25	
Marked	31	457	16	504
Recaptured	9	91	4	104
Total handled	42	1,215	16	1,273
Estimated total	134	6,049	54	6,237
95% CI upper bound	75	5,056	21	5,210
95% CI lower bound	240	7,364	119	7,624

<b>Hatchery origin smolts (four interval estimate)</b>					
	<u>Interval 1</u>	<u>Interval 2</u>	<u>Interval 3</u>	<u>Interval 4</u>	<u>Total</u>
Dates	4/18-5/8/08	5/9-5/22	5/23-5/29	5/30-6/17/08	4/18-6/17/08
Trap efficiency	0.20	0.30	0.30	0.34	
Marked	25	285	144	257	711
Recaptured	5	85	43	87	220
Total handled	36	1,584	2,750	869	5,239
Estimated total	156	5,268	9,063	2,548	17,034
95% CI upper bound	69	4,387	7,044	2,164	14,902
95% CI lower bound	303	6,327	11,737	3,037	20,293

Table 15. Estimated overwinter survival and out-migration for Sawtooth Fish Hatchery-reared presmolts released in the fall to Redfish, Alturas, and Pettit lakes (2000-Present).

<u>Out-migration Year</u>	<u>Redfish Lake</u>	<u>Alturas Lake</u>	<u>Pettit Lake</u>
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%

Table 16. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history (1993-Present).

Lake	Rearing origin	Date released	Number released	Number of suspected redds
Redfish	Full-term hatchery	1993	20	Unknown
Redfish	Full-term hatchery	1994	65	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	36	
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	Hatchery-produced anadromous	2001	14	12 to 15 suspected redds
Redfish	Full-term hatchery	2001	65	
Redfish	Hatchery-produced anadromous	2002	12	10 to 12 suspected redds
Redfish	Full-term hatchery	2002	178	
Redfish	Full-term hatchery	2003	312	42 suspected redds
Redfish	Full-term hatchery	2004	241	127 suspected redds
Redfish	Full-term hatchery	2005	173	78 suspected redds
Redfish	Full-term hatchery	2006	464	172 suspected redds
Redfish	Full-term hatchery	2007	494	195 suspected redds
Redfish	Full-term hatchery	2008	398	
Redfish	Hatchery-produced anadromous	2008	571	338 suspected redds
<b>Total</b>			<b>3,529</b>	

Table 17. Summary of sockeye salmon redd observations in Redfish Lake in 2008.

	Sockeye Beach	South Beach	Transfer Camp	West Side	Total
Final Count on 11/7/2008	66	191	79	2	338

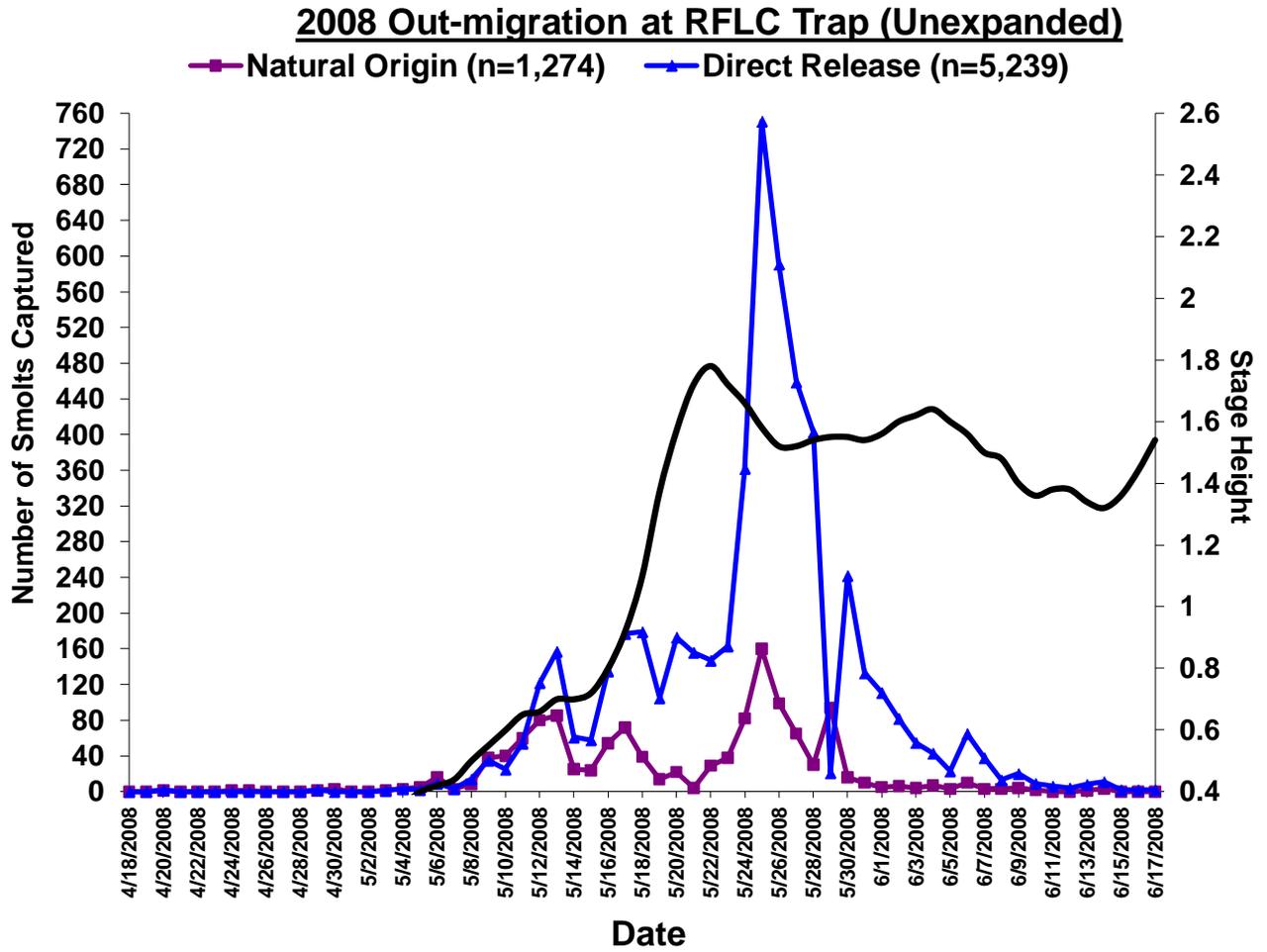


Figure 3. Daily capture of natural origin and hatchery origin sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2008 out-migration.

### Length Frequency for Natural and Hatchery Origin Sockeye Salmon smolts at Redfish Lake Creek trap 2008

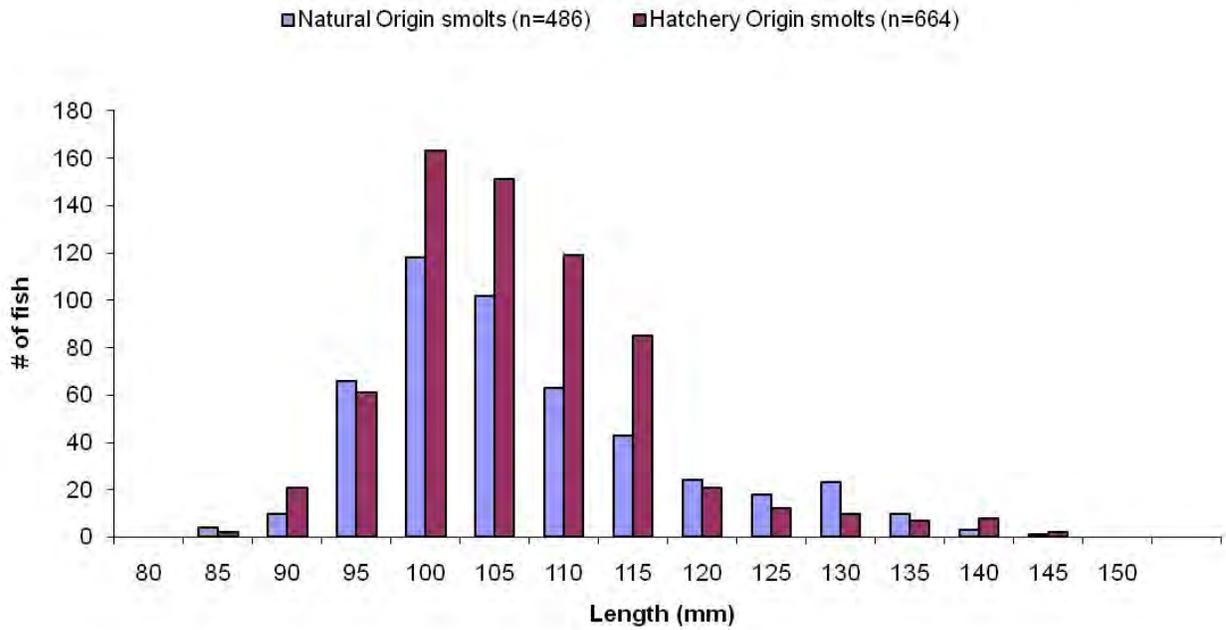


Figure 4. Length frequency of natural (n = 486), and hatchery origin (n = 664) sockeye salmon smolts collected at Redfish Lake Creek trap in 2008.

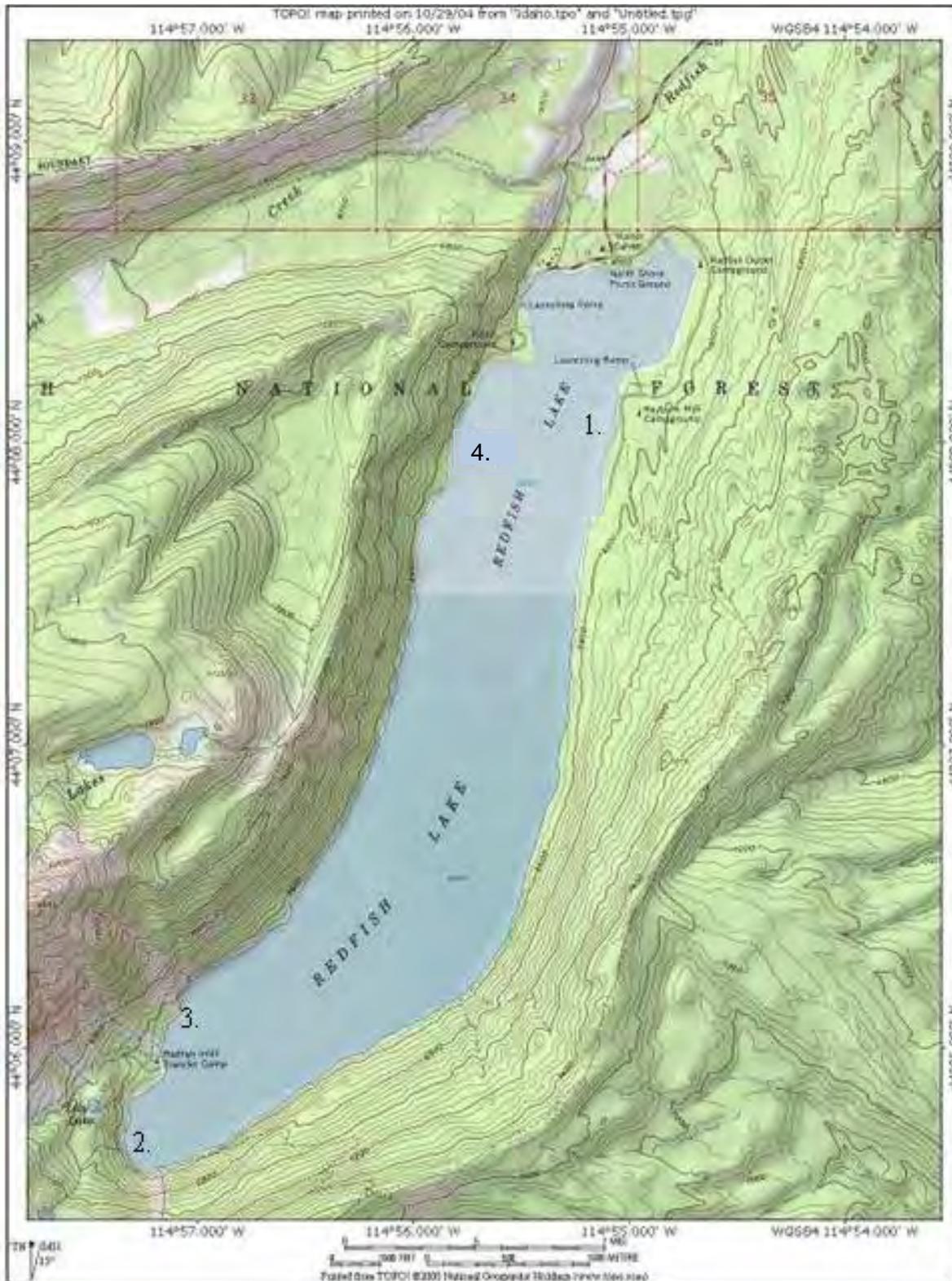


Figure 5. Spawning locations for sockeye salmon in Redfish Lake: 1) Sockeye beach, 2) the south beach near the slide, 3) the area near the U.S. Forest Service transfer camp dock, and 4) west side spawning area used in 2008.

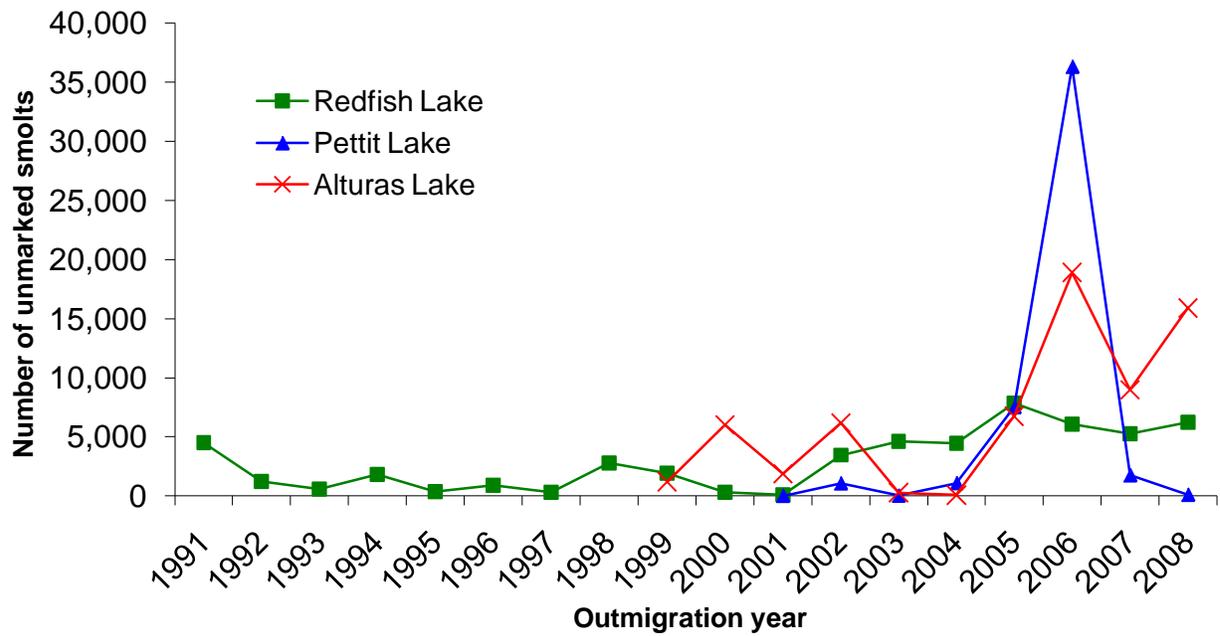


Figure 6. Natural origin sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2008 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

## LITERATURE CITED

- Bjornn, T. C., D. R. Craddock, and D. R. Corley. 1968. Migration and survival of Redfish Lake, Idaho sockeye salmon *Oncorhynchus nerka*. Transactions of the American Fisheries Society 97:360-373.
- Craddock, D. R. 1958. Construction of a two-way weir for the enumeration of salmon migrants. The Progressive Fish-Culturist 20:33-37.
- Hebdon, J. L., M. Elmer, and P. Kline. 2000. Snake River sockeye salmon captive broodstock program, research element, 1999. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Hebdon, J. L., J. Castillo, and P. Kline. 2002. Snake River sockeye salmon captive broodstock program, research element, 2000. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Hebdon, J. L., J. Castillo, C. Willard, and P. Kline. 2003. Snake River sockeye salmon captive broodstock program, research element, 2001. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P. 1994. Research and recovery of Snake River sockeye salmon, 1993. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., and J. Younk. 1995. Research and recovery of Snake River sockeye salmon, 1994. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Kline, P., and J. A. Lamansky. 1997. Research and recovery of Snake River sockeye salmon, 1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- MacDonald, P. D. M., and P. E. J. Green. 1988. User's Guide to Program MIX: an interactive program for fitting mixtures of distributions. *Release 2.3, January 1988*. Ichthus Data Systems, Hamilton, Ontario. iv+60 pp. ISBN 0-9692305-1-6.
- Peterson, M., B. Moore, K. Plaster and P. Kline. 2007. Snake River sockeye salmon captive broodstock program, research element 2006. IDFG Report no. 07-28. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Peterson, M., K. Plaster, L. Redfield, J. Heindel and P. Kline. 2008. Snake River sockeye salmon captive broodstock program, research element 2007. IDFG Report no. 08-10. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.
- Plaster, K., M. Peterson, D. Baker, J. Heindel, J. Redding, C. Willard and P. Kline. 2007. Snake River sockeye salmon captive broodstock program, research element 2005. IDFG Report no. 06-36. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

- Sandford, B. P., and S. G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River basin anadromous salmonids, 1990-1997. *Journal of Agricultural, Biological and Environmental Statistics*.
- Steinhorst, K., Y. Wu, B. Dennis, and P. Kline. 2004. Confidence intervals for fish out-migration estimates using stratified trap efficiency methods. *Journal of Agricultural, Biological, and Environmental Statistics* 9:284-299.
- Willard, C., J. L. Hebdon, J. Castillo, J. Gable, and P. Kline. 2004. Snake River sockeye salmon captive broodstock program, research element, 2002. Report to Bonneville Power Administration, Contract 5342.
- Willard, C., K. Plaster, J. Castillo, and P. Kline. 2005. Snake River sockeye salmon captive broodstock program, research element 2003. Report to Bonneville Power Administration, Contract 5342.

## **PART 4—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 Stanley Basin lakes could affect the sockeye salmon and kokanee populations in the lakes.

Bull trout spawner investigations were initiated in 1995 to track population response to no-harvest fishing regulations implemented by IDFG in 1994. Trend data of this nature have been successfully used to measure population response to fishing regulation changes implemented for adfluvial bull trout populations in Oregon and British Columbia (Ratliff 1992; Stelfox and Egan 1995). Index sections were established on Fishhook and Alpine creeks in 1998. Information collected in 2008 represented the eleventh year data were collected in these index reaches. Bull trout generally mature at five to six years of age (Leary et al. 1993); therefore, we would expect to see effects of no-harvest regulations become apparent in surveys conducted after 2000 as these cohorts represent those protected from potential harvest by anglers.

### **METHODS**

Monitoring of spawning bull trout was initiated in 1995 to measure bull trout population response to no-harvest fishing regulations implemented by IDFG in 1994. In 2008, we surveyed index reaches, which were established in 1998, on principal tributary streams of Redfish and Alturas lakes to enumerate bull trout spawners and redds. Surveys were conducted on Fishhook Creek (Redfish Lake drainage) and Alpine Creek (Alturas Lake drainage) August 28 and 29 and on September 11 and 12, 2008. These dates typically correspond with the initiation of spawning (first survey, we are typically able to count adult spawners) and the completion of spawning activities (second survey, we typically develop final redd count numbers). 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 prevented 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. 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 (between GPS waypoints 44° 08'36.37"N 114°57'29.97"W, and 44°08'53.69" N 114°55'39.13"W).

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

The adult 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 3 and continued until October 20, 2008. During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2008, 432 adult anadromous sockeye salmon and 89 adult bull trout were handled. Bull trout that were captured and passed received PIT tags (n = 27). Fourteen bull trout mortalities were recorded in 2008 (six associated with trapping, eight attributed to either angling or post spawn events).

## **RESULTS AND DISCUSSION**

### **Fishhook Creek**

We observed 29 adult bull trout (14 males, 14 females, and one unidentified) and eight developing redds on August 29, 2008 in the historic trend count area. During our second survey on September 11, we observed five adult bull trout and 13 complete redds (Figure 7). Redd counts on the second date included developing redds observed on the previous count (Table 18).

In the “new” section of Fishhook Creek we observed 23 adult bull trout (14 males, nine females) and five developing redds on August 29, 2008. During our second survey on September 11, we observed two adult bull trout and 14 complete redds (Figure 7). Redd counts on the second date included developing redds observed on the previous count (Table 18).

From the ten years of data, it appears that the no-harvest fishing regulation is positively affecting the bull trout population in Fishhook Creek. Redd counts in Fishhook Creek had been holding constant between 1998 and 2004, but recent increases in redds counted (varying between 11 and 30 redds counted each year) shows a dramatic increase in bull trout reproduction. Because bull trout may spawn in alternating or consecutive years (Fraleigh and Shepard 1989), year-to-year variation would be expected. Our findings are consistent with results from statewide monitoring efforts, which indicate that bull trout are increasing or at least stable across most of their range in Idaho (High et al. 2005).

### **Alpine Creek**

We observed no adult bull trout and no developing redds during the August 28, 2008 survey (Table 19). On September 11, we observed zero adult bull trout and zero completed redds (Figure 8). We did observe bull trout spawning below our trend site and could not identify why zero fish were utilizing the trend area for spawning habitat. We will try to identify a blockage to upstream migration before the count in 2009. If we continue to see that fish are not utilizing the trend area, we will establish a new index site below the established site. The Alpine Creek population had increased steadily since 1998; one redd was observed in 1998, and the number of redds has ranged from nine to 18 between 2000 and 2007. We have no evidence to believe that the population is collapsing (we observed many adults spawning below the trend area), we suspect that upstream passage is halting the use of the traditional spawning habitat within Alpine Creek. Monitoring bull trout populations with redd counts is advantageous, because they are low cost and cause little disturbance to spawning bull trout. Documentation of significant population changes have been identified from redd count data (Rieman and Meyers 1997).

We believe that our counts of redds in the trend sections were 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.

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

As mentioned previously in this report (Part 3, Results and Discussion, Sockeye Salmon Juvenile Out-Migrant Monitoring and Evaluation, Redfish Lake Creek Trap), during the out-migration season of 2008 trap efficiency at the juvenile out-migrant sockeye salmon trap on Redfish Lake Creek dropped from a five-year season average of 41% 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 out-migration estimates with reliable trap efficiencies, IDFG collected, PIT tagged, and transported bull trout away from the juvenile sockeye trap located on Redfish Lake Creek.

Eighteen adult bull trout were captured at the Redfish Lake Creek trap by hook and line, PIT tagged, and transported to a release site above Little Redfish Lake (Table 20). Four bull trout were subsequently recaptured at the trap site following their release. Four bull trout were found to have PIT tags from *O. nerka* tagging files detected in their stomachs (tag codes read through abdominal wall of adult bull trout).

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. Over the past few years, numbers of bull trout captured at the East Fork Salmon River weir have increased from 169 bull trout in 2004 to 227 bull trout in 2007 (E. Stark, IDFG, personal communication). Due to the appearance of an expanding bull trout population on the East Fork of the Salmon River and the fact that most of these bull trout are handled at the weir, we are planning to continue PIT tagging bull trout at the East Fork Salmon River (EFSR) weir (Sawtooth FH satellite weir) to determine if bull trout from this system migrate upriver to Redfish Lake to overwinter.

The collection of these data should provide us with a more complete picture of how bull trout populations have changed in the upper Salmon River drainage and whether we have predation issues within Redfish Lake that are not accounted for using our redd count trend sites. If increasing numbers of bull trout are migrating into the system to overwinter, we may see predation on *O. nerka* increase.

Table 18. Bull trout adult fish counts and redd counts in index sections of Fishhook Creek from 1998 to 2008.

Year	Dates	Number of bull trout observed	Number of redds
1998	8/22	40	5
	9/10	2	11
1999	8/22	40	0
	8/26	33	15
2000	8/31	16	12
	9/14	2	18
2001	8/28	31	15
	9/11	3	11
2002	9/04	23	6
	9/11	5	17
2003	8/27	40	6
	9/08	15	17
2004	8/30	31	7
	9/9	8	11
2005	8/30	24	12
	9/12	2	23
2006	8/29	32	16
	9/13	0	25
2007	8/29	41	21
	9/13	2	22
2008	8/29	29	8
	9/11	5	13

Table 19. Bull trout adult fish counts and redd counts in index sections of Alpine Creek from 1998 to 2008.

Year	Dates	Number of bull trout observed	Number of redds
1998	8/23	6	0
	9/11	6	1
1999 <sup>a</sup>	8/26	13	3
2000	8/30	18	6
	9/15	5	9
2001	8/28	8	11
	9/11	1	15
2002	8/30	20	8
	9/12	0	14
2003	8/27	27	11
	9/08	0	14
2004	8/31	16	6
	9/9	0	9
2005	8/30	16	9
	9/12	0	13
2006	8/28	15	6
	9/12	1	13
2007	8/28	15	17
	9/12	3	18
2008	8/28	0	0
	9/11	0	0

<sup>a</sup> Only one count completed.

Table 20. Bull trout relocation effort; juvenile out-migrant trapping at Redfish Lake Creek, 2008.

<b>Year</b>	<b>Bull trout captured, PIT tagged, relocated</b>	<b>Bull trout recaptured at trap site</b>	<b>Bull trout with <i>O. nerka</i> PIT tags detected in stomach</b>	<b>Bull trout mortalities associated with transport activities</b>
2008	18	4	4	0

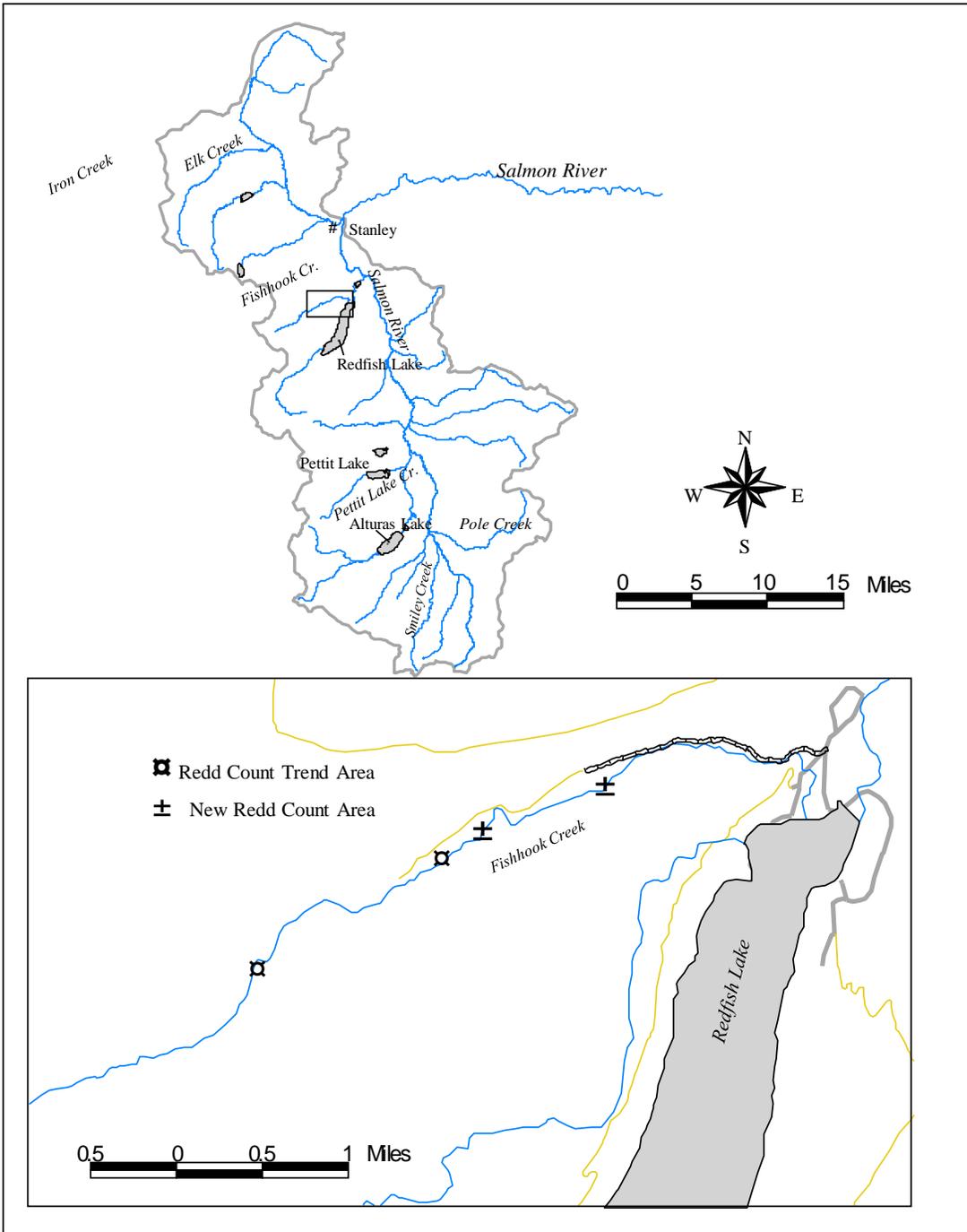


Figure 7. Location bull trout redd index sections in Fishhook Creek in 2008.

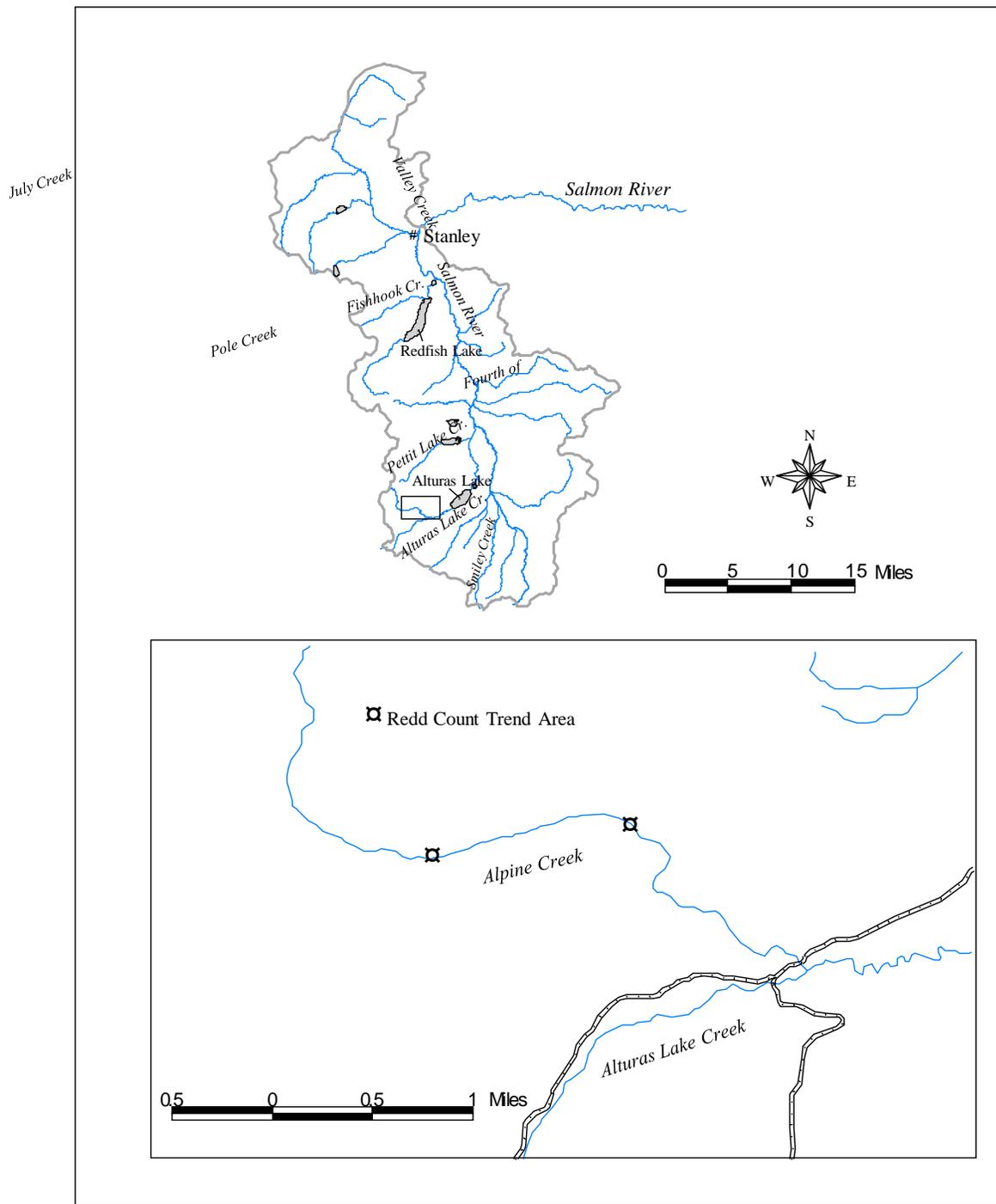


Figure 8. Location of bull trout redd index sections in Alpine Creek in 2008.

## LITERATURE CITED

- Beauchamp, D. A., and J. J. Van Tassell. 2001. Modeling seasonal trophic Interactions of adfluvial bull trout in Lake Billy Chinook, Oregon. *Transactions of the American Fisheries Society* 130:204-216.
- Bjornn, T. C. 1961. Harvest, age, and growth of game fish populations from Priest to Upper Priest Lakes. *Transactions of the American Fisheries Society* 118:597-607.
- Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout. *North American Journal of Fish Management* 21:343-352.
- Fraley, J. J., and B. Shepard. 1989. Life history, ecology and population status of migratory bull trout *Salvelinus confluentus* in the Flathead lake and river systems, Montana. *Northwest Science* 63:133-142.
- High, B., K. A. Meyer, D. J. Schill, and E. R. J. Mamer. 2005. Wild trout investigations. Job performance report 2004. Grant F-73-R-26. Report no. 05-24. Idaho Department of Fish and Game, Boise, Idaho.
- Leary, R. F., F. W. Allendorf, S. H. Forbes. 1993. Conservation genetics of bull trout in Columbia and Klamath River drainages. *Conservation Biology* 7:856-865.
- Ratliff, D. E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. *In* Howell, P. J. and D. V. Buchanan, editors. *Proceedings of the Gearhart Mountain bull trout workshop*. Oregon Chapter of the American Fisheries Society. Corvallis, Oregon.
- Rieman, B. E., and D. L. Meyers. 1997. Use of redd counts to detect trends in bull trout *Salvelinus confluentus* populations. *Conservation Biology* 11:1015-1018.
- Schoby, G. 2006. Home range analysis of bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhynchus clarkii lewisii*) in the Upper Salmon River Basin, Idaho. Master's Thesis. Idaho State University.
- Stelfox, J. D., and K. L. Egan. 1995. Bull trout investigations in the Smith-Dorien Creek/Lower Kananaskis Lake system. Alberta Environmental Protection, Fisheries Management Division, and Golder Associates Limited, Calgary, Canada.

## **APPENDICES**

Appendix A. Fork length (mm), weight (g) and age of *O. nerka* captured during midwater trawls conducted during September 2008 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age
<u>Redfish Lake</u>			
1	40	0.58	No scales
1	46	0.99	0
1	57	1.6	0
1	54	1.6	0
1	60	1.8	0
2	59	1.8	0
2	92	7.5	1
2	105	11.6	1
2	180	51.9	2
3	96	8.7	1
3	95	8.0	1
4	47	0.9	No scales
4	53	1.4	0
5	50	1.2	0
5	51	1.3	0
5	60	2.0	0
5	88	6.0	1
5	90	6.6	1
6	60	1.9	0
6	103	12.2	1
<u>Alturas Lake</u>			
1	91	6.6	1
1	98	8.5	1
1	96	8.0	1
1	101	10.1	1
1	102	8.9	1
1	98	8.7	1
1	103	10.4	1
1	116	14.7	1
1	140	26.6	2
1	179	47.8	2
2	65	2.3	0
2	78	3.8	0
2	64	2.4	0
2	55	1.6	0
2	76	3.9	1
2	79	4.0	1
2	78	4.1	No Scales
2	80	4.2	1
2	77	3.5	No Scales
2	76	3.5	No Scales
2	64	1.9	0
2	65	2.2	0
2	76	3.8	No Scales
2	71	3.0	0
2	69	2.8	0
2	127	19.2	1
2	112	13.9	1
2	148	31.2	2
2	53	1.3	0
3	74	3.6	No Scales
3	78	4.0	No Scales

**Appendix A. Continued.**

<b>Transect</b>	<b>Length (mm)</b>	<b>Weight (g)</b>	<b>Age</b>
3	100	9.9	1
3	97	8.4	1
3	99	8.5	1
3	98	8.8	No Scales
3	100	9.3	No Scales
3	47	0.9	0
3	115	16.0	1
3	107	11.9	1
3	107	9.5	1
3	103	10.8	1
3	95	8.6	1
3	101	8.3	No Scales
3	122	17.5	2
3	138	23.6	2
3	136	23.1	2
3	111	12.8	1
3	114	14.3	2
3	56	1.3	0
3	169	44.9	2
3	190	57.0	3
3	180	50.7	3
4	80	4.6	1
4	77	2.8	No Scales
4	96	9.0	No Scales
4	78	4.2	No Scales
4	79	4.4	No Scales
4	90	5.7	No Scales
4	77	3.9	No Scales
4	76	3.7	No Scales
4	89	5.5	1
4	100	9.2	No Scales
4	120	17.3	1
4	95	8.2	No Scales
4	155	36.7	2
4	116	15.4	1
4	137	25.7	2
4	148	28.3	2
4	163	40.9	2
4	156	37.4	2
5	59	1.6	0
5	78	4.0	No Scales
5	77	4.2	No Scales
5	85	5.6	1
5	103	10.6	No Scales
5	98	8.9	No Scales
5	130	21.4	2
5	169	41.2	2
6	58	1.6	1
6	79	3.8	No Scales
6	118	15.6	1
6	121	15.0	1

**Appendix A. Continued.**

<b>Transect</b>	<b>Length (mm)</b>	<b>Weight (g)</b>	<b>Age</b>
6	128	19.3	1
6	139	25.6	1
6	176	48.7	2
<u>Pettit Lake</u>			
1	75	4.3	0
1	84	6.5	0
1	187	79.3	2
2	60	2.2	0
2	61	2.5	0
3	68	3.1	0
4	47	1.1	0
4	50	1.2	0
4	54	1.9	0
4	72	3.6	0
4	193	79.5	2
5	65	2.5	0
5	63	2.4	0
5	70	3.7	0
5	192	75.0	2
6	165	55.0	2
6	190	81.7	2

Appendix B. Arrival dates at Lower Granite Dam for PIT-tagged sockeye salmon smolts during the 2008 migration year.

Date	Redfish Lake					Pettit Lake			Alturas Lake		
	Natural Origin	Fall Direct	Oxbow Smolts	Sawtooth Smolts	Eagle Smolts	Natural Origin	Fall Direct	Hatchery Smolts	Natural Origin	Fall Direct	Hatchery Smolts
4/30/2008											
5/1/2008											
5/2/2008											
5/3/2008											
5/4/2008											
5/5/2008											
5/6/2008											
5/7/2008								1			
5/8/2008											
5/9/2008											
5/10/2008											
5/11/2008											
5/12/2008											
5/13/2008	1										
5/14/2008											
5/15/2008			2	1							
5/16/2008			7					1			
5/17/2008			11	2							
5/18/2008			16	7					4		2
5/19/2008	2		4	13					3		1
5/20/2008			2	20					1	2	1
5/21/2008	1			7					1	2	
5/22/2008	2	2		5						5	1
5/23/2008	1			3			7		1	3	2
5/24/2008	2	3		1			8		1	4	
5/25/2008				1			4			2	
5/26/2008	1	1					4		1	2	2
5/27/2008	1	1				1	1		3	1	
5/28/2008	2						4		1	3	
5/29/2008		1							1	2	
5/30/2008		2							1	4	
5/31/2008											
6/1/2008							1		1	3	2
6/2/2008	2	6							2	3	1
6/3/2008							1			2	
6/4/2008									1	1	
6/5/2008	2						1			1	
6/6/2008	1										
6/7/2008	2										
6/8/2008	1	2							1		
6/9/2008		1									
6/10/2008									1		
6/11/2008	1	1									
6/12/2008	3										
6/13/2008											
6/14/2008										1	1
6/15/2008											
6/16/2008											
6/17/2008											
6/18/2008											
6/19/2008											
6/20/2008											
6/21/2008		1							1		
6/22/2008											
6/23/2008											
6/24/2008											
6/25/2008											
6/26/2008											
6/27/2008											
6/28/2008											
6/29/2008											
6/30/2008											
7/1/2008											

Appendix B. Continued.

---

7/2/2008  
7/3/2008  
7/4/2008

1

---

Total	26	21	42	60	1	31	2	25	41	13
-------	----	----	----	----	---	----	---	----	----	----

---

**Prepared by:**

Mike Peterson  
Senior Fisheries Research Biologist

Kurtis Plaster  
Senior Fisheries Technician

Laura Redfield  
Senior Fisheries Technician

Jeff Heindel  
Conservation Hatcheries Supervisor

**Approved by:**

IDAHO DEPARTMENT OF FISH AND GAME

---

Daniel J. Schill  
Fisheries Research Manager

---

Edward B. Schriever, Chief  
Bureau of Fisheries