FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

2009 Annual Project Progress Report

Part 1—Project Overview
Part 2—*Oncorhynchus nerka* Population Monitoring and Redfish Lake Sport Fishery Investigations
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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) (NOAA 2005).

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. Seventh 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 4,622,229 eyed eggs from 1991 through 2009 (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 3,236,528 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 70% 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 mid-October. 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 National Oceanic and Atmospheric Administration (NOAA) permit 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, 2009. 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*, redside shiner *Richardsonius balteatus*, dace *Rhinichthys* spp., and sculpin *Cottus* spp. Nonnative species present in Sawtooth Valley waters include lake trout *S. namaycush* (Stanley Lake only), and brook trout *S. fontinalis*. Rainbow trout 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.

2008 and 2009 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 2008, 235,369 sockeye salmon and 67,984 sockeye salmon eyed eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 4). Smolts were released to the Salmon River and Redfish Lake Creek on May 7, 2008. A total of 150,395 BY06 smolts were released at two separate release sites (73,808 below the river water intake to SFH, and 76,587 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at two locations, IDFG Sawtooth Fish Hatchery (SFH), and Oregon Department of Fish and Wildlife (ODFW) Oxbow Fish Hatchery (OFH). All sockeye released from SFH and OFH 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). All presmolts released in 2008 were brood year 2007 (BY07) age-0 fish reared at IDFG Sawtooth Fish Hatchery (SFH) and were adipose fin clipped (AD). 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. Three hundred ninety-eight hatchery-produced adult sockeye salmon (253 reared at NOAA Burley Creek Fish Hatchery, 145 reared at IDFG Eagle Fish Hatchery) and 571 anadromous returns sockeye salmon were released to Redfish Lake for volitional spawning in September. In November and December, 67,984 eyed eggs (24,678 reared at NOAA Burley Creek Hatchery, 43,306 reared at IDFG Eagle FH) were planted in Pettit Lake.

In 2009, 233,942 sockeye salmon and 75,079 sockeye salmon eyed eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). Smolts were released to the Salmon River on May 7, 2009. A total of 173,055 BY07 smolts were released at two separate release sites (99,374 below the river water intake to SFH, and 73,681 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at two locations: IDFG SFH and ODFW OFH. All sockeye smolts released were coded-wire-tagged, differentially marked (OFH fish were AD/RV clipped, SFH fish were AD-clipped) and had representative groups PIT tagged (10,937 OFH, 52,551 SFH). All presmolts released in 2009 were age-0 fish from brood year 2008 (BY08) reared at SFH. Redfish Lake received 34,561 presmolts (1,016 PIT tagged), Alturas Lake received 9,994 presmolts (1,019 PIT tagged), and Pettit Lake received 14,983 presmolts (1,018 PIT tagged) in October by direct lake releases. Six hundred eighty-two hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September. A total of 667 anadromous return adult sockeye salmon were released into Redfish Lake between September 8 and October 21, 2009 for volitional spawning. In November and December, 75,079 eyed eggs reared at NOAA Burley Creek Hatchery and Eagle Fish Hatchery were planted in Pettit and Alturas lakes (59,511 in Pettit Lake, 15,568 in Alturas Lake) in 2009.

Table 1. Eyed egg production by IDFG and NOAA facilities for the Snake River sockeye salmon captive broodstock program 1991—2009.

Brood year	Eyed eggs produced by IDFG	Eyed eggs produced by NOAA
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
2009	290,968	129,849
Total:	**2,596,625**	**2,025,604**

Table 2. Snake River sockeye salmon captive broodstock program egg and fish reintroduction history 1993—2009.

Year of reintroduction	Eyed eggs	Presmolts	Smolts	Hatchery-reared adults	Anadromous Adults
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	18	3
2000	65,200	72,114	148	71	200
2001	0	106,166	13,915	65	14
2002	30,924	140,410	38,672	178	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	67,984	84,005	150,395	398	571
2009	75,079	59,538	173,055	682	667
Total	**1,005,908**	**1,476,718**	**749,011**	**3,424**	**1,467**

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

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

Table 4. Sockeye salmon releases to Sawtooth Valley waters in 2008.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing Location[b]
Redfish Lake Creek (below weir)	Smolt (2006)	05/07/2008	76,587	AD/CWT	979	12.9	SFH
Salmon River (above SFH weir)	Smolt (2006)	05/07/2008	73,808	AD/LV/CWT	988	33.1	OFH
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	2	1,280.7	EFH
		09/16/2008	413	Mix	1	1,279.5	EFH
		09/16/2008	101	Mix	253	1,203.6	EFH
	Captive Reared	09/16/2008	253	Mix	145		NOAA-BC
		09/17/2008	145	PIT		1,235.6	EFH
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	IDFG-EFH

[a] AD = adipose fin-clip, CWT = coded-wire-tagged, right ventral fin-clip, coded-wire-tagged, AD/LV/CWT = adipose fin, left ventral fin-clip, coded-wire-tagged.

[b] SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EFH = Idaho Department of Fish and Game Eagle Fish Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

Table 5. Sockeye salmon releases to Sawtooth Valley waters in 2009.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing Location[b]
Redfish Lake Creek (below weir)	Smolt (2007)	05/07/2009	73,681	AD/RV/CWT	10,937	44.5	OFH
Salmon River (above SFH weir)	Smolt (2007)	05/07/2009	99,374	AD/CWT	52,551	14.8	SFH
Alturas Lake (direct lake)	Presmolt (2008)	10/07/2009	9,994	AD	1,019	6.8	SFH
Pettit Lake (direct lake)	Presmolt (2008)	10/07/2009	14,983	AD	1,018	6.2	SFH
Redfish Lake (direct lake)	Presmolt (2008)	10/07/2009	34,561	AD	1,016	6.0	SFH
Redfish Lake (direct lake)	Adult Captive	09/09/2009	60	AD	60	1,463	NOAA-BC
		09/11/2009	322	AD	322	1,208	EFH
		09/16/2009	69	AD	69	1,208	EFH
		9/16/2009	231	AD	231	2,114	NOAA-BC
	Adult Anadromous	9/8/2009	311	Mix		1,259	EFH
		9/9/2009	244	Mix		1,516	EFH
		9/9-10/21/2009	112	Mix		1,372.1	Direct
Pettit Lake (direct lake)	Eyed egg (2009)	11/9/2009	2,601	NA	NA	NA	IDFG-EFH
		12/3/2009	47,867	NA	NA	NA	IDFG-EFH
		12/3/2009	9,043	NA	NA	NA	NOAA-BC
Alturas Lake (direct lake)		12/10/2009	6,038	NA	NA	NA	IDFG-EFH
		12/10/2009	9,530	NA	NA	NA	NOAA-BC

[a] AD = adipose fin-clip, CWT = coded-wire-tagged, AD/RV/CWT = adipose fin, right ventral fin-clip, coded wire tagged, AD/LV/CWT = adipose fin, left ventral fin-clip, coded-wire-tagged.

[b] SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EFH = Idaho Department of Fish and Game Eagle Fish Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

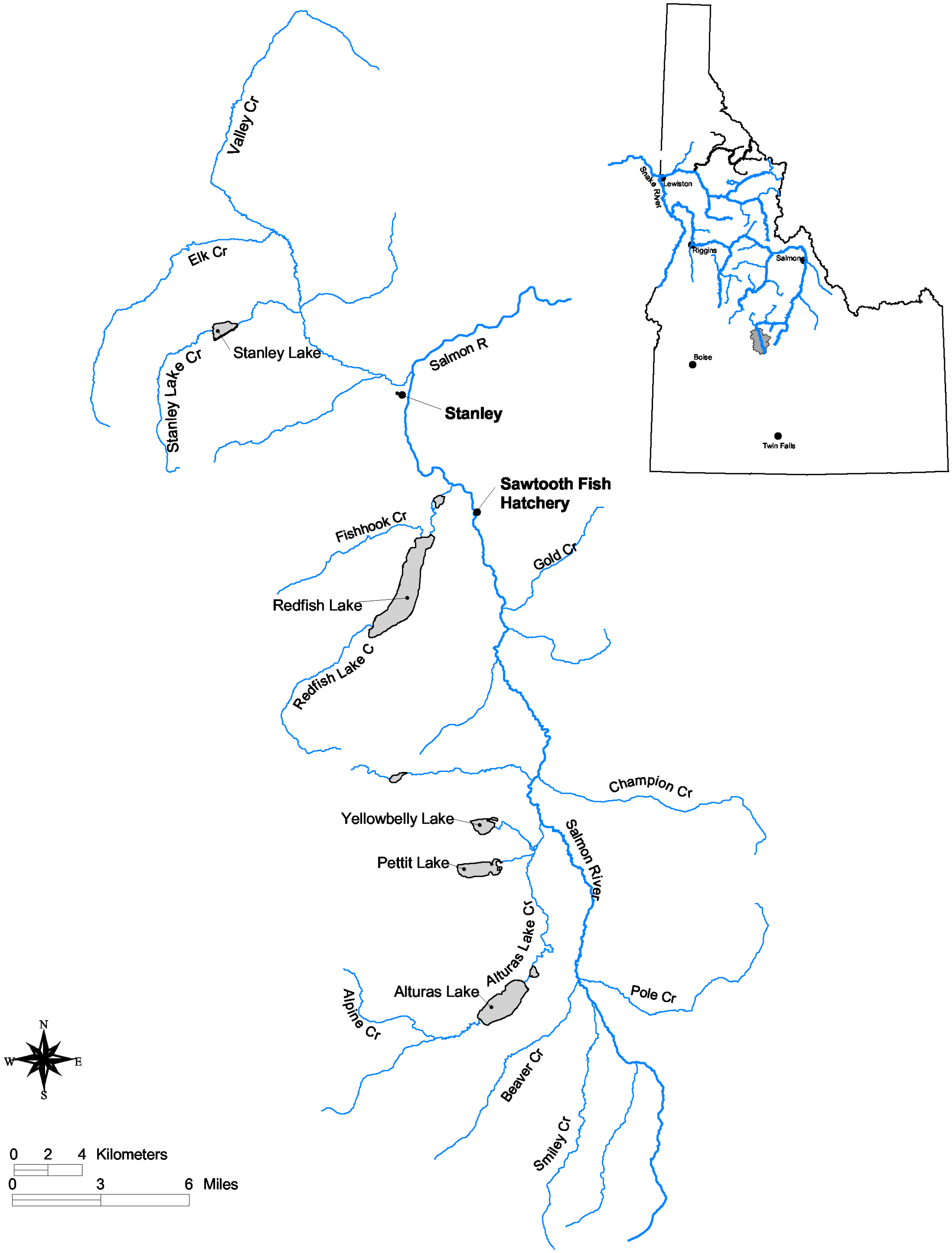

Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

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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 14–16, 2009. 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):

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

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. 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. 2006) 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 25 through August 6, 2009 (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 four weekdays, two weekend days, and any holiday during each 14-day interval. On each angler count day, the number of boats and bank anglers were counted from a boat for each day period (morning and evening strata). Angler count dates and times were selected randomly. Angler interviews were conducted following the completion of each instantaneous count. Anglers were asked how many fish they had harvested and/or released by species, how many hours they had fished, what their preferred target species was, whether or not they were aware of the Redfish Lake kokanee fishery, and the type of gear they used. All responses were recorded by creel personnel. 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 Application Software computer program developed by Soupir and Brown (2002) and used to estimate angler effort, catch rates, and harvest.

RESULTS AND DISCUSSION

Oncorhynchus nerka Population Monitoring

Redfish Lake

September trawl catch on Redfish Lake (six transects, Appendix A) included 20 natural origin *O. nerka* and zero hatchery origin sockeye salmon. *Oncorhynchus nerka* abundance was estimated at 28,923 fish (95% CI ± 32,197). The *O. nerka* population was 110% (within Redfish Lake) of the estimated abundance in 2008 (26,284 fish) and 39% of the estimated abundance of *O. nerka* for 2007 (73,702; Table 6).

Density and biomass were estimated at 47.0 fish/ha and 0.11 kg/ha, respectively (Table 6). This represented increases of 9% for densities and a 64% decrease in biomass from estimated levels in 2008 (Peterson et al. 2010). Age-0 and age-1 *O. nerka* were represented in the trawl sample from Redfish Lake. Age-0 fish had the highest density (44.7 fish/ha) and the highest biomass (0.09 kg/ha; Table 7).

Alturas Lake

September trawl catch on Alturas Lake (six transects, Appendix A) included 52 natural origin *O. nerka* and two hatchery origin sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 39,781 fish (95% CI ± 11,697), 117.7 fish/ha, and 3.50 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 (56.5 fish/ha) and contributed 48.0% of the biomass (Table 7). The estimates for abundance, density, and biomass were 39% lower, 32% lower, and 2% higher than 2008 estimates, respectively (Table 6).

Pettit Lake

September trawl catch on Pettit Lake (six transects, Appendix A) included nine natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 4,623 fish (95% CI ± 4,536), 40.2 fish/ha, and 0.08 kg/suitable ha, respectively (Table 6). Only age-0 fish were represented in the trawl sample. Age-0 fish had a density of 40.2 fish/ha and a biomass of 0.08 kg/ha; Table 7. The estimates for abundance, density, and biomass were 45% lower, 24% lower, and 93% lower than 2008 estimates, respectively.

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 (Andre Kohler, Shoshone Bannock Tribes, personal communication). We experience high levels of adult escapement variation in both Fishhook Creek and Alturas Lake Creek (Table 8), which appears to cause population fluctuations within these systems. Recent genetic findings, from both trawl and angler caught samples, suggest that the Pettit Lake residual sockeye population may be increasing and the nonnative kokanee population may actually be decreasing (Chris Kozfkay, IDFG, personal communication). Potential behavioral differences between non-native kokanee and sockeye may account for some of the population changes that occurred between 2008 and 2009. Pettit Lake is also very difficult to sample due to its relatively small size compared to the other two nursery lakes. 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). Kokanee control should remain as a priority for the program to control zooplankton abundance and minimize *O. nerka* population fluctuations.

Whether population fluctuations between 2008 and 2009 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 winter of 2010 (before kokanee enter the tributaries to spawn) and presented to the SBSTOC for discussion and modification.

Genetic samples collected from trawl-captured fish in 2009 were analyzed for the three basin lakes. However, due to contamination of sample tissue, we are unable to develop genotypes to distinguish these fish for population proportions (kokanee vs. sockeye). It is unclear how the samples became contaminated (following similar protocols from past years); however, changes in genetic protocols may cause us to develop new sampling protocols for field collections.

Redfish Lake Sport Fishery Investigations

In 2009, we contacted 32 angler parties (63 individual anglers) on Redfish Lake. Idaho residents made up 93.6% of those interviewed. Most anglers used lures (63.5%), followed by bait (31.7%). Total angler effort was estimated at 1,219 hours (95% CI ± 485.3; Table 9). This effort estimate represents a 50% decrease in fishing pressure between 2008 and 2009 (Table 10). Boat anglers expended more effort (68%) than bank anglers (32%), which was similar to results from 2008 (Peterson et al. 2010).

The season catch rate for all fish (caught) was 0.65 fish/hour. Catch rates increased 150% over the estimate from 2008 (Peterson et al. 2010). Kokanee catch rates (harvested and released) averaged 0.00 kokanee/hour for weekdays and 0.00 kokanee/hour for weekends (Table 11); these estimates were lower than the estimate of 0.10 kokanee/hour for the season in 2008. Bull trout catch and release rates averaged 0.55 bull trout/hour for weekdays and 0.21 bull trout/hour for weekends (IDFG regulations prohibit harvesting bull trout; Table 11). We also estimated that 665 bull trout were caught and released from Redfish Lake during 2009 (Table 12). The season catch rate for bull trout is higher than observed rates from 2007 and 2008 (0.12 and 0.08 bull trout/hour, respectively). We have seen a trend of overall increase in bull trout catch rates since monitoring began in 1996 (Figure 2). Cutthroat trout had catch rates of 0.08 fish/hour harvested for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 757 fish (95% CI ± 154.8). This was an overall increase of 49% from the 2008 estimate. The majority (87.8%) of all fish caught were released. Kokanee harvest was estimated at zero fish (95% CI ± 0) and the number of kokanee released was estimated at zero (95% CI ± 0.00) (Table 12). In 2009, we observed the lowest harvest rate for kokanee since 2001 and it was the second time since the re-establishment of the kokanee fishery in 1995 (Table 10) that we have observed zero harvest. Because of the low harvest rate of 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 2009. As of the completion of this report, we have not seen an impact from this program. We are currently investigating the idea of re-establishing a rainbow trout fishery in Redfish Lake. Creel data from 1986 and 1987 (Reingold and Davis 1987; Davis and Reingold 1988) suggests that a rainbow trout fishery within Redfish Lake could produce between 12,000-15,000 hours of effort and provide a potential increase in the number of kokanee caught and harvested as by-catch to the fishery.

No hatchery-produced sockeye salmon (adipose-clipped) were observed by creel personnel during 2009. 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. Because kokanee were not observed during the creel, impacts from the fishery are assumed to be zero for 2009.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2009.

Year	Population (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
2009	28,923 (32,197)	47.0	0.11
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[a]	80.7	1.6
1992	39,481 (2,498)	64.2	1.0
1990	24,431 (11,000)	39.7	0.8
	Alturas Lake (338 surface hectares)		
2009	39,781 (11,697)	117.7	3.50
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 (± 95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Pettit Lake (160 surface hectares)		
2009	4,623 (4,536)	40.2	0.08
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

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

Table 7. Estimated 2009 *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
Redfish Lake (615 surface ha)						
No. captured	19	1	0	0	NA	20
Mean length (mm) (±95 CI)	56.9	93	NA	NA	NA	58.7
Mean weight (g) (±95 CI)	2.0	8.4	NA	NA	NA	2.33
Abundance	27,482	1,441	NA	NA	NA	28,923
95% CI High	56,317	5,144	NA	NA	NA	61,120
95% CI Low	0	0	NA	NA	NA	0
Density (fish/ha)	44.7	2.33	NA	NA	NA	47.03
Biomass (kg/ha)	0.09	0.02	NA	NA	NA	0.11
Alturas Lake (338 surface ha)						
No. captured	4	26	23	1	0	54
Mean length (mm) (±95 CI)	68.8	122.5	148.8	188	NA	133.8
Mean weight (g) (±95 CI)	2.75	19.4	49.6	61.3	NA	29.4
Abundance	2,961	19,110	16,970	739	NA	39,781
95% CI High	6,777	32,391	27,057	1,940	NA	51,478
95% CI Low	0	5,829	6,883	0	NA	28,084
Density (fish/ha)	8.8	56.5	50.2	2.2	NA	117.7
Biomass (kg/ha)	0.02	1.10	2.24	0.14	NA	3.50
Pettit Lake (160 surface ha)						
No. captured	9	0	0	0	0	9
Mean length (mm) (±95 CI)	60	NA	NA	NA	NA	60
Mean weight (g) (±95 CI)	2.1	NA	NA	NA	NA	2.1
Abundance	4,623	NA	NA	NA	NA	4,623
95% CI High	9,159	NA	NA	NA	NA	9,159
95% CI Low	87	NA	NA	NA	NA	87
Density (fish/ha)	40.2	NA	NA	NA	NA	40.2
Biomass (kg/ha)	0.08	NA	NA	NA	NA	0.08

Table 8. Estimated kokanee escapement to Fishhook Creek 1991 to 2009 and Alturas Lake Creek 1992 to 2009. Data obtained from the Shoshone-Bannock Tribes.

Year	Fishhook Creek	Alturas Lake Creek
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
2009	1,796	1,627

Table 9. Estimated angler effort on Redfish Lake for the 2009 fishing season.

Redfish Lake	Boat	Bank	Tube	Total
Hours fished	828	391	0	1,219
±95% CI	384	281	0	485

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

	Kokanee catch rates (fish/hour)					
	Harvested (fish/hour)	**Released (fish/hour)**	**Kokanee harvested**	**Bull trout catch rate (fish/hour)**	**Angler parties interviewed**	**Estimated hours fished/season**
1996	0.19	0.08	844	0.09	107	3,351
1997	0.19	0.37	466	0.08	117	2,874
1998	0.13	0.17	1,362	0.08	205	7,963
1999	0.38	0.15	1,187	0.28	227	3,951
2000	0.02	0.06	67	0.08	63	3,063
2001	0.00	0.06	0	0.27	88	2,391
2002	0.09	0.16	129	0.16	100	2,127
2003	0.10	0.05	424	0.24	98	2,477
2004	0.13	0.26	621	0.31	96	2,791
2005	0.21	0.09	637	0.09	85	3,620
2006	0.07	0.24	222	0.35	131	2,635
2007	0.03	0.09	56	0.12	53	1,922
2008	0.05	0.04	106	0.08	41	2,424
2009	0.00	0.00	0	0.55	32	1,219

Table 11. Catch rates (fish/hour) for summer 2009 on Redfish Lake categorized by day type and species.

	Kokanee		**Cutthroat Trout**		**Bull Trout**		**All Fish**		
Day Type	**Kept**	**Released**	**Kept**	**Released**	**Kept**	**Released**	**Kept**	**Released**	**Caught**
Weekday	0.00	0.00	0.08	0.00	0.00	0.55	0.08	0.57	0.65
Weekend Day	0.00	0.00	0.12	0.00	0.00	0.21	0.12	0.22	0.34
Season Avg.	0.00	0.00	0.08	0.00	0.00	0.55	0.08	0.57	0.65

Table 12. Estimated number of fish harvested and released on Redfish Lake during the summer 2009.

	Caught				
Redfish Lake	**Kokanee**	**Cutthroat Trout**	**Bull Trout**	**Other**	**All Fish ± 95% CI**
Harvested	0	92	0	0	92 ± 128.9
Released	0	0	665	0	665 ± 1,368.3

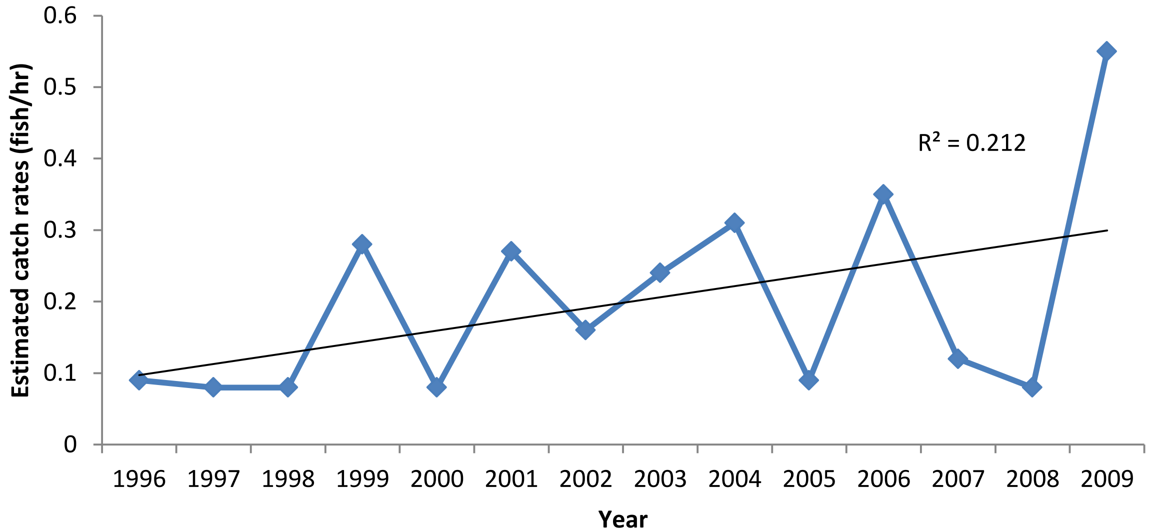

Figure 2. Estimated bull trout catch rates from 1996-2009 within Redfish Lake. The trend line is used to show the catch rate increase within the lake. The equation for the trend line is y = 0.0156 x + 0.0819 with an R^2 of 0.212.

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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 2008 release of adipose fin-clipped presmolts numbering 57,093 sockeye, 16,864 sockeye, and 10,048 sockeye to Redfish, Alturas, and Pettit lakes, respectively (Table 13). All presmolts released in 2008 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. 2008, 2010). The trap was operated from April 11 through June 21, 2009 and contains nine bays, five of which were fitted with incline bar traps. IDFG staff checked the trap at least twice daily in 2009. 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 up to 50 wild smolts/day for future genetic analyses (Redfish Lake = 919, Alturas Lake = 103, Pettit Lake = 174).

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 2009, 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 21 to May 24, 2009. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 16,864 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2008 (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. Activities conducted by the Shoshone-Bannock Tribes are reported under separate cover.

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 21 to May 18, 2009. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 10,048 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2008 (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. Activities conducted by the Shoshone-Bannock Tribes are reported under separate cover.

Salmon River and Redfish Lake Creek Smolt Groups

Ninety-nine thousand three hundred seventy-four (99,374) BY07 smolts were released near the river water intake of SFH (Table 13). This release included smolts reared at Sawtooth Fish Hatchery (SFH). All fish released were adipose fin-clipped and coded-wire-tagged with a representative group (n = 52,551) PIT tagged.

A total of 73,681 BY07 smolts were released into Redfish Lake Creek below the out-migrant weir (Table 13). This release group originated from smolts reared at OFH. All fish were adipose/right ventral fin-clipped and coded-wire-tagged with a representative group (n = 10,937) PIT tagged.

Main Stem Snake and Columbia River Dams

In 2009, sockeye salmon smolts were transported (if collected in juvenile facilities within the hydrosystem corridor) and released below Bonneville Dam according to a USACE PIT tag study (methods and results can be found in BioMark and Quantitative Consultants, Inc. 2010). As a result, migration corridor survival evaluations were only conducted to Lower Granite Dam (LGR) for this project. Sockeye salmon smolt survival 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 8 and October 21, 2009, 1,349 adult sockeye salmon were released to Redfish Lake (Table 16). Adult releases included 667 anadromous return adults, 291 adults raised at NOAA Burley Creek Hatchery, and 391 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, and five male and five female anadromous return sockeye salmon were fitted with gastric implant radio transmitters prior to release. Telemetry investigations of adult locations began September 9, 2009 and continued weekly through November 7, 2009. 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, 2009 and continuing until November 7, 2009. Suspected redds were generally enumerated by two observers on each count date. On the final count date, three observers 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 2009. 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 2009.

Unmarked Juvenile Out-migrant Monitoring

In 2009, unmarked out-migrants produced from program fish releases to Redfish Lake included: 1) age-1 out-migrants produced from 494 hatchery-origin adults released for volitional spawning in 2007 2) age-2 out-migrants produced from 464 hatchery-origin adults released in 2006. 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 2009. Any age-1 unmarked out-migrants would have been produced by residual sockeye or kokanee found within Alturas Lake (no eyed egg releases to Alturas Lake in 2007). Unmarked out-migrants produced from program fish releases to Pettit Lake included age-2 out-migrants from 79,908 eyed eggs released in 2006, and age-1 out-migrants produced from 51,008 eyed eggs released in 2007. The proportions of age-1 and age-2 unmarked emigrants were determined for 2009 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 6 and continued until October 20, 2009. During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2009, 584 adult anadromous sockeye and 72 adult bull trout were captured.

RESULTS AND DISCUSSION

SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

Redfish Lake Creek Trap

A total of 5,204 sockeye salmon smolts (1,392 natural origin and 3,812 hatchery origin) were trapped during the 2009 out-migration season (Figure 3). Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 114 mm (range 84 mm to 142 mm; Figure 4) and 99.7 mm (range 77 mm to 138 mm; Figure 4), respectively. Sockeye salmon smolt lengths were slightly longer for natural origin and slightly shorter for hatchery origin in 2009 than during the 2008 out-migration season.

Based on observed trapping efficiencies and discharge during out-migration monitoring, we determined that using one trapping interval for the natural origin smolts was appropriate for estimating total natural origin sockeye salmon smolt out-migration. Of the 1,392 natural origin smolts handled in 2009, 537 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 33% during 2009. 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 2009, 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 2009 total natural origin sockeye smolt out-migration was estimated at 4,552 fish (95% CI 4,051—5,125; Table 13). The proportion of age-1 natural origin smolts was estimated at 69%, which equals 3,141 smolts; the proportion of age-2 natural origin smolts was estimated at 31%, which equals 1,411 smolts. As referenced in the Methods section of this report, age proportions were estimated using the MIX software application.

Of the 3,812 fall direct-released smolts handled in 2009, 599 were marked and released upstream of the weir to estimate trap efficiency. Total fall direct-released smolt out-migration was estimated at 14,090 fish (95% CI 11,582—17,352; Table 13). Overwinter survival and out-migration for this group was 24.7% of the number of presmolts planted in 2008 (Table 15). The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated at 94% (95% CI ± 0.7%), which equals 13,245 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 6% (95% CI ± 0.7%), which equals 845 smolts. These proportions are similar to those observed from past years.

Alturas Lake Creek Trap

Six hundred two sockeye salmon smolts (316 natural origin and 286 hatchery origin) were trapped during the 2009 out-migration season. Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 93 mm (range 79 mm to 127 mm) and 87 mm (range 75 mm to 125 mm), respectively. The average size of out-migrating sockeye smolts was similar to 2008 (Peterson et al. 2010).

Total natural origin sockeye smolt out-migration for Alturas Lake was estimated at 4,869 fish (95% CI 3,288–7,825; see SBT annual report to BPA for methods and calculations), and hatchery origin smolt out-migration was estimated at 5,278 fish (95% CI 3,275–6,942; 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-outmigration for the fall direct-release group was 31% of the number of presmolts planted in 2008 (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 93% (95% CI ± 2.0%), which equals 4,528 smolts; and the proportion of age-2, natural origin smolts was estimated at 7% (95% CI 4%-8%), which equals 341 smolts. The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated, using the MIX software application, at 96% (95% CI ± 2.0%), which equals 5,067 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 4% (95% CI ± 2.0%), which equals 211 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 2009 was estimated at 3,008 fish (95% CI not calculated; see SBT annual report to BPA for methods and calculations) and hatchery origin smolt out-migration was estimated at 5,484 fish (95% CI not calculated; see SBT annual report for methods and calculations; Table 13). Overwinter survival and out-migration for fall 2008 direct-released presmolts was 54% (Table 15). Fork length of natural origin and fall direct-released sockeye salmon smolts captured averaged 113 mm (range 91 mm to 140 mm) and 106 mm (range 90 mm to 171 mm), respectively. Scales for aging were collected from natural origin smolts at the Pettit Lake Creek trap in 2009. The proportion of age-1, natural origin smolts was estimated using the MIX software application at 82% (95% CI 69.1%–94.3%), which equals 2,458 smolts; the proportion of age-2, natural origin smolts was estimated at 18% (95% CI 5.7%–30.9%), which equals 550 smolts. Age class proportions were similar for Pettit Lake as seen in 2008 (Peterson et al. 2010).

Salmon River and Redfish Lake Creek Smolt Groups

We released 73,681 BY07 smolts into Redfish Lake Creek below the out-migrant weir on May 7, 2009. This release group consisted of smolts reared at Oregon Department of Fish and Wildlife Oxbow FH. All fish released were adipose/right ventral fin-clipped and coded-wire-tagged with a representative group (n = 10,937) PIT tagged. Fork length of the Redfish Lake Creek smolt group averaged 146 mm (range 80 mm to 201 mm) and these fish had an average weight of 31.3 g/fish.

A total of 99,374 BY07 smolts were released into the Salmon River below the Sawtooth FH river water intake upstream of the weir on May 7, 2009. This release included smolts reared at Sawtooth FH. All fish were adipose fin-clipped and coded-wire-tagged with a representative group (n = 52,551) PIT tagged. The average length and weight of the Salmon River smolt group was 101 mm (range 70 mm to 180 mm) and 10.6 g/fish (range 13.2 to 25.1 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).

Main Stem 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 28% (Redfish Lake natural origin smolts) to 89% (Alturas Lake hatchery fall direct release smolts). The average survival rate for all the release groups was 50% to LGR (up from 44% survival in 2008; Peterson et al. 2010). An estimated 1,275 (28% survival) and 5,636 (40% 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 2,532 (52% survival) for natural origin smolts and 4,697 (89% survival) for fall direct-release smolts. Survival from the Pettit Lake Creek trap to LGR was estimated at 1,474 (49% survival) for natural origin smolts and 3,510 (64% survival) for fall direct-release smolts. An estimated 46,706 (47% survival) sockeye smolts survived to LGR from the Salmon River smolt release group and 22,104 (30% 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 2009 was 87,934 (Table 13).

This was the fourth 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

A total of 1,349 prespawn adult sockeye (682 full-term captive reared and 667 anadromous return) salmon were released into Redfish Lake in 2009. The first redd was observed near Sockeye Beach at Redfish Lake on October 2, 2009. Redd counts were finalized with three observers in one boat on November 9. Redd construction timing was similar to observations made in the past (Willard et al. 2006, Plaster et al. 2007, Peterson et al. 2008, 2010). During the final counts, 201 redds (areas of excavation) were identified (Table 17). Eighty-seven redds were located near the U.S. Forest Service Transfer dock, 102 redds were located within the southern snorkel transect area and 12 were located at Sockeye Beach (Table 17; Figure 5). This count is lower than the 2008 count of 338 suspected redds (Peterson et al. 2010) even though we released an additional 75 females into the lake. 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 2009. Radio-tagged fish moved to areas where redds were observed, and carcasses were recovered to verify spawning.

Additional spawning activity was observed during 2009. A total of nine areas of excavation were located in Little Redfish Lake, Redfish Lake Creek had eight sockeye redds observed between Redfish Lake and Little Redfish Lake, and one sockeye salmon redd was counted on Fishhook Creek in 2009.

Unmarked Juvenile Out-migrant Monitoring

In 2009, 4,552 unmarked smolts (95% CI 4,051 to 5,125) were estimated to have out-migrated from Redfish Lake (Table 14), 4,869 unmarked smolts (95% CI 3,288 to 7,825) were estimated to have out-migrated from Alturas Lake, and 3,008 unmarked smolts were estimated to have out-migrated from Pettit Lake (Table 13, Figure 6). While the SBSTOC believes it is important to utilize reintroduction strategies that produce natural origin smolts (e.g., prespawn adult releases and eyed egg introductions), it is important to note the difficulty in evaluating the effectiveness of these release strategies in the presence of kokanee 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 emigrate from basin lakes. 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 (Chris Kozfkay, IDFG, personal communication). Beginning in 2010 or 2011, we should be able to analyze out-migrants to determine which release strategies are producing the unmarked smolts leaving the basin lakes.

Table 13. Summary of 2009 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[a]	Number tagged prior to release	PIT tags detected at trap	Smolt out-migration estimate	Number tagged at trap	Estimated SURPH survival at LGR	SURPH[c] 95% CI (±)	Estimated no. at LGR
Redfish Lake								
Natural origin smolt	NA	NA	NA	4,552	537	28.00%	9.80%	1,275
FDR presmolt (SFH)	57,093	1,006	166	14,090	599	40.00%	5.90%	5,636
Alturas Lake[b]								
Natural origin smolt	NA	NA	NA	4,869	316	52.00%	21.60%	2,532
FDR presmolt (SFH)	16,864	974	7	5,278	286	89.00%	25.50%	4,697
Pettit Lake[b]								
Natural origin smolt	NA	NA	NA	3,008	96	49.00%	21.60%	1,474
FDR presmolt (SFH)	10,048	1,005	194	5,484	66	64.00%	50.90%	3,510
Salmon River								
Hatchery origin smolt (SFH)	99,374	52,551	NA	99,374	NA	47.00%	1.90%	46,706
Redfish Lake Creek								
Hatchery origin smolt (OFH)	73,681	10,937	NA	73,681	NA	30.00%	3.90%	22,104

[a] Total released from hatchery: presmolts = 2008, smolts = 2009.
[b] Data from Alturas and Pettit lake trap obtained from Shoshone-Bannock Tribes biologists.
[c] 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 11 to June 21, 2009.

Natural Origin smolts (one interval estimate)		
	Interval 1	**Total**
Dates	4/11-6/21/09	4/11-6/21/09
Trap efficiency	0.35	0.35
Marked	537	537
Recaptured	188	188
Total handled	1,599	1,599
Estimated total	4,552	4,552
95% CI upper bound	5,125	5,125
95% CI lower bound	4,051	4,051

Hatchery origin smolts (two interval estimate)			
	Interval 1	**Interval 2**	**Total**
Dates	4/11-5/22	5/23-6/21	4/11-6/21/09
Trap efficiency	0.36	0.16	0.28
Marked	347	252	599
Recaptured	126	40	166
Total handled	3,088	912	4,000
Estimated total	8,462	5,628	14,090
95% CI upper bound	9,773	7,581	17,354
95% CI lower bound	7,375	4,200	11,582

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).

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

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
Redfish	Full-term hatchery	2009	682	
	Hatchery-produced anadromous	2009	667	201 suspected redds
		Total	**4,891**	

Table 17. Summary of sockeye salmon redd observations in Redfish Lake in 2009.

	Sockeye Beach	**South Beach**	**Transfer Camp**	**West Side**	**Total**
Final Count on 11/9/2009	12	102	87		201

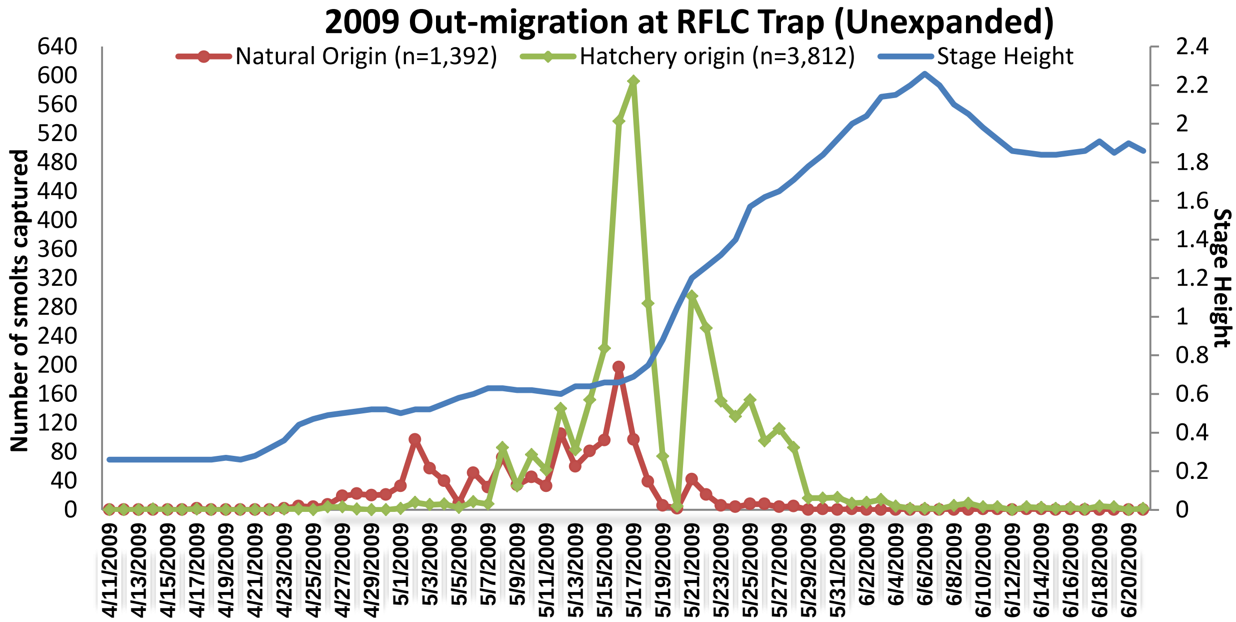

Figure 3. Daily capture of natural origin and hatchery origin sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2009 out-migration.

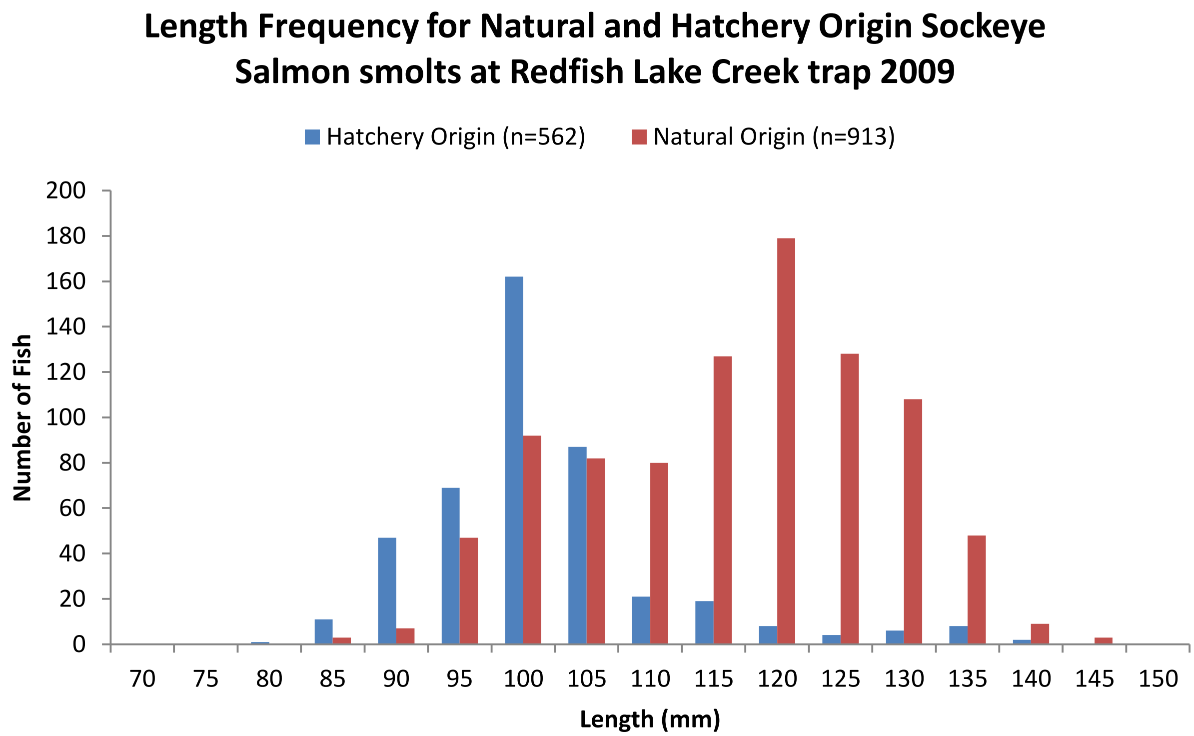

Figure 4. Length frequency of natural (n = 486), and hatchery origin (n = 664) sockeye salmon smolts collected at Redfish Lake Creek trap in 2009.

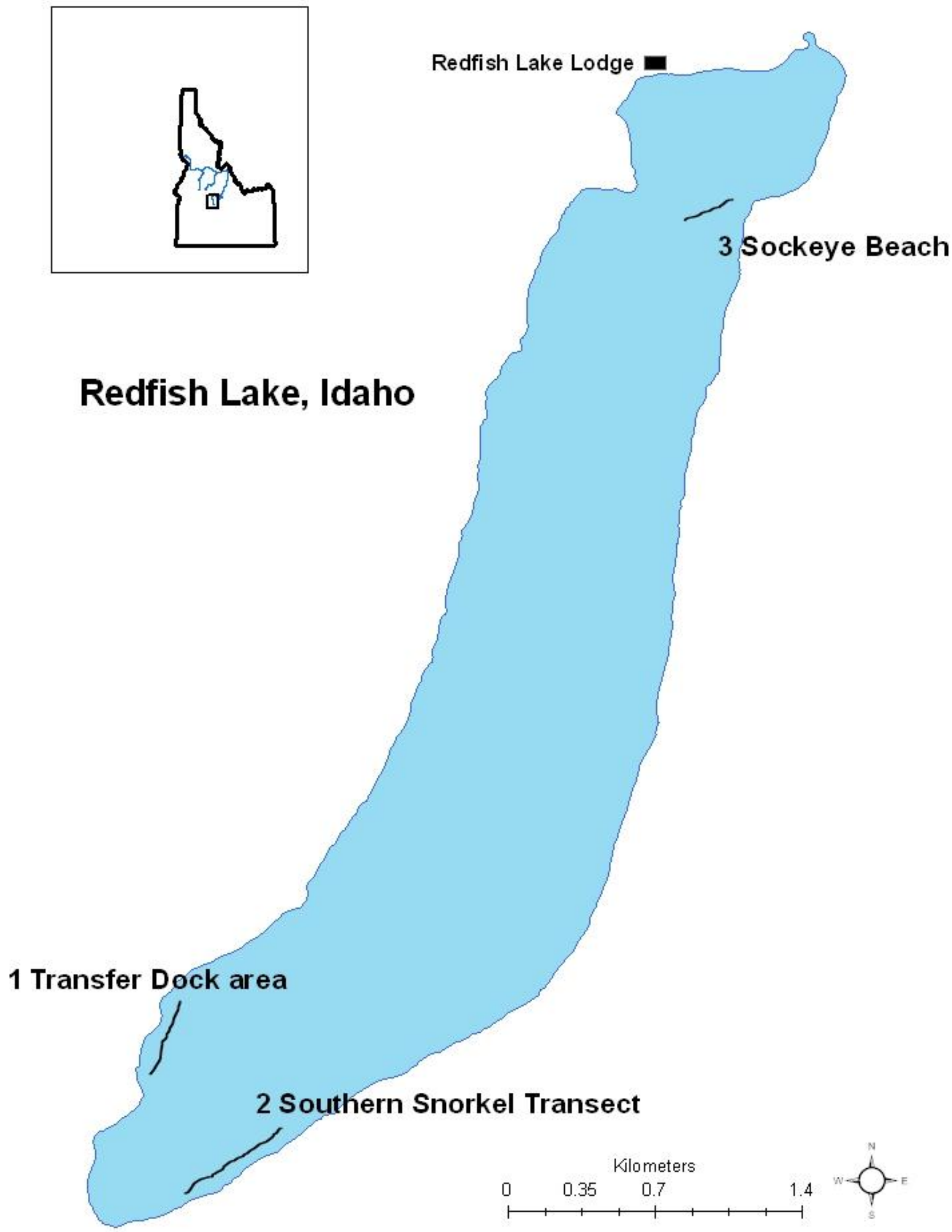

Figure 5. Spawning locations for sockeye salmon in Redfish Lake: 1) area near the U.S. Forest Service transfer camp dock, 2) Southern snorkel transect area, and 3) Sockeye beach used in 2009.

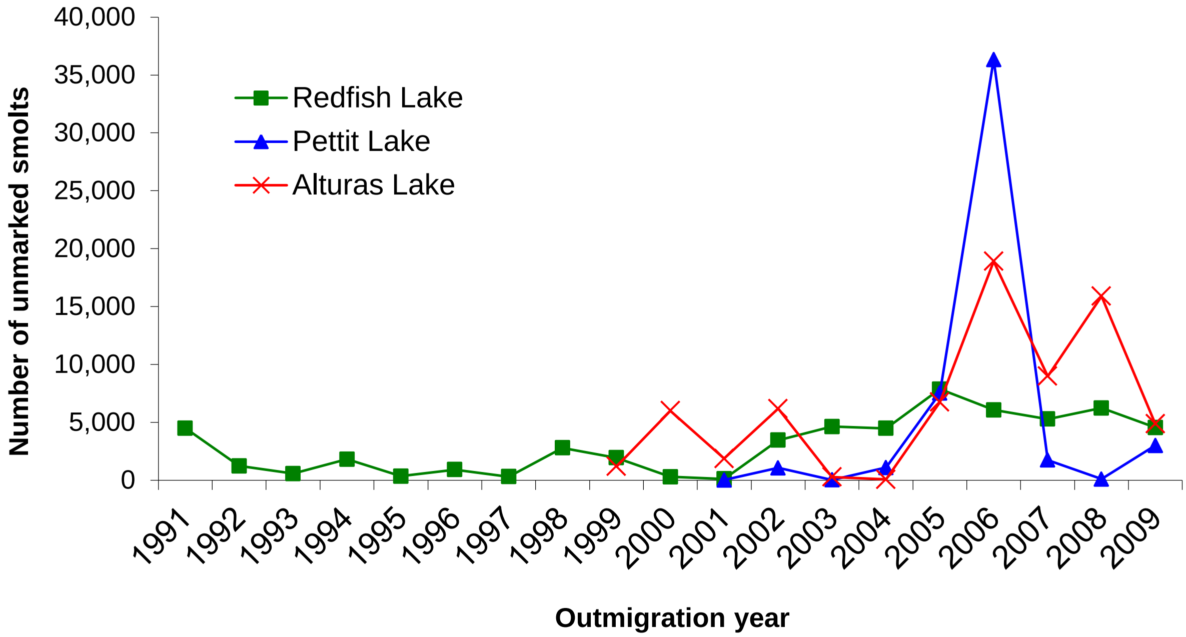

Figure 6. Natural origin sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2009 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

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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 recovery of sockeye salmon and kokanee populations in the lakes. Bull trout spawner investigations were initiated in 1995 to monitor Redfish and Alturas lakes bull trout populations. Index sections were established on Fishhook and Alpine creeks (tributaries to Redfish Lake and Alturas Lake, respectively) in 1998. Information collected in 2009 represented the 12th year data were collected in these index reaches.

METHODS

In 2009, we surveyed the index reaches of Fishhook Creek and Alpine Creek on August 27 and 28 and September 10 and 11, 2009 to enumerate bull trout spawners and redds (Figures 7 and 8, respectively). These dates typically correspond with the initiation of spawning (first survey) and the completion of spawning activities and redd construction (second survey). No suitable tributary streams feed Pettit Lake and, as such, bull trout spawner surveys were not conducted on this system. Index sections were established with global positioning satellite (GPS) equipment. Two observers walked from the lower boundary of the index section upstream and recorded visual observations of bull trout and known or suspected bull trout redds. Coordinates of redd locations were recorded with a handheld GPS unit. In order to avoid omission of completed redds during the final count, redds were flagged during the first count. Flagging prevents omitting redds from the final count that were obscured over time.

In 2007, an additional area was surveyed for bull trout redds in Fishhook Creek (identified as Fishhook Creek lower site). The new section includes the lower portion of Fishhook Creek upstream of the first gradient gain above Redfish Lake and ends at the wilderness boundary located between GPS waypoints 44° 08.889N 114.55.660W, and 44°08.639N 114°57.384W (Figure 7).

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

As mentioned previously in this report (Part 3, page 30), during the out-migration season of 2009, trap efficiency at the juvenile out-migrant sockeye salmon trap on Redfish Lake Creek dropped from a five-year season average of 42% to 33%. 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 on the release of handled sockeye salmon used to measure the trap efficiency. In an attempt to develop accurate juvenile sockeye out-migration estimates with reliable trap efficiencies, IDFG attempted to capture bull trout at Redfish Lake Creek trap using angling methods. Each captured bull trout was scanned prior to tagging for juvenile sockeye salmon PIT tags. If smolt tags were identified, they were recorded and the bull trout received a PIT tag (cheek implant) and was transported four miles downstream from the confluence of Redfish Lake Creek and the Salmon River for release.

The adult sockeye 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 6 and continued until October 20, 2009.

RESULTS AND DISCUSSION

Fishhook Creek

In the upper site trend section of Fishhook Creek, we observed 6 adult bull trout and 7 redds on August 27, 2009. During our second survey on September 11, we observed 8 adult bull trout and 14 new redds for a total of 21 completed redds (Table 18). We observed one adult bull trout and two redds on August 27, 2009 in the lower site trend section on Fishhook Creek. During our second survey of the lower site on September 10, we observed 7 adult bull trout and a total of 12 complete redds.

During the 12 years of data collection, we have observed fluctuating population trends in the data. The cyclic appearance in the data suggests normal variation within this population. Copeland and Meyers (2011) identified similar patterns within multiple salmonid populations in Idaho during the same period. Redd counts in Fishhook Creek had been stable or slightly increasing since 1998. Our findings 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). Because bull trout may spawn in alternating or consecutive years (Fraley and Shepard 1989), year-to-year variation would be expected.

Alpine Creek

We observed no adult bull trout and no completed redds on both our August 27, 2009 and September 10, 2009 surveys (Table 19). We were unable to identify a blockage to upstream migration before the count in 2009. This was the second year in a row we observed no fish utilizing the original trend area. If we continue to see that fish are not utilizing the trend area, we will establish an additional trend area 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 adults spawning below the trend area); we suspect that upstream passage is halting the use of the traditional spawning habitat within Alpine Creek. If we establish a second trend site below the original site, we hope to gain additional information about the population and identify whether we are seeing actual population changes. 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

We captured 11 adult bull trout at the Redfish Lake Creek trap by hook and line that were PIT tagged and transported to the release location on the main Salmon River. No juvenile sockeye salmon smolt PIT tags were detected in the stomachs of the captured bull trout (Table 20).

During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2009, 568 adult anadromous sockeye salmon and 72 adult bull trout were handled. A portion of the bull trout that were captured and passed received PIT tags (n = 46). A total of six bull trout mortalities were collected on the upstream side of the weir and are attributed to either angling or post spawn events.

Work done by Schoby (2006) suggests that bull trout in the upper Salmon River migrate from spawning tributaries in early October and that some individuals migrate to Redfish Lake to overwinter. Since 2008, our adult sockeye weir has been operated until mid- to late October, enabling us to collect data on bull trout moving into Redfish Lake to overwinter. The collection of this data should provide us with additional information on how bull trout populations fluctuate in the upper Salmon River drainage and whether predation issues within Redfish Lake are occurring that are not detected by using redd data alone. If increasing numbers of bull trout are migrating into the system to overwinter, we may see predation on *O. nerka* increase within the lake resulting in decreased egg-to-smolt survival as well as lower migration survival during out-migration. With the increase in adult sockeye returns during 2008-2009, we have begun monitoring the egg-to-smolt survival and will continue to monitor the bull trout population to identify changes when possible.

Table 18. Bull trout adult fish counts and redd counts in index sections of Fishhook Creek from 1998 to 2009.

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
2009	8/27	5	7
	9/11	8	21

Table 19. Bull trout adult fish counts and redd counts in index sections of Alpine Creek from 1998 to 2009.

Year	Dates	Number of bull trout observed	Number of redds
1998	8/23	6	0
	9/11	6	1
1999[a]			
	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
2009	8/27	0	0
	9/9	0	0

[a] Only one count completed.

Table 20. Bull trout relocation effort juvenile out-migrant trapping at Redfish Lake Creek for 2008-2009.

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

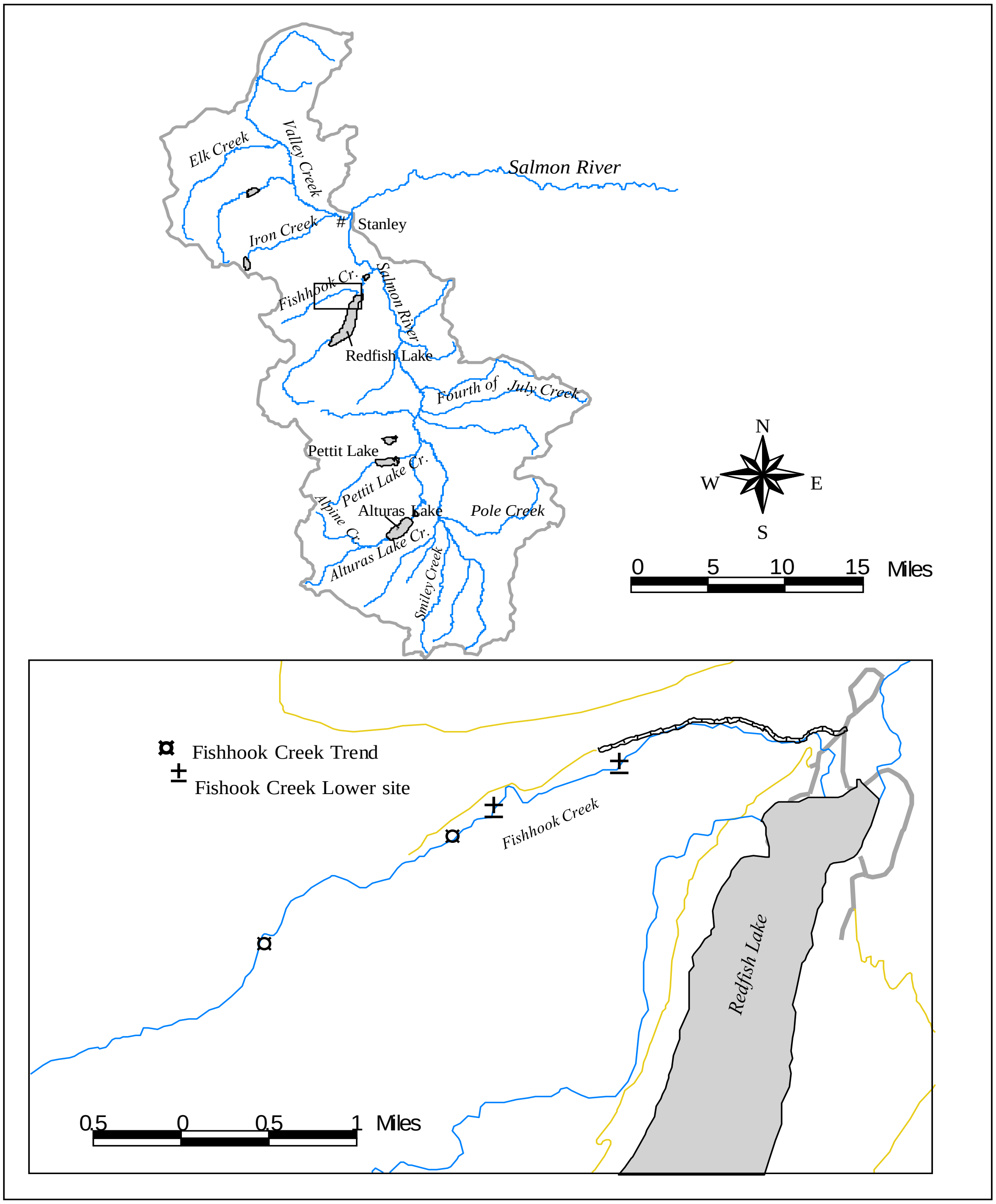

Figure 7. Location of bull trout redd index sections in Fishhook Creek in 2009.

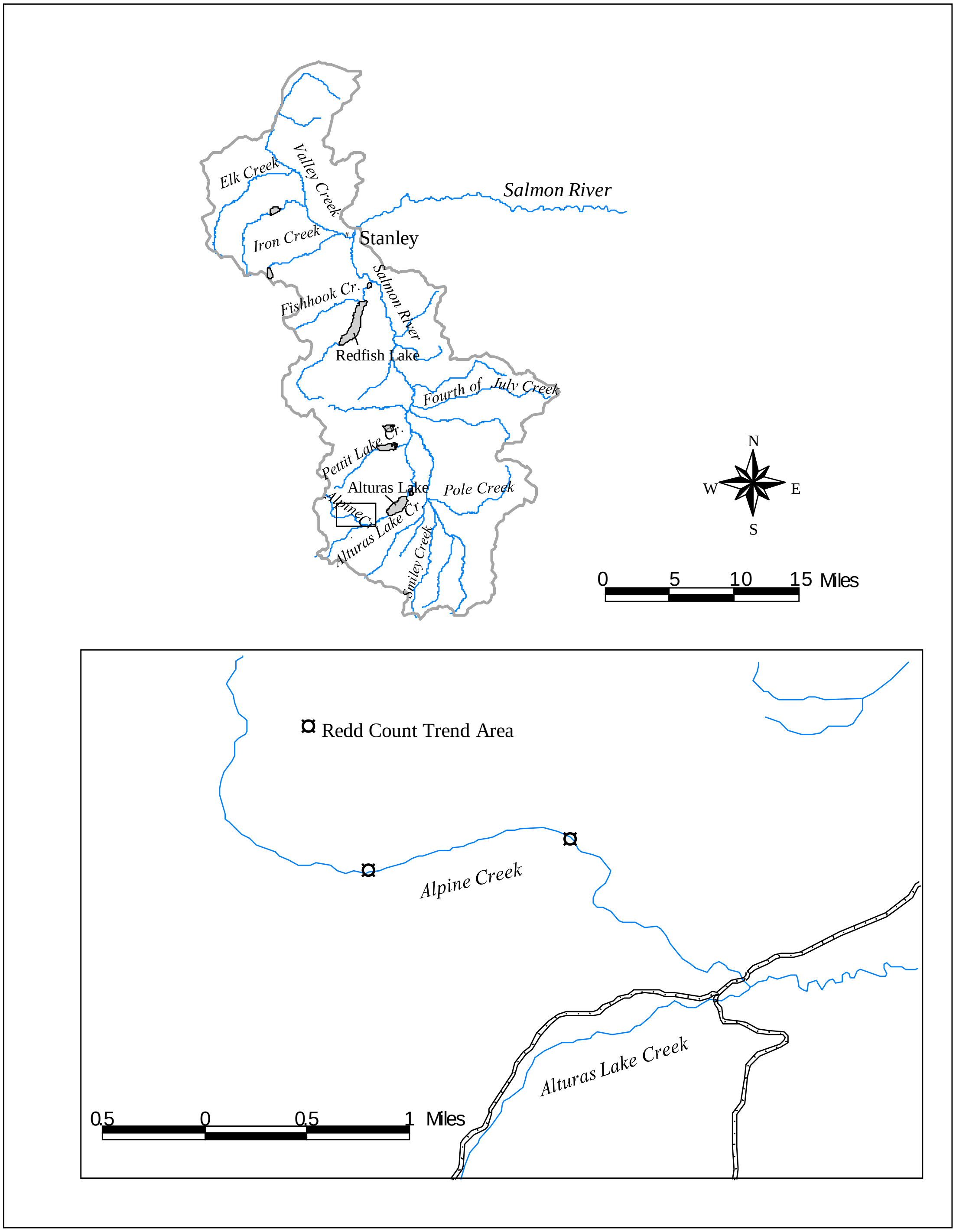

Figure 8. Location of bull trout redd index sections in Alpine Creek in 2009.

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APPENDICES

Appendix A. Fork length, weight (g), and age of *O. nerka* captured during midwater trawls conducted during September 2009 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age
Redfish Lake			
1	64	2.7	
2	45	0.9	0
2	48	1.2	0
2	53	1.4	0
2	56	1.8	0
2	63	2.4	0
2	65	2.9	0
2	62	2.3	0
2	65	2.8	0
2	74	4.1	0
2	93	8.4	1
4	38	0.5	0
4	58	1.8	0
5	42	0.9	0
5	53	1.4	0
5	55	1.8	0
5	72	3.8	0
6	48	1.1	0
6	53	1.4	0
6	67	2.9	0
Alturas Lake			
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

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
3	78	4.0	No Scales
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

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
6	121	15.0	1
6	128	19.3	1
6	139	25.6	1
6	176	48.7	2
Pettit Lake			
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 2009 migration year.

	Redfish Lake					Pettit Lake			Alturas Lake		
Date	**Natural Origin**	**Fall Direct**	**Hatchery Smolts**	**Oxbow Smolts**	**Sawtooth Smolts**	**Natural Origin**	**Fall Direct**	**Hatchery Smolts**	**Natural Origin**	**Fall Direct**	**Hatchery Smolts**
5/7/2009											
5/8/2009			1								
5/9/2009											
5/10/2009											
5/11/2009	1										
5/12/2009	1										
5/13/2009					2						
5/14/2009	1				22						
5/15/2009		1			439						
5/16/2009			1	4	506						
5/17/2009			1	9	573						
5/18/2009			1	135	679						
5/19/2009	1	1	3	308	1,658				1		
5/20/2009	1		2	126	1,232				4		
5/21/2009	1	2	8	32	794				1		1
5/22/2009	6		1	4	221		1		3	1	1
5/23/2009											
5/24/2009											
5/25/2009	2	1	2		5	2	10	1			3
5/26/2009	3	5	7		8	5	33	5	1	14	7
5/27/2009	1	3	4		5	2	24	1	2	12	5
5/28/2009	2	3	5	2	2		8	1		5	6
5/29/2009	2		3	1	4		2			1	4
5/30/2009			2		8		1			2	2
5/31/2009	1	1	3		7	1				1	
6/1/2009		1	2		9		2			1	1
6/2/2009		3	4		41		2				
6/3/2009		1	5		54					1	
6/4/2009	1		1		23					1	
6/5/2009			3		32		1				
6/6/2009		1	10		24	1	2			1	
6/7/2009		1	1		3		1				
6/8/2009					7					2	
6/9/2009			1		1		1				
6/10/2009					3						
6/11/2009		2			1						
6/12/2009		1			1						
6/13/2009			1		3					1	
6/14/2009					1						
6/15/2009			2				1				
6/16/2009			1		1						
6/17/2009			1		1						
6/18/2009					1						
6/19/2009							1				
6/20/2009			1								
6/21/2009			2								
6/22/2009											
6/23/2009											
6/24/2009			1								
6/25/2009							1				
6/26/2009											
6/27/2009											
6/28/2009					1						
6/29/2009											
6/30/2009					1						
7/1/2009											
Total	24	27	80	621	6,373	11	91	8	12	43	30

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