FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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Snake River Sockeye Salmon Captive Broodstock Program Research Element

2006 Annual Project Progress Report

Part 1—Project Overview
Part 2—*Oncorhynchus nerka* Population Monitoring and Redfish Lake Sport Fishery Investigations
Part 3—Sockeye Salmon Smolt Monitoring and Evaluation And Sockeye Salmon Spawning Investigations and Unmarked Juvenile Out-migrant Monitoring
Part 4—Predator Surveys

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EXECUTIVE SUMMARY

On November 20, 1991, the National Oceanic Atmospheric Administration listed Snake River sockeye salmon *Oncorhynchus nerka* as endangered under the Endangered Species Act of 1973. In 1991, the Shoshone-Bannock Tribes (SBT) and Idaho Department of Fish and Game (IDFG) initiated the Snake River Sockeye Salmon Captive Broodstock Program to conserve and rebuild populations in Idaho. Restoration efforts are focused on Redfish, Pettit, and Alturas lakes within the Sawtooth Valley. The first release of hatchery-produced adults occurred in 1993. The first release of juvenile sockeye salmon from the captive broodstock program occurred in 1994. In 1999, the first anadromous adult returns from the captive broodstock program were recorded when six jacks and one jill were captured at the IDFG Sawtooth Fish Hatchery.

In 2006, progeny from the captive broodstock program were released using four strategies: 1) eyed-eggs were planted in Pettit and Alturas Lakes in November and December; 2) age-0 presmolts were released to Alturas, Pettit, and Redfish lakes in October; 3) age-1 smolts were released into Redfish Lake Creek and the upper Salmon River in May; and 4) hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September.

Oncorhynchus nerka population monitoring was conducted on Redfish, Alturas, and Pettit lakes using a midwater trawl in September 2006. Population abundances were estimated at 82,796 fish for Redfish Lake, 105,779 fish for Alturas Lake, and 33,246 fish for Pettit Lake.

Angler surveys were conducted from May 28 through August 5, 2006 on Redfish Lake to estimate kokanee harvest. On Redfish Lake, we interviewed 131 anglers and estimated that 222 kokanee were harvested. The calculated kokanee catch rate was 0.07 fish/hour for each kokanee kept.

The juvenile out-migrant trap on Redfish Lake Creek was operated from April 20 to May 22, 2006. We estimated that 6,065 natural origin and 17,185 hatchery origin sockeye salmon smolts out-migrated from Redfish Lake in 2006. The hatchery origin component originated from a 2005 fall presmolt direct-release. The juvenile out-migrant traps on Alturas Lake Creek and Pettit Lake Creek were operated by the SBT from April 19 to May 19, 2006 and April 20 to May 17, 2006, respectively. The SBT estimated 36,336 natural origin and 9,860 hatchery origin sockeye salmon smolts out-migrated from Pettit Lake and estimated 18,911 natural origin and 6,356 hatchery origin sockeye salmon smolts out-migrated from Alturas Lake in 2006. The hatchery origin component of sockeye salmon out-migrants originated from fall presmolt direct-releases made directly to Pettit and Alturas lakes in 2005.

In 2006, the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC) chose to have all Snake River sockeye salmon juveniles (tagged and untagged) transported due to potential enhanced survival. Therefore, mainstem survival evaluations were only conducted to Lower Granite Dam. Unique PIT tag interrogations from Sawtooth Valley juvenile out-migrant traps to Lower Granite Dam were utilized to estimate survival rates for out-migrating sockeye salmon smolts. Survival rate comparisons were made between smolts originating from Redfish, Alturas, and Pettit lakes and the various release strategies. Alturas Lake hatchery origin smolts tagged at the out-migrant trap recorded the highest survival rate of 64.0%.

In 2006, 464 hatchery origin adult sockeye salmon were released to Redfish Lake for natural spawning. We observed 173 areas of excavation in the lake from spawning events. This was the highest number of redds observed in Redfish Lake since the program was initiated. Suspected redds were approximately 3 m x 3 m in size and were constructed by multiple pairs of adults.

To monitor the predator population found within the lakes, we monitored bull trout spawning in Fishhook Creek, a tributary to Redfish Lake; and in Alpine Creek, a tributary to Alturas Lake. This represented the ninth consecutive year that the index reaches have been surveyed on these two streams. Adult counts (32 adults) and redd counts (25 redds) in Fishhook Creek increased compared to counts conducted since monitoring began in 1998. Bull trout numbers (16 adults) and the number of redds observed (13 redds) have gradually increased in Alpine Creek compared to counts from initial monitoring.

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PART 1—PROJECT OVERVIEW

BACKGROUND

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 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 27 stocks of Pacific salmon and steelhead *Genus: Oncorhynchus* in the Columbia River basin currently listed as threatened or endangered under the Endangered Species Act (www.nwr.noaa.gov/1salmon/salmesa/index).

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 two 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 was founded from the following sources: 1) 16 anadromous adult returns that were trapped between 1990 and 1998 and retained for hatchery spawning, 2) 26 residual adults that were trapped between 1992 and 1995 and retained for hatchery spawning, and 3) 886 smolts that were trapped between 1991 and 1993, reared until maturity, and spawned in the hatchery. Second, third, and fourth 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 (Baker et al. 2005a, 2005b). 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).

The IDFG and NOAA Fisheries captive broodstock programs have produced approximately 3,478,809 eyed-eggs from 1991 through 2006 (Table 1). Each year approximately 800 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 2,389,100 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 under 69% ([2,389,100/3,478,809]*100) for the program.

Release plans are influenced by the 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). 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 that for six out of the 11 years, the out-migration was dominated by age-1 smolts. 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 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. 2003; Willard et al. 2005). This report details fisheries research information collected between January 1 and December 31, 2006, including Sawtooth Valley lakes *O. nerka* population monitoring, 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 are focused on Redfish, Pettit, and Alturas lakes in the Sawtooth Valley located within the Sawtooth National Recreation Area (Figure 1). These lakes were identified as critical spawning and rearing habitat under the ESA listing. Lakes in the Sawtooth Valley are glacial-carved and are 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. Sport-fishing 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.

2005 and 2006 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 2005, 152,438 sockeye salmon and 51,239 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 4). All presmolts released in 2005 were age-0 fish from brood year 2004 (BY04) reared at IDFG Sawtooth Fish Hatchery (SFH). Redfish Lake received 39,870 presmolts, Alturas Lake received 16,949 presmolts, and Pettit Lake received 15,289 presmolts in October by direct lake releases. A total of 78,330 BY03 smolts were released below the Sawtooth Fish Hatchery weir and at Redfish Lake Creek. A representative group of 2,016 fish released were PIT tagged, and all fish were adipose fin-clipped before release. One hundred seventy-three hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September of 2005. In November, 51,239 eyed-eggs (36,197 reared at NOAA Burley Creek Hatchery and 15,042 reared at EAG) were planted in Pettit Lake.

In 2006, 193,344 sockeye salmon and 184,596 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). All presmolts released in 2006 were age-0 fish from brood year 2005 (BY05) reared at IDFG Sawtooth Fish Hatchery (SFH). Redfish Lake received 61,804 presmolts, Alturas Lake received 26,994 presmolts, and Pettit Lake received 18,494 presmolts in October by direct lake releases. Eighty-six thousand fifty-two sockeye salmon smolts (BY04) were released (39,622 smolts reared at Sawtooth Fish Hatchery were released near the river water intake at Sawtooth Fish Hatchery, and 46,430 smolts reared at Oregon Department of Fish and Wildlife Oxbow Fish Hatchery were released just downstream of the Redfish Lake Creek Trap). Four hundred sixty-four hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning on September 8, 2006. In November and December, 79,908 eyed-eggs (32,069 reared at NOAA Burley Creek Hatchery and 47,839 reared at EAG) were planted in Pettit Lake. Alturas Lake received 104,688 eyed-eggs (77,482 reared at NOAA Burley Creek Hatchery and 27,206 reared at EAG).

Table 1. Eyed-egg production by the Idaho Department of Fish and Game (IDFG) and the National Oceanic and Atmospheric Administration (NOAA) facilities for the Snake River sockeye salmon captive broodstock program.

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	2,780	0
1996	110,756	412,500
1997	152,760	168,165
1998	15,580	47,533
1999	63,168	65,400
2000	253,047	96,698
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
Total:	**1,909,513**	**1,569,296**

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

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	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
Total:	**811,837**	**1,251,070**	**323,885**	**2,079**	**229**

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 2005.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Salmon River (below SFH weir)	smolt (2003)	05/10/2005	39,061	AD	0	36.6	19,867 (SFH) 19,194 (OFH)
Redfish Lake Creek (Below weir)	Smolt (2003)	05/10/2005	39,269	AD	2,016	33.7	19,855 (SFH) 19,414 (OFH)
Alturas Lake (direct lake)	presmolt (2004)	10/05/2005	16,949	AD	1,007	5.7	SFH
Pettit Lake (direct lake)	presmolt (2004)	10/05/2005	15,289	AD	1,008	5.4	SFH
Redfish Lake (direct lake)	presmolt (2004)	10/06/2005	39,870	AD	1,006	6.1	SFH
Redfish Lake (direct lake)	adult (2000) (2001) (2002)	09/07/2005 09/07/2005 09/07/2005	9 9 155	None None None	0 0 0	3,700.0 2,700.0 1,500.0	NOAA-BC NOAA-BC NOAA-BC
Pettit Lake (direct lake)	eyed-egg (2005) (2005)	11/30/2005 11/30/2005	15,042 36,197	NA NA	NA NA	NA NA	EAG NOAA-BC

[a] AD = adipose fin-clip.

[b] 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 2006.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Salmon River (above SFH weir)	smolt (2004)	05/04/2006	39,622	AD	1,011	17.5	SFH
Redfish Lake Creek (Below weir)	Smolt (2004)	05/10/2006	46,430	AD	1,011	52.8	OFH
Alturas Lake (direct lake)	presmolt (2005)	10/02/2006	26,994	AD	1,016	6.1	SFH
Pettit Lake (direct lake)	presmolt (2005)	10/02/2006	18,494	AD	1,021	6.2	SFH
Redfish Lake (direct lake)	presmolt (2005)	10/03/2006	61,804	AD	1,021	6.2	SFH
Redfish Lake (direct lake)	adult (2002)	09/08/2006	38	AD	38	3,300.0	NOAA-MML
	(2002)	09/08/2006	11	AD	11	2,300.0	NOAA-BC
	(2003)	09/08/2006	174	AD	174	1,950.0	NOAA-MML
	(2003)	09/08/2006	144	AD	144	1,600.0	NOAA-BC
	(2003)	09/08/2006	73	AD	73	1,600.0	NOAA-BC
	(2004)	09/08/2006	16	AD	16	600.0	NOAA-MML
	(2004)	09/08/2006	8	AD	8	600.0	NOAA-BC
Pettit Lake (direct lake)	eyed-egg (2006)	11/21/2006	47,839	NA	NA	NA	EAG
	(2006)	12/06/2006	32,069	NA	NA	NA	NOAA-BC
Alturas Lake (direct lake)	eyed-egg (2006)	11/28/2006	38,992	NA	NA	NA	NOAA-BC
	(2006)	11/28/2006	17,884	NA	NA	NA	EAG
	(2006)	12/06/2006	38,490	NA	NA	NA	NOAA-BC
	(2006)	12/06/2006	9,322	NA	NA	NA	EAG

[a] AD = adipose fin-clip.

[b] 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.

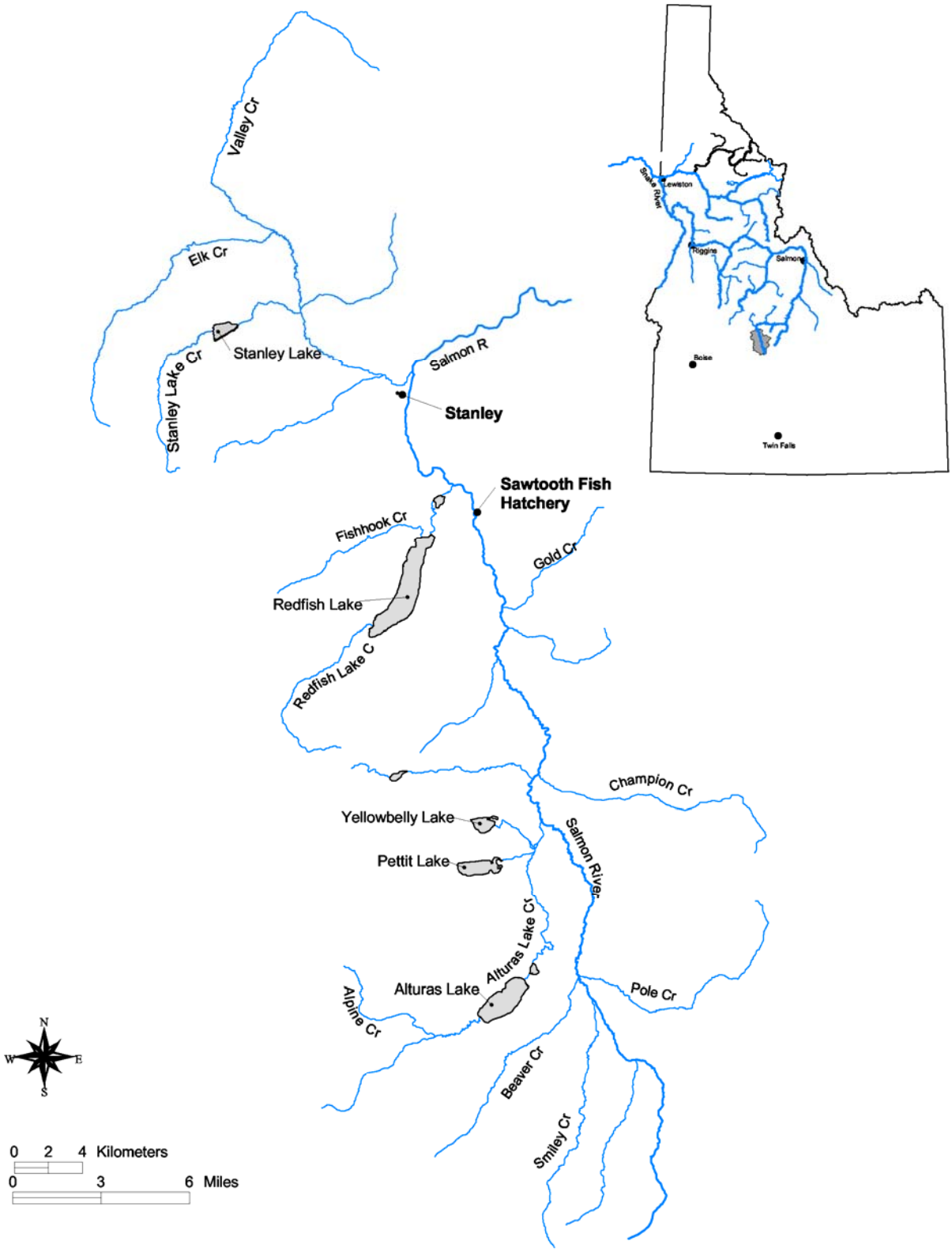

Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

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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 20-22, 2006. 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, Mendenhall, and Ott (1990):

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

Previous years confidence limits were calculated differently and after consultation with a statistical expert, the above formula was deemed correct and will be used in all future estimates.

Fork length (1 mm) and weight (0.1 g) were recorded for all trawl-captured *O. nerka*. Sagittal otoliths and scales were removed from a subsample of *O. nerka* (a minimum of five fish from every 10 mm length group) and returned to the laboratory. Three program technicians aged scales and otoliths to determine length ranges for age classification. Scales were mounted between microscope slides before aging and otoliths were read "dry." 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 95% ethanol and delivered to the IDFG Genetics Laboratory for DNA analysis.

Redfish Lake Sport Fishery Investigations

A roving creel survey was conducted from May 28 through August 5, 2006 (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 (1500 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 creeled kokanee that were checked by creel survey personnel. Fin clips were stored in 95% 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

September trawl catch (seven transects, Appendix A) included 70 natural origin *O. nerka* and zero hatchery origin sockeye salmon. *Oncorhynchus nerka* abundance was estimated at

82,796 fish (95% CI ± 47,407). The *O. nerka* population increased 47% within Redfish Lake over the estimated abundance in 2005 of 56,220 fish, and abundances were similar to the estimate for 2004 of 82,258 *O. nerka* (Table 6).

Density and biomass were estimated at 135 fish/ha and 2.37 kg/ha, respectively (Table 6). This represented increases of 47% (43.2 fish/ha) for densities and a six fold increase in biomass from estimated levels in 2005 (Plaster et al. 2007). Age-0, age-1, age-2, and age-3 *O. nerka* were represented in the trawl sample from Redfish Lake. Age-1 fish had the highest density (52 fish/ha) and age-3 had the highest biomass (1.17 kg/ha) (Table 7). The dramatic increase in biomass is likely due to sampling bias associated with the use of new trawling gear initiated in 2005 (Plaster et al. 2007). As we become more familiar with the new gear, capture efficiencies will likely increase to some arbitrary point and then stabilize. As we continue to learn more about the new gear capabilities, we are becoming more efficient using the gear. This should allow us to identify if the different gear types are affecting trend data collected by trawling the basin lakes.

Alturas Lake

September trawl catch on Alturas Lake (six transects, Appendix A) included 150 natural origin *O. nerka* and zero hatchery origin sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 105,779 fish (95% CI ± 50,702), 313 fish/ha, and 3.51 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 (181 fish/ha) and contributed 52% of the biomass (Table 7). The estimates for abundance, density, and biomass represent increases over 2005 estimates of four fold, two fold, and 23 fold, respectively.

As mentioned above, the use of new trawl gear likely played a part in the difference between last year's and this year's estimates. After gaining a year of experience running the new gear, we have confidence that this year's estimates are likely closer to the actual representation of the *O. nerka* population within the lake. However, we have observed large fluctuations in abundance estimates in past years within Alturas Lake (Table 6). These fluctuations may be explained to some degree by sampling bias associated with the number of transects (net tows) conducted each year. In past years, multiple lakes were trawled in one night not allowing for consistent numbers of transects to be completed for each lake. We have standardized the use of six transects as a minimum on the lake to help reduce some of the variation we see between years.

Pettit Lake

September trawl catch on Pettit Lake (six transects, Appendix A) included 54 natural origin *O. nerka* and one hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 33,246 fish (95% CI ± 12,416), 208 fish/ha, and 7.45 kg/suitable ha, respectively (Table 6). Age-0, age-1, age-2, and age-3 fish were represented in the trawl sample. Age-2 fish had the highest density (106 fish/ha) and contributed 39% of the biomass (Table 7). The estimates for abundance, density, and biomass represent increases over 2005 estimates of 39%, 39%, and 235%, respectively. This is likely the result of increased knowledge using the new gear as mentioned above.

The capture of one hatchery origin sockeye salmon during trawl sampling along with the capture of another hatchery origin sockeye salmon during a hook-and-line sampling trip may

suggest that the number of residual sockeye salmon within Pettit Lake is on the rise. We recommend that SBSTOC develop and discuss options to evaluate and monitor whether this population is increasing. The SBT conducts night snorkeling on Redfish Lake to monitor the residual population within the lake, which may prove to be a feasible way to monitor the population on Pettit Lake.

With the additional knowledge we have gained by using the new trawling gear for a year, it appears we have also increased our ability to capture fish from the older age classes. In 2005, we captured a total of 12 age-2 or older *O. nerka*, in comparison to 2006 when we captured 87 age-2 or older *O. nerka*. 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.

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. It appears that zooplankton abundance levels have remained high enough for *O. nerka* to grow within each lake (Robert Griswold, personal communication). We have also experienced high levels of adult escapement in both Fishhook Creek and Alturas Lake Creek over the past two years (Table 8), which may have led to more recruitment into the systems.

Whether population fluctuations between 2005 and 2006 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 2007 (before kokanee enter the tributaries to spawn) and presented to the SBSTOC for discussion and modification.

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

Redfish Lake Sport Fishery Investigations

In 2006, we contacted 73 angler parties (131 individual anglers) on Redfish Lake. Idaho residents made up 90% of those interviewed. Most anglers used lures (52%), followed by bait (38%), a combination (7%), and flies (3%). Total angler effort was estimated at 2,635 hours (95% CI $\pm$ 275) (Table 9). This effort estimate represents a 27% decrease in fishing pressure between 2005 and 2006 (Table 10). Boat anglers expended more effort (71%) than bank anglers (29%), which was similar to results from 2005 (Plaster et al. 2007).

The season catch rate for all fish (harvested and released) was 0.72 fish/hour. Catch rates increased 64% over the estimate from 2005 (Plaster et al. 2007). Kokanee catch rates (harvested and released) averaged 0.19 kokanee/hour for weekdays and 0.36 kokanee/hour for weekends (0.31 kokanee/hour for the season, Table 11). These estimates were also slightly higher than the estimate 0.30 kokanee/hour for the season in 2005. Bull trout catch and release rates averaged 0.54 bull trout/hour for weekdays and 0.27 bull trout/hour for weekends (IDFG regulations prohibit harvesting bull trout) (Table 11). The season catch rate for bull trout

represents a five-fold increase over the estimate from the 2005 season. 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, redside shiner, sucker *catostomus spp*.) accounted for a combined catch rate (harvested and released) of 0.04 fish/hour for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 2,259 fish (95% CI ± 464). This was an overall increase of 43% from the 2005 estimate. The majority (89%) of all fish caught were released. Much of the increase was a result of the increased catch rate associated with bull trout. Anglers captured 727 more bull trout in 2006 than the previous year (Plaster et al. 2007). Kokanee harvest was estimated at 222 fish (95% CI ± 33) and the number of kokanee released was estimated at 757 (95% CI ± 78) (Table 12). The harvest of kokanee declined an estimated 65%; however, the number released increased 122% over levels from 2005 (Plaster et al. 2007). In 2006, we observed the lowest harvest rate for kokanee since 2002 and the fourth 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 recommend that an angler education program be initiated 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. This program should begin in the spring of 2007 to monitor if any additional fishing pressure is applied to Redfish Lake as a result of the program. The results from the 2007 creel survey will be compared to 2006 data to determine the success of the angler education program.

No hatchery-produced sockeye salmon (adipose-clipped) were observed by creel personnel during 2006. 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 creel kokanee. Genetic analysis of fin clips obtained from creel kokanee (n = 48) has not been completed for 2006.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2006.

Year	Population (±95% CI)[b]	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
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)		
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
	Pettit Lake (160 surface hectares)		
2006	33,246 (12,416)	207.8	7.45
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.
[b] Methodology change for the way confidence intervals were calculated (see text).

Table 7. Estimated 2006 *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	20	30	12	8	0	70
Mean length (mm) (±95 CI)	54.4	98.6	145.0	191.0	NA	NA
Mean weight (g) (±95 CI)	1.37	9.05	31.10	70.00	NA	NA
Abundance	23,664	31,886	16,549	10,697	NA	82,796
95% CI High	35,661	64,187	28,936	22,881	NA	130,203
95% CI Low	11,667	0	4,162	0	NA	35,389
Density (fish/ha)	39	52	27	17	NA	135
Biomass (kg/ha)	0.052	0.389	0.759	1.174	NA	2.374
			Alturas Lake (338 surface ha)			
No. captured	39	85	19	7	0	150
Mean length (mm) (±95 CI)	57.1	102.5	131.5	189.0	NA	NA
Mean weight (g) (±95 CI)	1.45	9.31	19.90	65.50	NA	NA
Abundance	31,115	61,055	8,652	4,957	NA	105,779
95% CI High	66,102	74,558	15,481	12,014	NA	156,481
95% CI Low	0	47,552	1,823	0	NA	55,077
Density (fish/ha)	92	181	26	14	NA	313
Biomass (kg/ha)	0.154	1.830	0.565	0.960	NA	3.509
			Pettit Lake (160 surface ha)			
No. captured	3	10	28	13	0	54
Mean length (mm) (±95 CI)	54.7	119.4	139.8	194.7	NA	NA
Mean weight (g) (±95 CI)	1.60	17.79	27.50	75.62	NA	NA
Abundance	1,851	6,475	16,888	8,032	NA	33,246
95% CI High	5,115	12,131	26,033	13,801	NA	45,662
95% CI Low	0	819	7,743	2,263	NA	20,830
Density (fish/ha)	12	40	106	50	NA	208
Biomass (kg/ha)	0.019	0.731	2.901	3.795	NA	7.446

Table 8. Estimated kokanee escapement to Fishhook Creek 1991 to 2006 and Alturas Lake Creek 1992 to 2006. 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

Table 9. Estimated angler effort for the 2006 fishing season on Redfish Lake.

Redfish Lake	Boat	Bank	Tube	Total
Hours fished	1,871	764	0	2,635
±95% CI	212	159	0	275

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/hr)	Angler parties interviewed	Estimated hours fished/season
1996	0.19	0.08	844	0.09	107	3,351
1997	0.19	0.37	466	0.08	117	2,874
1998	0.13	0.17	1,362	0.08	205	7,963
1999	0.38	0.15	1,187	0.28	227	3,951
2000	0.02	0.06	67	0.08	63	3,063
2001	0.00	0.06	0	0.27	88	2,391
2002	0.09	0.16	129	0.16	100	2,127
2003	0.10	0.05	424	0.24	98	2,477
2004	0.13	0.26	621	0.31	96	2,791
2005	0.21	0.09	637	0.09	85	3,620
2006	0.07	0.24	222	0.35	131	2,635

Table 11. Catch rates (fish/hour) for summer 2006 on Redfish Lake categorized by day type and species.

	Kokanee		Cutthroat Trout		Bull Trout		All Fish	
Day Type	Kept	Released	Kept	Released	Kept	Released	Kept	Released
Weekday	0.06	0.13	0.02	0.06	0.00	0.54	0.08	0.73
Weekend Day	0.07	0.29	0.01	0.01	0.00	0.27	0.08	0.59
Season Avg.	0.07	0.24	0.01	0.02	0.00	0.35	0.08	0.64

Table 12. Estimated number of fish harvested and released on Redfish Lake during the summer 2006.

	Harvested				
Redfish Lake	Kokanee	Cutthroat Trout	Bull Trout	Other	All Fish ± 95% CI
Harvested	222	38	0	0	260 ± 57
Released	757	100	1,091	51	1,999 ± 438

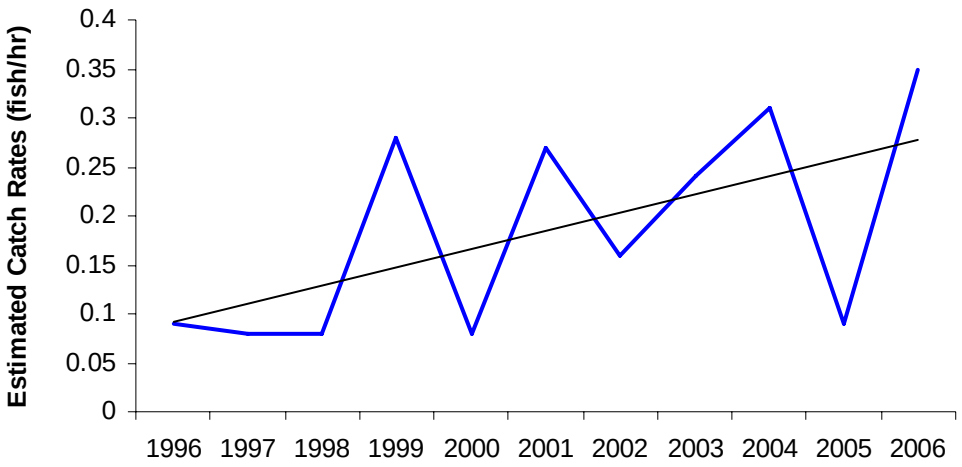

Figure 2. Estimated bull trout catch rates from 1996-2006 within Redfish Lake. The trend line is used to show the population increase within the lake. The equation for the trend line is $y = 0.0185\ x + 0.0738$ with an R^2 of 0.33.

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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 disposition 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 2005 release of 39,870, 16,949, and 15,289 adipose fin-clipped presmolts to Redfish, Alturas, and Pettit lakes, respectively. All presmolts released in 2005 were reared at the Sawtooth Fish Hatchery.

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 the hatchery. Currently, prespawn adults are released only to Redfish Lake.

Currently, 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). The trap was operated from April 20, 2006 through May 22, 2006 and contains nine bays, five of which were fitted with incline bar traps. IDFG staff checked the trap at least twice daily in 2006. The trap is fished until high water forces us to remove it, until fish stop emigrating from the lake, or until June 15 (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), 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, and 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) fits mixture distributions to grouped data by utilizing a maximum likelihood estimator. All captured non-target species were counted and released immediately.

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), 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 generated separately for natural origin and fall direct-released hatchery origin sockeye salmon smolts.

During the spring of 2006, we experienced extremely high flow events earlier than normal and the trapping season was reduced by a month. Natural origin out-migrants were estimated as mentioned above; however, based on past data collection (project files 2000-2005) and that hatchery origin fish typically out-migrate after natural origin fish, we felt that we missed the majority of the fall direct-release out-migrants that left the basin in the spring of 2006. We developed a method to back-calculate the number of fall direct-release fish utilizing the Survival by Proportional Hazards model (SURPH) developed by Lady et al. (2001). The SURPH model uses PIT tag detections at various dams to develop a Cormack/Jolly-Seber estimate of survival to Lower Granite Dam (LGR). We used the estimate provided by SURPH for PIT tagged fall direct-released fish that survived from the release to LGR and divided that number by the survival estimate for fall direct-released fish from the trap to the dam. This method also provides us with an estimate of overwinter survival for the fall direct-release fish. Due to the use of several survival estimates to estimate total fall direct-release hatchery origin out-migrants, no CIs were calculated for the estimate of fall direct-released out-migrants.

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 genetic and proximate analysis. These fish were measured for fork length (0.1 mm) and weighed to the nearest 0.1 g. Proximate sampled fish were sacrificed or were trap mortalities.

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 19 to May 19, 2006. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 16,949 adipose fin-clipped presmolts (reared at Sawtooth Fish Hatchery) released into the lake in October 2005. 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 Shoshone Bannock Tribes.

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 20 to May 17, 2006. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 15,289 adipose fin-clipped presmolts (reared at Sawtooth Fish Hatchery) released into the lake in October 2005. The Pettit Lake Creek weir traps at 100% efficiency under low spring flow conditions (personal communication, Doug Taki, Shoshone Bannock Tribes); 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 Shoshone Bannock Tribes.

Salmon River and Redfish Lake Creek Smolt Groups

Thirty-nine thousand six hundred twenty-two (39,622) BY04 smolts were released near the river water intake of Sawtooth Fish Hatchery (Sawtooth FH). This release group included

smolts reared at Sawtooth FH. All fish released were adipose fin-clipped and coded-wire tagged with a representative group (n = 1,011) PIT tagged.

A total of 46,430 BY04 smolts were released into Redfish Lake Creek below the out-migrant weir. This release included smolts reared at Oregon Department of Fish and Wildlife Oxbow Fish Hatchery (Oxbow FH). All fish were adipose/right ventral fin-clipped and coded-wire tagged with a representative group (n = 1,011) PIT tagged.

Mainstem Snake and Columbia River Dams

In 2006, 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 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. 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.

ADULT SPAWNING MONITORING AND EVALUATION

Sockeye Salmon Spawning Investigations

On September 8, 2006, 464 adult sockeye salmon were released to Redfish Lake (Table 16). The hatchery origin adults were reared at NOAA's Manchester Marine Laboratory and NOAA's Burley Creek Hatchery. Sex was determined by ultrasound, and efforts were made to release fish of equal sex ratios. No anadromous adults were released in 2006.

In order to assist in identifying spawning locations, five male and six female hatchery-produced sockeye salmon were implanted with radio transmitters prior to release. Telemetry investigations of adult locations began September 13, 2006 and continued weekly through November 6, 2006. Fish locations were recorded weekly by boat tracking.

Redd counts were also conducted once a week (coinciding with radio telemetry events) beginning on September 27, 2006 and continued until November 6, 2006. Suspected redds were generally enumerated by two observers on each count date. On the final count date, two 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 2006. 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 because two anadromous fish were observed there in 2004.

Unmarked Juvenile Out-migrant Monitoring

In 2006, unmarked out-migrants produced from program fish releases to Redfish Lake included age-1 out-migrants produced from 241 hatchery-origin adults released for volitional

spawning in 2004, and age-2 out-migrants produced from 315 hatchery-origin adults released in 2003. Unmarked out-migrants produced from program fish releases to Alturas Lake included age-2 out-migrants from 49,700 eyed-eggs released into Alturas Lake in 2003. No releases occurred in 2004 within Alturas Lake that would have produced age-1 unmarked out-migrants in 2006. 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-1 out-migrants produced from 49,134 eyed-eggs released in 2004 and age-2 out-migrants produced from 149,966 eyed-eggs released in 2003. The proportions of age-1 and age-2 unmarked out-migration were determined for 2006 Redfish, Alturas, and Pettit Lake out-migrants by aging scales. The methods are discussed for this analysis above.

RESULTS AND DISCUSSION

SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

Redfish Lake Creek Trap

A total of 1,811 sockeye salmon smolts (1,079 natural origin and 732 hatchery origin) were trapped during the 2006 out-migration season (Figure 3). We captured significantly less sockeye smolts during the 2006 out-migration trapping season than in 2005. As mentioned previously this is likely due to the high flow conditions that were experienced during the spring of 2006. Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 99 mm (range 78 mm to 143 mm; Figure 4) and 98 mm (range 82 mm to 135 mm; Figure 5), respectively. Sockeye smolt lengths were slightly shorter in 2006 than during the previous out-migration season (Plaster et al. 2007).

Based on observed trapping efficiencies and discharge during out-migration monitoring, we determined that using a single season trapping interval for the natural origin smolts was appropriate for estimating total natural origin sockeye salmon smolt out-migration. Of the 1,079 natural origin smolts handled in 2006, 370 were marked and released upstream of the weir to estimate trapping efficiency. Trap efficiency decreased from the previous five-year average of 42% to 18% during 2006. This was likely due to predation at the trap by small mammals, piscivorous birds, and bull trout and not due to the high flows that were observed. Several personnel visually observed pine martin, 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 2007, we will begin a 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 2006 total natural origin sockeye smolt out-migration was estimated at 6,065 fish (95% CI 4,837 to 7,504; Table 13). The proportion of age-1 natural origin smolts was estimated at 84.2% (95% CI 79.9%-88.5%), which equals 5,107 smolts; the proportion of age-2 natural origin smolts was estimated at 15.8% (95% CI 11.0%-19.6%), which equals 958 smolts. As referenced in the Methods section of this report, age proportions were estimated using the MIX software application. The above proportions were similar to out-migration proportions we saw last year (Plaster et al. 2007).

Of the 732 fall direct-released smolts handled in 2006, 323 were marked and released upstream of the weir to estimate trap efficiency. However, due to high flows trap efficiencies for hatchery origin smolts was not calculated. Total fall direct-released smolt out-migration was estimated at 17,185 fish (based on SURPH back-calculations; therefore, no 95% CI were

calculated; Table 14). Overwinter survival and out-migration for this group was 43% of the number of presmolts planted in 2005. The overwinter survival and the fall direct-release estimates were among the highest estimates we have seen since the beginning of the project and may be a product of the method of estimation and are likely not directly comparable to past years. However, they still fall within ranges we have observed in the past (Table 15). The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated, using the MIX software application, at 96.1% (95% CI 93.7%-98.5%), which equals 16,514 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 3.9% (95% CI 1.5%-6.3%), which equals 671 smolts. As mentioned above, these proportions are similar to those observed from past years.

Alturas Lake Creek Trap

One-thousand one hundred twenty-five sockeye salmon smolts (842 natural origin and 283 hatchery origin) were trapped during the 2006 out-migration season. Numbers trapped and handled were probably affected by the spring run-off conditions, as they are slightly lower than the previous year (Plaster et al. 2007). Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 94 mm (range 75 mm to 116 mm) and 97 mm (range 85 mm to 123 mm), respectively. The average size of out-migrating sockeye smolts was lower than in 2005 (Plaster et al. 2007).

Total natural origin sockeye smolt out-migration for Alturas Lake was estimated at 18,911 fish (95% CI not calculated; see Shoshone Bannock Tribe annual report for methods and calculations) and hatchery origin smolt out-migration was estimated at 6,356 fish (95% CI not calculated; see Shoshone Bannock Tribe annual report for methods and calculations) (Table 14). The estimate for natural origin smolts was the highest we have observed since the initiation of the project in 1991 (Figure 7). The high estimate is attributed to either kokanee fallout from the lake or residual production. Genetic samples were collected from out-migrating sockeye smolts and could possibly be used to identify the source of out-migrants (whether these fish were produced by kokanee or residuals). It is also possible that the high estimate is a result of the method of estimation. If numbers continue to increase, we may need to begin a monitoring program on Alturas Lake to develop trend data on residuals, similar to the snorkel surveys performed on Redfish Lake. Overwinter survival and out-migration for the fall direct-release group was 38% of the number of presmolts planted in 2005. Scales for aging were collected from hatchery origin smolts at the Alturas Lake Creek trap in 2006. The proportion of age-1, adipose fin-clipped, hatchery origin smolts was estimated, using the MIX software application, at 98.8% (95% CI 96.4%-100.0%), which equals 6,280 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 1.2% (95% CI 0.0%-3.6%), which equals 76 smolts. This is the first year that sufficient numbers of scales were collected to estimate age proportions using the MIX software for Alturas Lake Creek. We will continue to collect scales from these fish and monitor proportions for this population.

Pettit Lake Creek Trap

At the Pettit Lake Creek trap, 11,587 sockeye smolts (9,114 natural origin and 2,473 fall-released) were trapped during the 2006 out-migration season. Fork length of natural origin and fall direct-released sockeye salmon smolts captured averaged 107 mm (range 74 mm to 136 mm) and 101 mm (range 85 mm to 116 mm), respectively.

Total natural origin sockeye smolt out-migration for Pettit Lake was estimated at 36,336 fish (95% CI not calculated; see Shoshone Bannock Tribe annual report for methods and calculations) and hatchery origin smolt out-migration was estimated at 9,860 fish (95% CI not calculated; see Shoshone Bannock Tribe annual report for methods and calculations) (Table 14). The estimate of natural origin smolts was the highest we have observed out-migrating from Pettit Lake. Similar to Alturas Lake Creek, this may be the result of methods used to estimate the number of out-migrants given high flow events that occurred during the spring of 2006. However, as mentioned earlier in this report, we have collected evidence that suggests an increasing residual population within Pettit Lake, and we recommend that night snorkel surveys be performed at Pettit Lake similar to those done on Redfish Lake. Overwinter survival and out-migration for fall 2005 direct-released presmolts was 64%. Scales for aging were collected from natural origin and hatchery origin smolts at the Pettit Lake Creek trap in 2006. The proportion of age-1, natural origin smolts was estimated, using the MIX software application, at 91.6% (95% CI 88.5%-94.7%), which equals 33,284 smolts; the proportion of age-2, natural origin smolts was estimated at 8.4% (95% CI 5.8%-11.0%), which equals 3,052 smolts. The proportion of age-1, adipose fin-clipped, hatchery origin smolts was estimated, using the MIX software application, at 93.8% (95% CI 89.3%-98.3%), which equals 9,249 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 6.2% (95% CI 3.2%-9.2%), which equals 611 smolts. Age class proportions were similar for Pettit Lake as seen in 2005 (Plaster et al. 2007).

Salmon River and Redfish Lake Creek Smolt Groups

We released 39,622 BY04 smolts to the Salmon River above the Sawtooth FH river water intake upstream of the weir on May 4, 2006. 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 = 1011) PIT tagged. Fork length of the Salmon River smolt group averaged 124 mm (range 98 mm to 104 mm), and these fish had an average weight of 17.5 g/fish.

A total of 46,430 BY04 smolts were released into Redfish Lake Creek below the out-migrant weir on May 9, 2006. 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 = 1011) PIT tagged. The average weight of the Redfish Lake Creek smolt group was 52.8 g/fish. 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 14; Appendix B). Estimates reflect numbers of smolts that arrived at LGR based on results from data analyses using the SURPH model (Table 14). Survival among release groups ranged from 45% (fall direct-release fish within Pettit Lake) to 64% (fall direct-release fish within Alturas Lake). The average survival rate for all the release groups was 59% to LGR. An estimated 3,336 (55% survival) and 9,968 (58% 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 11,725 (62% survival) for natural origin smolts and 4,068 (64% survival) for fall direct-release smolts. Survival from the Pettit Lake Creek trap to LGR was estimated at 22,892 (63% survival) for natural origin smolts and 4,437 (45% survival) for fall

direct-release smolts. An estimated 24,566 (62% survival) sockeye smolts survived to LGR from the Salmon River smolt release group and 28,787 (62% survival) sockeye smolts survived from the Redfish Lake Creek smolt release. The total estimate for sockeye smolts that out-migrated from Stanley Basin lakes and survived to LGR for 2006 was 109,779 (Table 14).

This was the first year we have 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 at Sockeye Beach on Redfish Lake on September 27, 2006. Redd counts were finalized with two observers in a boat on November 6, 2006. This was the first year that we observed adults utilizing Sockeye Beach as a spawning location since the initiation of the project. We also observed redds within the lake earlier than in the past two year (Willard et al. 2006, Plaster et al. 2007). During the final counts, 172 redds (areas of excavation) were identified (Table 16). Fifty-two redds were located at the Transfer Camp, 86 redds were located at the south beach area, and 34 were located at Sockeye Beach (Table 17; Figure 6). 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 2006. Redd counts were conducted in cooperation with SBT biologists for verification of accurate redd count numbers. Radio tagged fish moved to areas where redds were observed; however, we were unable to collect any adult carcasses in 2006 to verify these fish had spawned.

No completed redds or areas of excavation were located in Little Redfish Lake in 2006.

Unmarked Juvenile Out-migrant Monitoring

In 2006, 6,065 unmarked smolts (95% CI 4,837 to 7,504) were estimated to have out-migrated from Redfish Lake, 18,911 unmarked smolts (95% CI not calculated) were estimated to have out-migrated from Alturas Lake, and 36,336 unmarked smolts were enumerated to have out-migrated from Pettit Lake (Figure 7). 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 (Willard 2005). 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. Initially, we were not as successful at assigning juveniles to potential parents as we had hoped; however, we have made steps towards utilizing these techniques by adding additional microsatellite markers (originally 7 loci, currently we are using 11 loci). 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 (Christine Kozfkay, personal communication).

Table 13. Out-migration estimate for natural origin sockeye salmon smolts captured at the Redfish Lake Creek trap from April 21 to May 22, 2006.

Natural Origin Smolts (single interval estimate)	
	Total
Dates	4/21-5/22
Trap efficiency	0.18
Marked	370
Recaptured	65
Total handled	1,079
Estimated total (single interval estimate)	6,065
95% CI upper bound	7,504
95% CI lower bound	4,837

Table 14. Summary of 2006 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 95% CI (±)	Estimated no. at LGR
Redfish Lake								
Natural origin smolt	NA	NA	NA	6,065	370	55%	15.7%	3,336
FDR presmolt (SFH)	39,870	1,008	16	17,185	323	58%	15.7%	9,968
Alturas Lake[b]								
Natural origin smolt	NA	NA	NA	18,911	224	62%	17.6%	11,725
FDR presmolt (SFH)	16,949	1,011	NA	6,356	79	64%	25.5%	4,068
Pettit Lake[b]								
Natural origin smolt	NA	NA	NA	36,336	292	63%	21.6%	22,892
FDR presmolt (SFH)	15,289	1,010	152	9,860	111	45%	9.8%	4,437
Salmon River								
Hatchery origin smolt (SFH)	39,622	1,011	NA	39,622	NA	62%	9.8%	24,566
Redfish Lake Creek								
Hatchery origin smolt (OFH)	46,430	1,011	NA	46,430	NA	62%	23.5%	28,787

[a] Total released from hatchery.
[b] Data from Alturas and Pettit lake trap obtained from Shoshone-Bannock Tribes biologists.
[c] 95% CIs are 2 standard errors.

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

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%

Table 16. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history.

Lake	Rearing origin	Date released	Number released	Number of suspected redds
Redfish	Full-term hatchery	1993	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
		Total	**2,066**	

Table 17. Summary of sockeye salmon redd observations in Redfish Lake in 2006.

	Sockeye Beach	South Beach	Transfer Camp	Total
Preliminary Count on 10/23/2006	13	69	29	111
Final Count on 11/6/2006	34	86	52	172

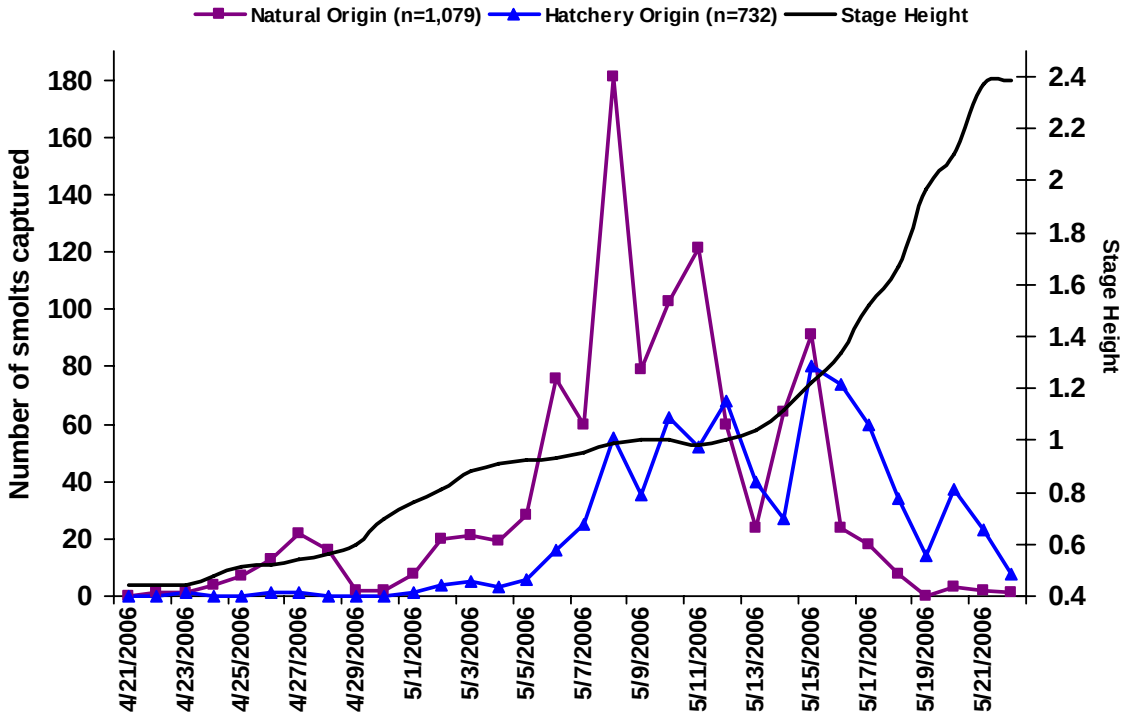

Figure 3. Daily capture of natural origin and hatchery origin sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2006 out-migration.

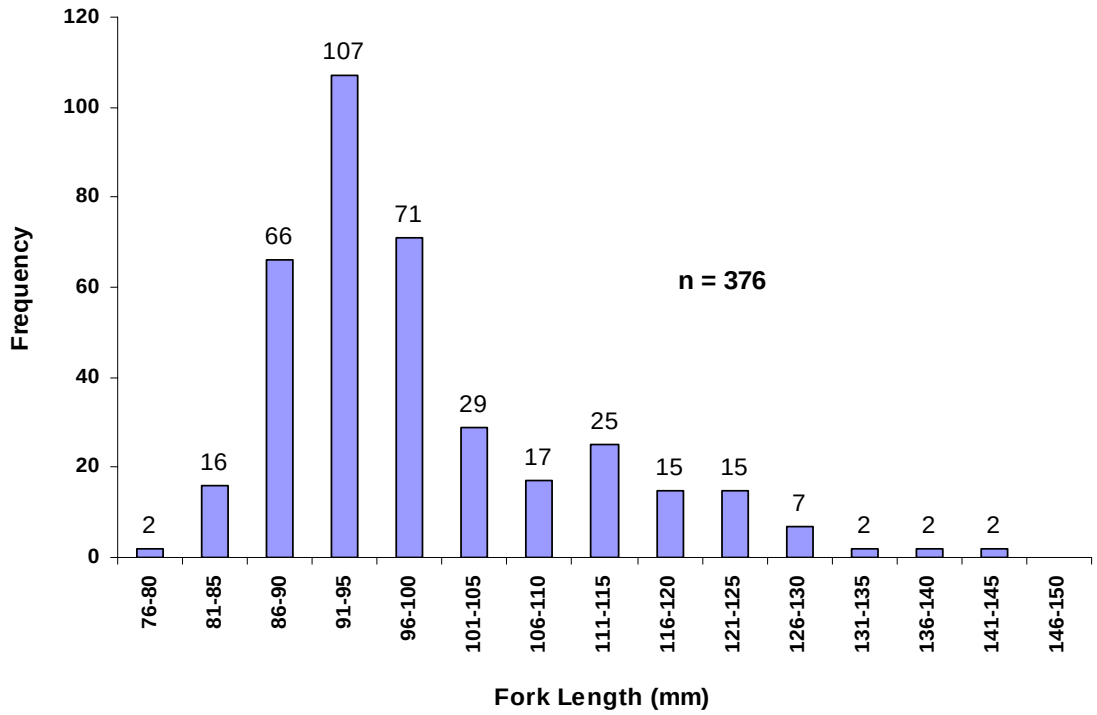

Figure 4. Length frequency of natural origin sockeye salmon smolts collected at Redfish Lake Creek trap in 2006.

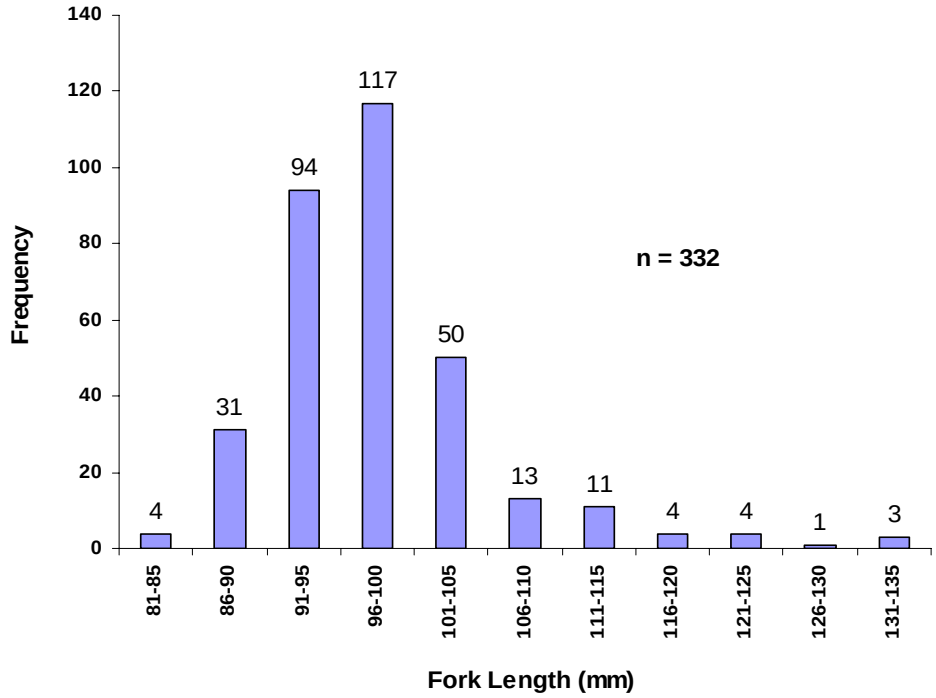

Figure 5. Length frequency of fall-direct released sockeye salmon smolts collected at Redfish Lake Creek trap in 2006.

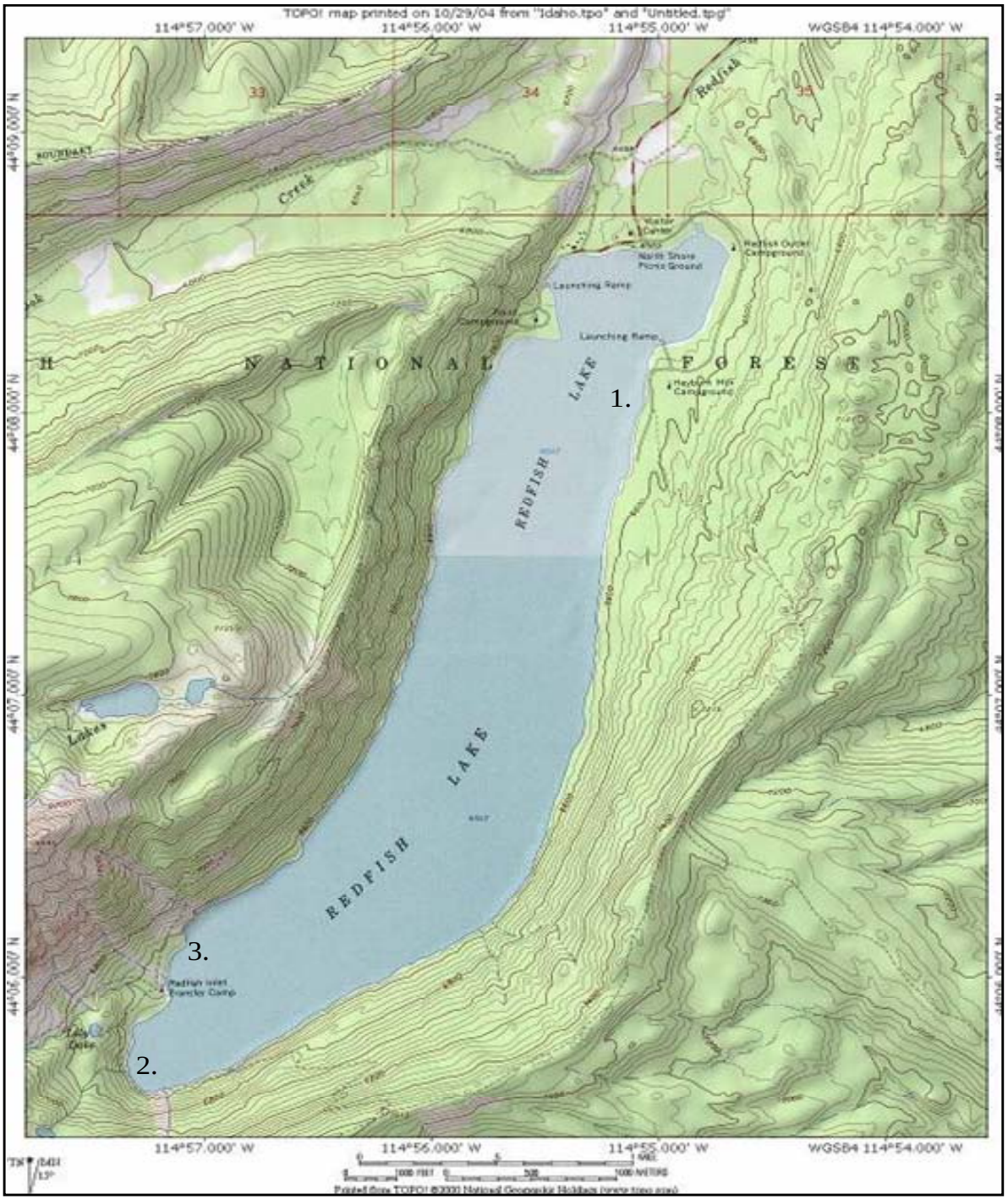

Figure 6. Spawning locations for sockeye salmon in Redfish Lake: 1) Sockeye beach, 2) the south beach near the slide, and 3) the area near the U.S. Forest Service transfer camp dock.

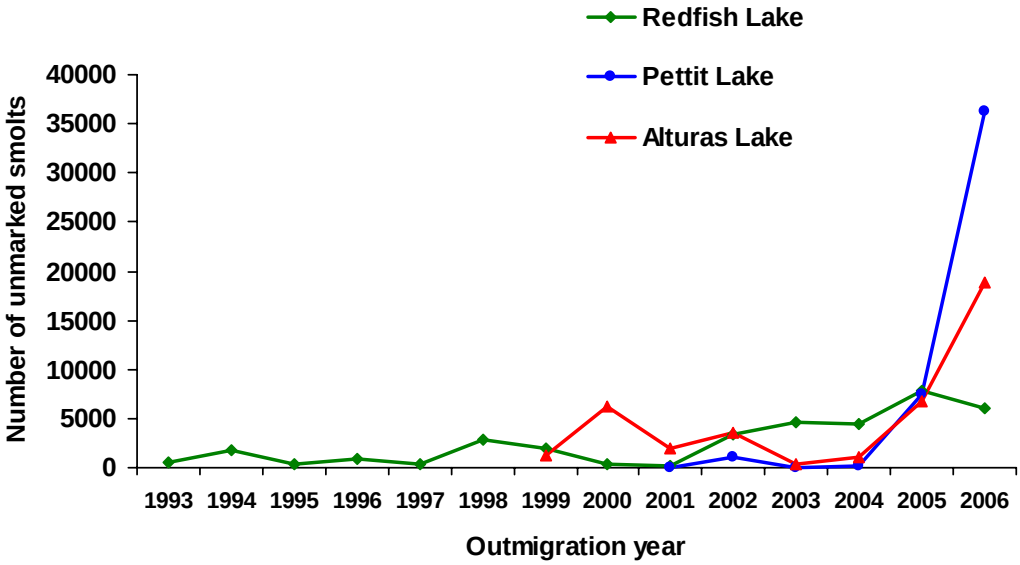

Figure 7. Natural origin sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2006 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

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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 the lake could affect the sockeye salmon and kokanee populations in the lake.

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 2006 represented the eighth 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 to become apparent in surveys conducted after 2000. Bull trout spawners post 2000 represent cohorts 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 2006, 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 September 12 and 13, 2006. 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 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 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.

RESULTS AND DISCUSSION

Fishhook Creek

We observed 32 adult bull trout (13 males, 13 females, and 6 unknown) and 16 developing redds on August 29, 2006. Water temperature at 1022 hours was 8.0°C. During our second survey on September 13, we observed zero adult bull trout and 25 complete redds (Figure 8). Redd counts on the second date included developing redds observed on the previous count (Table 18).

From the eight years of data, it appears that the no-harvest fishing regulation is 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 25 redds counted each year) shows a dramatic increase in bull trout reproduction. Because bull trout may spawn in alternating or consecutive years (Fraley 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 15 adult bull trout (9 males, 3 females, and 3 unknown) and six developing redds during the August 28, 2006 survey. Water temperature was 10.0°C at 1300 hours. On September 12, we observed one adult bull trout and 13 completed redds (Figure 9). Water temperature was 11.0°C at 1601 hours. Redd counts on the second date included developing redds and completed redds observed during the previous count (Table 19). The Alpine Creek population has increased steadily since 1998; one redd was observed in 1998, and the number of redds has ranged between 9 and 15 between 2000 and 2006.

This effort represented the only attempt to monitor bull trout populations in the upper Salmon River drainage upstream of the Yankee Fork of the Salmon River (Tom Curet, personal communication). 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). 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.

As mentioned previously in this report (Part 2), during the out-migration season of 2006, trap efficiency at the juvenile out-migrant sockeye salmon trap on Redfish Lake Creek dropped from a five year season average of 42% to an average of 18%. The marked decrease in trap efficiency was attributed to avian, mammalian, and fish predation observed by trap tenders. Mammalian predation was controlled (to some extent) by setting traps along the fish trap location and lethal removal of mink occurred as they were captured (n = 2). 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 is proposing to collect, PIT tag, and transport bull trout away from the juvenile sockeye trap located on Redfish Lake Creek.

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 weir have increased (from 169 bull trout in 2004 to 263 bull trout in 2006, Vidergar, 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 PIT tag bull trout at the East Fork Salmon River (EFSR) weir (Sawtooth FH satellite weir) and 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 responded to “no harvest regulations” 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 2006.

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

Table 19. Bull trout adult fish counts and redd counts in index sections of Alpine Creek from 1998 to 2006.

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

[a] Only one count completed.

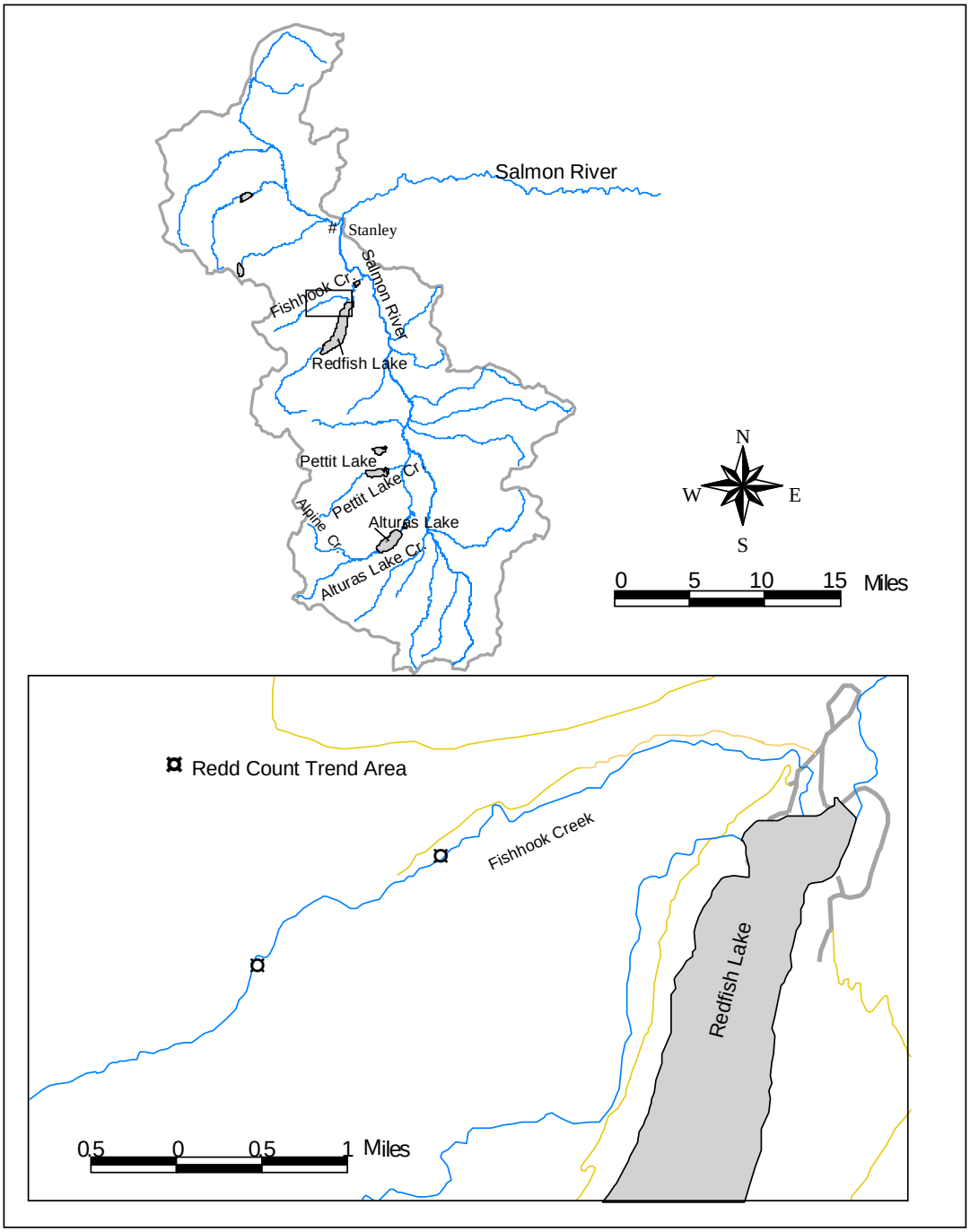

Figure 8. Location bull trout redd index sections in Fishhook Creek in 2006.

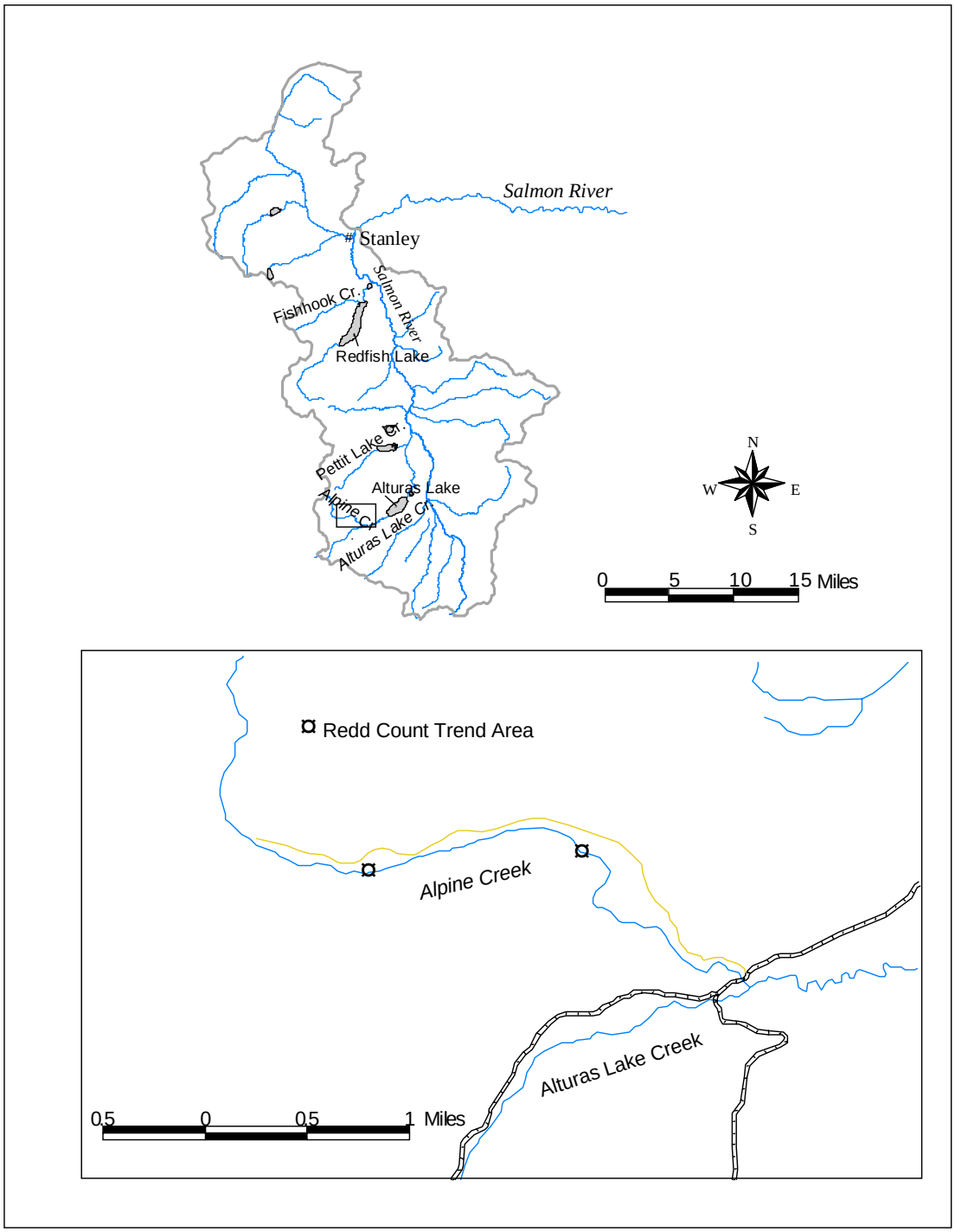

Figure 9. Location of bull trout redd index sections in Alpine Creek in 2006.

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APPENDICES

Appendix A. Fork length, weight (g) and age of *O. nerka* captured during midwater trawls conducted during September 2006 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age
Redfish Lake			
1	48	1.0	0
1	56	1.1	0
1	57	1.4	0
1	58	1.5	0
1	64	1.9	0
1	94	5.5	1
1	94	6.7	1
1	102	8.8	1
1	102	8.6	1
1	116	13.7	1
1	118	16.2	1
1	131	24.4	2
1	141	26.9	2
1	162	43.9	2
1	190	67.5	3
2	44	0.7	0
2	129	23.5	1
2	142	28.9	2
2	163	51.0	2
2	169	47.6	3
2	172	51.4	3
2	182	61.5	3
2	200	74.5	3
3	48	1.0	0
3	82	4.4	1
3	88	5.9	1
3	129	21.4	1
3	135	25.6	1
3	141	28.1	2
4	37	0.4	0
4	46	0.9	0
4	60	1.6	0
4	89	5.4	1
4	90	6.2	1
4	90	5.4	1
4	98	7.2	1
4	142	27.2	2
4	149	34.8	2
4	193	74.2	3
4	216	91.6	3
5	58	1.4	0
5	60	1.8	0
5	62	1.8	0
5	68	2.8	0
5	80	4.1	1
5	82	4.5	1
5	84	3.9	1
5	86	5.5	1
5	86	5.2	1
5	90	6.2	1
5	92	5.9	1
5	92	6.4	1
5	94	6.3	1

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
5	94	6.2	1
5	103	9.6	1
5	104	9.9	1
5	126	20.0	1
5	138	24.7	2
5	140	25.2	2
5	141	26.8	2
5	149	31.7	2
6	50	1.1	0
6	52	1.3	0
6	95	6.9	1
7	53	1.2	0
7	53	1.2	0
7	55	1.5	0
7	59	1.7	0
7	93	6.4	1
7	206	91.9	3
Alturas Lake			
1	49	0.9	0
1	51	1.0	0
1	54	1.2	0
1	56	1.5	0
1	63	2.2	0
1	65	1.9	0
1	67	2.3	0
1	70	2.7	1
1	80	4.5	1
1	93	6.7	1
1	95	6.8	1
1	96	6.8	1
1	96	7.4	1
1	96	7.0	1
1	100	9.7	1
1	105	9.1	1
1	106	9.7	1
1	106	9.6	1
1	109	11.3	1
1	112	13.5	1
1	113	11.8	1
1	115	13.8	1
1	118	15.0	1
1	148	31.1	2
2	69	2.3	0
2	82	4.3	1
2	91	6.0	1
2	96	7.2	1
2	103	8.9	1
2	104	9.8	1
2	107	10.3	1
2	111	10.5	1
2	113	13.0	1
2	120	13.4	2
2	128	18.3	2
2	131	18.8	2
2	172	49.3	3
3	54	1.2	0

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
3	64	1.9	0
3	91	5.9	1
3	91	5.6	1
3	93	6.9	1
3	99	8.5	1
3	102	10.3	1
3	105	9.5	1
3	112	11.6	1
3	115	13.6	1
3	116	13.1	1
3	116	12.4	1
3	118	16.4	1
3	119	14.7	1
4	48	0.8	0
4	48	1.0	0
4	49	0.9	0
4	49	0.8	0
4	51	0.9	0
4	52	1.1	0
4	53	1.2	0
4	54	1.3	0
4	54	1.1	0
4	54	1.1	0
4	60	1.4	0
4	61	1.6	0
4	62	1.6	0
4	63	1.7	0
4	63	1.8	0
4	68	2.3	0
4	68	2.2	0
4	68	2.1	0
4	72	2.6	1
4	72	2.6	1
4	73	2.9	1
4	75	3.0	1
4	92	5.8	1
4	93	5.3	1
4	100	7.8	1
4	104	10.7	1
4	109	10.5	1
4	110	10.5	1
4	112	12.7	1
4	113	12.5	1
4	114	13.8	1
4	115	12.7	1
4	118	12.3	1
4	119	12.9	1
4	121	15.9	2
4	126	16.9	2
4	127	16.3	2
4	137	22.9	2
4	150	31.1	2
4	153	30.2	2
4	181	60.0	3
4	192	70.7	3
4	194	71.0	3
4	205	79.4	3

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
5	43	0.5	0
5	61	1.8	0
5	87	5.3	1
5	89	5.4	1
5	96	6.2	1
5	98	6.6	1
5	99	7.2	1
5	100	8.0	1
5	102	9.3	1
5	103	9.1	1
5	105	9.0	1
5	110	12.5	1
5	112	11.2	1
5	113	11.8	1
5	114	12.2	1
5	114	13.8	1
5	116	13.1	1
5	119	12.2	1
5	121	13.9	2
5	122	16.5	2
5	126	16.5	2
5	130	18.0	2
6	44	0.6	0
6	48	0.9	0
6	50	1.0	0
6	56	1.1	0
6	57	1.4	0
6	58	1.9	0
6	60	1.6	0
6	66	2.1	0
6	67	2.5	0
6	92	6.3	1
6	92	6.8	1
6	93	5.7	1
6	93	6.7	1
6	95	6.2	1
6	96	5.5	1
6	96	6.5	1
6	101	8.1	1
6	103	10.0	1
6	108	9.4	1
6	109	11.4	1
6	112	11.8	1
6	112	13.0	1
6	113	12.6	1
6	114	12.9	1
6	120	13.5	1
6	121	15.8	2
6	124	15.6	2
6	130	18.3	2
6	141	25.5	2
6	143	23.8	2
6	188	64.0	3
6	191	64.0	3

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
Pettit Lake			
1	46	0.7	0
1	125	21.3	1
1	132	20.7	2
1	137	24.5	2
1	138	26.5	2
1	142	25.3	2
1	144	29.3	2
1	146	32.1	2
1	158	50.8	2
1	159	36.1	2
1	181	54.9	3
2	115	13.7	1
2	122	18.3	1
2	123	19.6	1
2	128	20.0	1
2	134	25.6	2
2	140	26.1	2
2	140	27.3	2
2	142	25.4	2
2	188	69.7	3
2	241	144.4	3
3	96	8.7	1
3	117	16.5	1
3	126	20.9	1
3	128	20.3	2
3	130	20.5	2
3	137	25.7	2
3	137	27.4	2
3	137	26.9	2
3	148	34.6	2
3	151	32.8	2
3	184	61.5	3
3	243	134.1	3
4	145	28.6	2
4	198	84.6	3
5	49	1.2	0
5	69	2.9	0
5	122	19.8	1
5	136	26.3	2
5	140	24.7	2
5	142	26.1	2
5	181	56.1	3
5	197	76.6	3
6	120	19.1	1
6	127	22.4	2
6	128	19.4	2
6	134	26.5	2
6	143	30.3	2
6	172	49.9	3
6	173	47.3	3
6	176	55.9	3
6	189	67.2	3
6	208	80.8	3

Appendix B. Arrival dates at Lower Granite Dam for PIT-tagged sockeye salmon smolts during the 2006 migration year.

	Redfish Lake					Pettit Lake			Alturas Lake		
Date	Natural origin	Fall Direct	Hatchery smolts[a]	Sawtooth smolts[b]	Oxbow smolts[c]	Natural origin	Fall Direct	Hatchery smolts[a]	Natural origin	Fall Direct	Hatchery smolts[a]
5/5/2006											
5/6/2006	2										
5/7/2006	5										
5/8/2006											
5/9/2006	1			1							
5/10/2006	1			12							
5/11/2006	2		1	42							
5/12/2006	1			34							
5/13/2006	2			19					1		
5/14/2006	1			18	1				1		
5/15/2006	1		1	11					2		
5/16/2006	5		1	3	9						
5/17/2006	2		5	3	26				5	2	1
5/18/2006	1		2	1	13	3			2	2	2
5/19/2006	2	1	3		1	3			6	1	1
5/20/2006	4	2	1		1	5	5	3	2	5	
5/21/2006		1	1			2	2	1		1	
5/22/2006			4			3	11			1	
5/23/2006					1		1	1		1	2
5/24/2006	1		2				1	1			
5/25/2006		1	1				2				
5/26/2006		2	1			1	9				
5/27/2006		2								1	
5/28/2006				1			2			1	
5/29/2006		1	1				4			1	
5/30/2006		2	1		1		3			1	
5/31/2006		3	2				1			5	
6/1/2005		3					5				
6/2/2006						1	2				
6/3/2006							1				
6/4/2006						1					
6/5/2006							1				
6/6/2006		3									
6/7/2006		1									
6/9/2006		1									
6/10/2006											
6/11/2006		1									
6/12/2006											
6/13/2006											
6/14/2006											
6/15/2006											
6/16/2006		1									
Total	31	25	27	145	53	19	50	6	19	22	6

[a] Ad-clipped hatchery smolts captured and tagged at trap locations.
[b] Sawtooth smolts released into the main Salmon River upstream of the Sawtooth Fish Hatchery weir.
[c] Oxbow smolts released downstream of the Redfish Lake Creek juvenile trap site.

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