FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

2003 Annual Project Progress Report

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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 2003, progeny from the captive broodstock program were released using three strategies: eyed-eggs were planted in Pettit and Alturas lakes in November and December, age-0 presmolts were released to Alturas, Pettit, and Redfish lakes in October, and 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 2003. Age-0 through age-4 *O. nerka* were captured in Redfish Lake, and population abundance was estimated at 81,727 fish. Age-0 through age-3 *O. nerka* were captured in Alturas Lake, and population abundance was estimated at 46,234 fish. Age-0 through age-3 *O. nerka* were captured in Pettit Lake, and population abundance was estimated at 11,961 fish.

Angler surveys were conducted from May 25 through August 7, 2003 on Redfish Lake to estimate kokanee harvest. On Redfish Lake, we interviewed 179 anglers and estimated that 424 kokanee were harvested. The calculated kokanee catch rate was 0.09 fish/hour.

The juvenile out-migrant trap on Redfish Lake Creek was operated from April 15 to May 29, 2003. We estimated that 4,637 wild/natural and 12,226 hatchery-produced sockeye salmon smolts out-migrated from Redfish Lake in 2003. The hatchery-produced component included an estimated 5,352 out-migrants produced from a summer direct-release made to Redfish Lake in 2002 and 6,874 out-migrants produced from a fall direct-release made in 2002. The juvenile out-migrant traps on Alturas Lake Creek and Pettit Lake Creek were operated by the SBT from April 23 to June 5, 2003 and April 25 to June 4, 2003, respectively. The SBT enumerated 28 wild/natural and 13,329 hatchery-produced sockeye salmon smolts that out-migrated from Pettit Lake and estimated 286 wild/natural and 553 hatchery-produced sockeye salmon smolts out-migrated from Alturas Lake in 2003. The hatchery-produced component of sockeye salmon out-migrants originated from presmolt releases made directly to Pettit and Alturas lakes in 2002.

Median travel times for passive integrated transponder (PIT) tagged smolts from the Redfish Lake Creek trap site to Lower Granite Dam were estimated for wild/natural smolts and hatchery-produced smolts. Median travel times for smolts originating from the Redfish Lake Creek trap were 10.6 d for wild/natural smolts, 6.2 d for summer direct-released smolts, and 7.1 d for fall direct-released smolts. Median travel times for PIT-tagged smolts from the Pettit Lake Creek trap site to Lower Granite Dam were estimated for hatchery-produced smolts.

Median travel times for smolts originating from the Pettit Lake Creek trap were 14.1 d for fall direct released smolts and 13.6 d for fall direct released smolts.

Cumulative unique PIT tag interrogations from Sawtooth Valley juvenile out-migrant traps to mainstem Snake and Columbia river dams were utilized to estimate detection rates for out-migrating sockeye salmon smolts. Detection rate comparisons were made between smolts originating from Redfish, Alturas, and Pettit lakes and the various release strategies. Pettit Lake fall direct released smolts recorded the highest detection rate of 37.14%.

In 2003, 312 hatchery-produced adult sockeye salmon were released to Redfish Lake for natural spawning. We observed 42 areas of excavation in the lake from spawning events. Suspected redds were approximately 3 m x 3 m in size and were constructed by multiple pairs of adults.

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 sixth consecutive year that the index reaches have been surveyed on these two streams. Adult counts (40 adults) and redd counts (17 redds) in Fishhook Creek were similar to counts conducted since monitoring began in 1998. Bull trout numbers (27 adults) and the number of redds observed (14 redds) have gradually increased in Alpine Creek compared to counts from initial monitoring.

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PART 1—PROJECT OVERVIEW

BACKGROUND

The Idaho Department of Fish and Game (IDFG) initiated the Snake River sockeye salmon *Oncorhynchus nerka* captive broodstock program in May 1991 in response to the decline of anadromous returns to the Sawtooth Valley in central Idaho. Waples et al. (1991) described Snake River sockeye salmon as a species on the threshold of extinction, and it was listed as endangered under the Endangered Species Act (ESA) on November 20, 1991 (ESA; 16 U.S.C.A. §§1531 to 1544). Snake River sockeye salmon are one of 27 stocks of Pacific salmon and steelhead *O. mykiss* in the Columbia River basin currently listed as threatened or endangered under the Endangered Species Act (www.nwr.noaa.gov/1salmon/salmesa/index).

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 and 1896) described the Sawtooth Valley lakes as being important spawning and rearing areas for sockeye salmon; actual adult escapement enumeration or estimations were not conducted. Adult sockeye salmon escapement to Redfish Lake was enumerated from 1954 through 1966 by the IDFG, University of Idaho, and the United States Bureau of Commercial Fisheries. During this time, adult escapement ranged from a high of 4,361 in 1955 to a low of 11 in 1961 (Bjornn et al. 1968). Adult escapement enumeration was reinitiated in 1985 by the IDFG. Between 1985 and 1990, 62 adults were estimated to have returned to the Sawtooth Valley. No redds or anadromous adults were identified in Redfish Lake in 1990. Hydropower development, water withdrawal and diversions, water storage, harvest, predation, and inadequate regulatory mechanisms were outlined as factors contributing to the Snake River sockeye salmon's decline (Federal Register 1991).

The National Marine Fisheries Service (NMFS) listed Snake River sockeye salmon as an endangered species under the 1973 Endangered Species Act (as amended in 1978) in November of 1991 (Federal Register 1991). A population is considered a distinct population segment and, hence, a species for purposes of the Endangered Species Act if it represents an evolutionary significant unit of the biological species (Waples 1991). To be considered an evolutionary significant unit, a stock must satisfy two criteria: 1) it must be reproductively isolated from other conspecific population units; and 2) it must represent an important component in the evolutionary legacy of the biological species (Waples 1991). At the time of listing, the Redfish Lake sockeye salmon population was the only remaining sockeye salmon population of the Snake River sockeye salmon stock. Snake River sockeye salmon are one of three remaining stocks of sockeye salmon in the Columbia River system; the other two stocks, Okanogan Lake sockeye salmon and Wenatchee Lake sockeye salmon, are located in tributaries of the upper Columbia River. Approximately 1,127 river kilometers separate Snake River sockeye salmon from the nearest sockeye salmon populations in the upper Columbia River. Additionally, there has been no reported evidence of straying of sockeye salmon from the upper Columbia River into Redfish Lake (Waples et al. 1991; Winans et al. 1996). Mitochondrial DNA analyses completed in 2003 confirmed the genetic isolation of the upper Columbia River stocks from the Snake River sockeye salmon stock (Faler and Powell 2003).

Sockeye salmon returning to Redfish Lake travel a greater distance from the Pacific Ocean (1,448 river kilometers) and to a higher elevation (2,138 meters) than any other sockeye salmon population in the world. Additionally, Redfish Lake supports the species' southernmost population within its recognized range (Burgner 1991). Together these characteristics presented a strong argument for the ecological uniqueness of the Snake River habitat and for the unique adaptive genetic characteristics of the Snake River sockeye salmon stock (Waples et al. 1991).

Additional 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 life cycle in freshwater. They remain in Redfish Lake until maturation and spawn in Fishhook Creek, a tributary creek to Redfish Lake, in August and September.

Kokanee are 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.

CAPTIVE PROPAGATION

Captive propagation is utilized to enhance at-risk populations by maximizing survival and reproduction potential in a protective rearing environment. For many endangered populations, captive breeding appears to be the only possible way to avoid extinction (Theodorou and Couvet 2004; Ebenhard 1995). Ex situ captive broodstock programs conserve breeders and their genetics in captivity until the census population size increases and negative environmental threats are improved, allowing reintroduction back into the wild (Hedrick and Miller 1992; Fernandez and Caballero 2001). Additionally, captive rearing is used to reinforce wild populations with the introduction of captive individuals without the introduction of exogenous genes, a practice known also as supportive breeding (Ryman and Laikre 1991; Wang and Ryman 2001; Theodorou and Couvet 2004). Waples and Do (1994) describe supplementation by captive broodstocks as a form of mitigation that safeguards genetic resources, as opposed to fixing the factors for declines in a population. Thus, sustainable increases in population abundance will only be achieved if the underlying causes of the population’s decline are addressed.

In salmonids, captive broodstock programs are specialized forms of artificial production that can take advantage of the high fecundity of Pacific salmon and steelhead and the increased survival benefits protective culture provides (Flagg et al. 1995). Unlike conventional salmon hatchery programs, captive broodstock programs retain a portion of the F_1 generation (produced from spawning captive broodstock parents) through maturation and spawning; the remaining progeny produced during a spawn year are reintroduced into the habitat (Hebdon et al. 2004). Sockeye salmon normally live four to six years and can have fecundities of 2,500 eggs per female (Burgner 1991). The relatively short generation time of these and other Pacific salmon and their potential to produce large numbers of offspring make them suitable for captive broodstock rearing (Flagg et al. 1995). Three captive broodstocks have been implemented to aid in recovery of Pacific sockeye salmon stocks: 1) Snake River sockeye salmon 2) British Columbia Sackinaw Lake sockeye salmon, and 3) British Columbia Owikeno Lake sockeye salmon (Berejikian et al. 2004).

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 (Johnson 1993; Johnson and Pravecek 1995, 1996; Pravecek and Johnson 1997; Pravecek and Kline 1998; Kline and Heindel 1999; Kline et al. 2003a, 2003b; Kline and Willard 2001; Willard et al. 2003a; Baker et al. 2005a, 2005b). 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 2,493,975 eyed-eggs from 1991 through 2003 (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 July and/or August, 3) presmolt transfers to net pens for in-lake rearing in May and release in August, 4) smolt releases to outlet streams in May, and 5) prespawn adult releases (hatchery-reared and anadromous) 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 1,627,990 sockeye salmon eggs and fish have been reintroduced to Sawtooth Valley waters (Table 2). Overall survival to release (over different strategies) from the eyed-egg stage of development has averaged just over 65% ([1,627,990/2,493,975]*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. Smolt fork length ranges between 45 mm and 120 mm. Adult sockeye salmon begin arriving at Redfish Lake Creek in mid-July and continue escapement through early September. Sockeye salmon spawn over submerged beach substrate of the lake; spawning peaks in mid-October. Returning adults are primarily two-ocean fish (Bjornn et al. 1968).

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

PROJECT GOALS

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

PROJECT OBJECTIVES

1. Develop captive broodstocks from Redfish Lake sockeye salmon, culture broodstocks, and produce progeny for reintroduction.

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

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

4. Utilize genetic analysis to discern the origin of wild and broodstock sockeye salmon to provide maximum effectiveness in their utilization within the broodstock program.

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

Idaho Department of Fish and Game's participation in the Snake River Sockeye Salmon Captive Broodstock Program includes two areas of effort: 1) sockeye salmon captive broodstock culture, and 2) sockeye salmon research and evaluations. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to sockeye salmon captive broodstock culture appears under a separate cover (Baker et al. 2005b). Research and evaluation activities associated with Snake River sockeye salmon are permitted under the ESA (NOAA) Nos. 1120, 1124, and 1233 (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; and Willard et al. 2003b). This report details fisheries research information collected between January 1 and December 31, 2003, 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.

<u>2002 and 2003 Captive Broodstock Program Egg and Juvenile Supplementation</u>

All hatchery-produced sockeye salmon released to Sawtooth Valley waters were adipose fin-clipped; selected release groups received an additional mark (ventral fin clip) to distinguish hatchery rearing origin and/or release strategy. A subsample of some of the release groups was PIT tagged prior to release.

In 2002, 179,272 sockeye salmon and 30,924 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 4). All presmolts released in 2002 were age-0 fish from brood year 2001 (BY01). Redfish Lake received 61,500 adipose and right ventral fin-clipped presmolts reared at Oregon Department of Fish and Wildlife Bonneville Fish Hatchery (BFH) in August and 45,001 adipose fin-clipped presmolts reared at IDFG Sawtooth Fish Hatchery (SFH) in October by direct lake releases. Twelve anadromous adult sockeye salmon (hatchery-origin) and 178 BY99 hatchery produced adult sockeye salmon (131 reared at NOAA Manchester Marine Lab and 47 reared at IDFG Eagle Fish Hatchery

[EAG]) were released to Redfish Lake for volitional spawning in September. Alturas Lake received 6,123 adipose and right ventral fin-clipped presmolts (reared at BFH) from a direct lake release in August. Pettit Lake received 7,805 adipose and right ventral fin-clipped presmolts in August (reared at BFH) and 19,981 adipose fin-clipped and coded-wire-tagged presmolts in October (reared at SFH) by direct lake releases. In November, 30,924 eyed-eggs (BY02, reared at NOAA Burley Creek Hatchery) were planted in Pettit Lake. Redfish Lake Creek received 38,672 adipose fin-clipped and coded-wire-tagged age-1 smolts (BY00, reared at SFH) in May; the smolts were released directly below the Redfish Lake Creek juvenile out-migrant trap.

In 2003, 77,103 sockeye salmon and 199,666 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). All presmolts released in 2003 were BY02 age-0 fish (reared at SFH) and adipose fin-clipped. Redfish Lake received 59,810 presmolts, Alturas Lake received 2,017 presmolts, and Pettit Lake received 14,961 presmolts in October by direct lake releases. Three hundred twelve hatchery-produced adult sockeye salmon (94 reared at NOAA Manchester Marine Lab, 183 reared at NOAA Burley Creek Hatchery, and 35 reared at EAG) were released to Redfish Lake for volitional spawning in September. In November and December, 149,966 eyed-eggs (11,662 reared at NOAA Burley Creek Hatchery and 138,304 reared at EAG) were planted in Pettit Lake. In December, Alturas received 49,700 eyed-eggs (41,272 reared at NOAA Burley Creek Hatchery and 8,428 reared at EAG).

Table 1. Eyed-egg production by IDFG and 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
Total:	**1,364,945**	**1,129,030**

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	255,271	0	120	0
1998	0	141,871	81,615	0	0
1999	20,311	40,271	9,718	18	3
2000	65,200	72,114	148	71	200
2001	0	106,166	13,915	65	14
2002	30,924	140,410	38,672	178	12
2003	199,666	76,788	0	315	0
Total:	526,868	940,514	159,407	972	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 x 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 2002.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Redfish Lake Creek (below trap)	smolt (2000)	05/07/2002	38,672	AD/CWT	995	27.6	SFH
Alturas Lake (direct lake)	presmolt (2001)	08/27/2002	6,123	AD/RV	1,463	10.6	BFH
Pettit Lake (direct lake)	presmolt (2001)	08/27/2002	7,805	AD/RV	1,434	11.35	BFH
	(2001)	10/08/2002	19,981	AD/CWT[c]	2,013	14.80	SFH
Redfish Lake (direct lake)	presmolt (2001)	08/28/2002	31,000	AD/RV	1,002	11.35	BFH
	(2001)	08/29/2002	30,500	AD/RV	—	11.35	BFH
	(2001)	10/08/2002	45,001	AD	1,015	15.30	SFH
Redfish Lake (direct lake)	adult (1999)	09/11/2002	101	None	0	1,350.0	NOAA-MML
	(1999)	09/11/2002	47	None	47	1,900.0	EAG
	(1999)	09/12/2002	30	None	0	1,350.0	NOAA-MML
	(1999)	09/12/2002	12	None	0	1,900.0	Anadromous
Pettit Lake (direct lake)	eyed-egg (2002)	12/05/2002	30,924	NA	NA	NA	NOAA-BC

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

[b] BFH = Oregon Department of Fish and Game Bonneville Hatchery; SFH = Idaho Department of Fish and Game Sawtooth Hatchery; EAG = Idaho Department of Fish and Game Eagle Hatchery; NOAA-MML = National Oceanic and Atmospheric Administration Manchester Marine Lab; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

[c] 9,987 of the 19,981 presmolts were coded-wire tagged.

Table 5. Sockeye salmon releases to Sawtooth Valley waters in 2003.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Alturas Lake (direct lake)	presmolt (2002)	10/06/2003	2,017	AD	2,017	8.0	SFH
Pettit Lake (direct lake)	presmolt (2002)	10/06/2003	14,961	AD	2,014	10.7	SFH
Redfish Lake (direct lake)	presmolt (2002)	10/07/2003	59,810	AD	1,519	11.0	SFH
Redfish Lake (direct lake)	adult (2000)	09/15/2003	48	None	0	1,200.0	NOAA-BC
	(2000)	09/16/2003	135	None	135	1,745.0	NOAA-BC
	(2000)	09/16/2003	94	None	0	1,395.0	NOAA-MML
	(2000)	09/17/2003	35	None	0	1,500.0	EAG
Pettit Lake (direct lake)	eyed-egg (2003)	11/25/2003	11,662	NA	NA	NA	NOAA-BC
		11/25/2003	70,795	NA	NA	NA	EAG
		12/03/2003	45,451	NA	NA	NA	EAG
		12/10/2003	22,058	NA	NA	NA	EAG
Alturas Lake (direct lake)	eyed-egg (2003)	12/11/2003	41,272	NA	NA	NA	NOAA-BC
	(2003)	12/11/2003	8,428	NA	NA	NA	EAG

[a] AD = adipose fin-clip.

[b] SFH = Idaho Department of Fish and Game Sawtooth Hatchery; EAG = Idaho Department of Fish and Game Eagle Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery; NOAA-MML = National Oceanic and Atmospheric Administration Manchester Marine Lab.

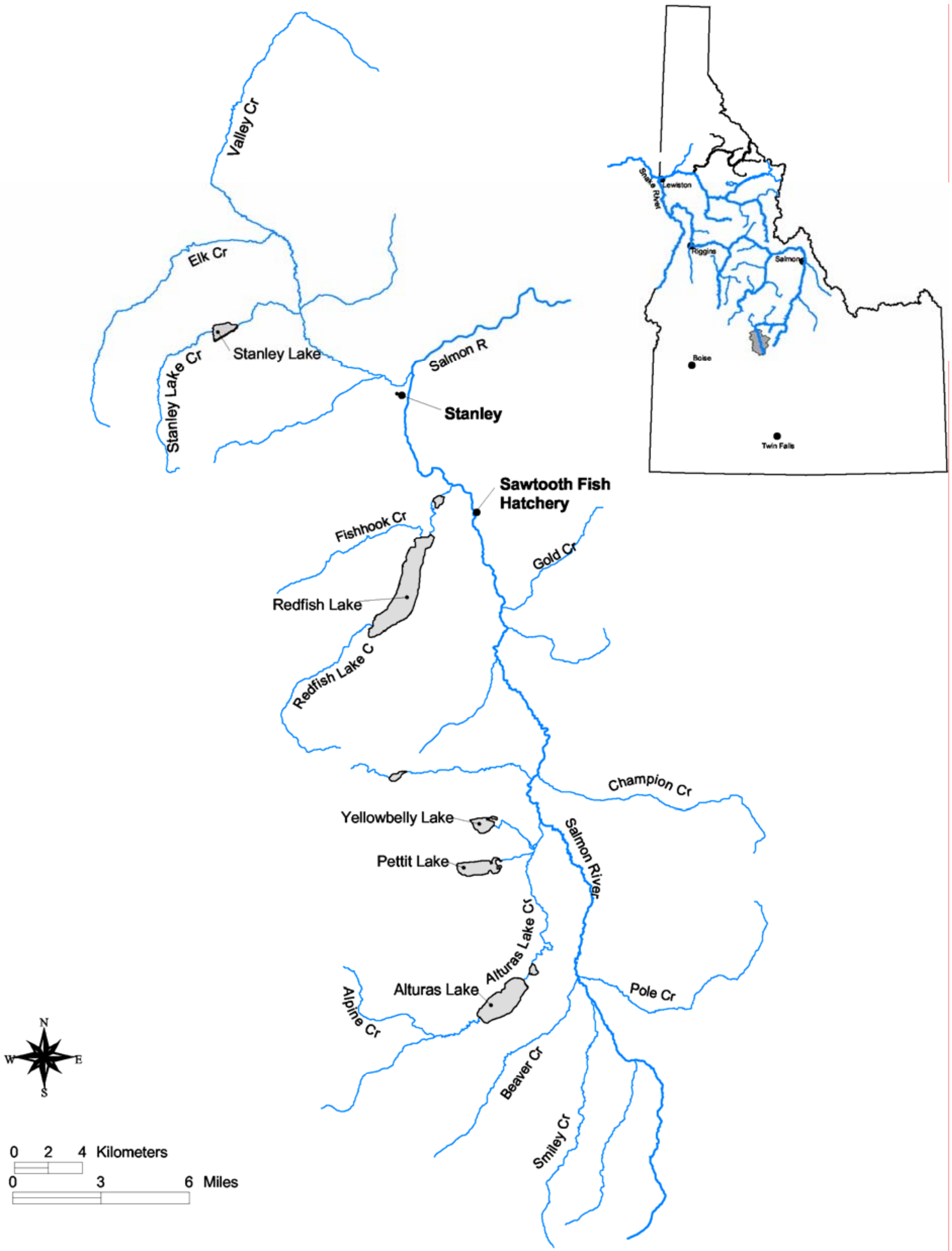

Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

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PART 2—*ONCORHYNCHUS NERKA* POPULATION MONITORING

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 by the SBT) is necessary for making responsible decisions regarding the reintroduction of sockeye salmon juveniles from the captive broodstock program.

METHODS

To estimate *O. nerka* 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 (current sampling gear does not efficiently sample fish >250 mm fork length). In addition, 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 24-26, 2003. Trawling was performed in a stepped-oblique fashion as described by Rieman (1992) and Kline (1994). A minimum of four 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).

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* and returned to the laboratory. Three program technicians aged scales and otoliths to determine length ranges for age classification. Scales were pressed into acetate before aging and otoliths were read "dry." 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 analysis and proximate analysis (proximate analysis results are presented in Part 5 of this report). 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. The myxosporean parasite, *Myxobolus cerebralis*, which can cause salmonid whirling disease, is present in the upper Salmon River.

RESULTS

Redfish Lake

September trawl catch (five transects, Appendix A) included 85 wild/natural *O. nerka* and zero hatchery-produced sockeye salmon. *Oncorhynchus nerka* abundance was estimated at 81,727 fish (95% CI ± 25,995). Density and biomass were estimated at 133 fish/ha and 1.56 kg/ha, respectively (Table 6). Age-0 through age-4 *O. nerka* were captured in the trawl on

Redfish Lake. Age-0 fish had the highest density (109 fish/ha) and contributed 13.48% of the biomass. Age-4 fish had the highest biomass (.81 kg/ha), which was 51.92% of the total biomass (Table 7).

Redfish Lake samples were found to be negative for *M. cerebralis* (tissue from nine fish assayed) in 2003 using polymerase chain reaction (PCR) testing.

Alturas Lake

September trawl catch on Alturas Lake (five transects, Appendix A) included 25 wild/natural *O. nerka* and zero hatchery-produced sockeye salmon*.* We estimated *O. nerka* abundance, density, and biomass at 46,234 fish (95% CI ± 26,442), 137 fish/ha, and 5.50 kg/ha, respectively (Table 6). Age-0 through age-3 *O. nerka* were captured in the trawl. Age-2 fish had the highest density (51 fish/ha) and contributed 44.35% of the biomass (Table 7).

Alturas Lake samples were found to be positive for *M. cerebralis* (three of ten fish assayed) in 2003 using PCR testing. This was the first year since sampling was initiated in 1991 in which samples examined for whirling disease tested positive in Alturas Lake.

Pettit Lake

September trawl catch on Pettit Lake (four transects, Appendix A) included 24 wild/natural *O. nerka* and two hatchery-produced (one adipose fin-clipped and one adipose right ventral fin-clipped) sockeye salmon. The adipose fin-clipped, hatchery-produced sockeye salmon (reared at BFH) was from an August 2002 presmolt release. The adipose right ventral fin-clipped hatchery-produced sockeye salmon (reared at SFH) was from an October 2002 release. We estimated *O. nerka* abundance, density, and biomass at 11,961 fish (95% CI ± 3,255), 75 fish/ha, and 3.33 kg/ha, respectively (Table 6). Age-0 through age-3 fish were captured in the trawl. The age-2 fish were hatchery-produced sockeye salmon and were not included in the abundance estimate. Age-1 fish had the highest density (49 fish/ha) and contributed 39.10% of the biomass (Table 7).

Pettit Lake samples were found to be negative for *M. cerebralis* (tissue from 12 fish assayed) in 2003 using PCR testing.

DISCUSSION

Redfish Lake

In 2003, the population abundance estimate was the highest (81,727 fish) since trawling was initiated in Redfish Lake in 1990. Since 2000, when the Redfish Lake population abundance estimate was the lowest recorded (10,268 fish), the population abundance has gradually increased. Age-0 fish were the largest component (82%) of the total population abundance estimate in 2003. The age-0 component was produced from either adult kokanee spawning in Fishhook Creek in the fall of 2002 or sockeye salmon released for volitional spawning in 2002. Adult kokanee spawner escapement to Fishhook Creek was estimated at 8,626 fish in 2002. This was the highest adult escapement estimate since the 1996 escapement estimate of 10,662 fish (D. Taki, Shoshone-Bannock Tribes, personal communication).

Following the documented reduction of *O. nerka* biomass in 2000, we theorized that the reduced grazing pressure would allow zooplankton biomass to increase. According to data from the SBT (November 2002 SBSTOC minutes), mean summer zooplankton biomass (June to October) in Redfish Lake reached approximately 2,200 mg/m^2 during the summer of 2000 (no lake fertilization was conducted). Compared to years previous to 2000, zooplankton biomass was the highest since zooplankton biomass monitoring was initiated in 1994. *Daphnia* spp., *Holopedium* spp., and *Bosmina* spp. contributed the majority of the increase in biomass to total zooplankton numbers. This one-year increase in zooplankton biomass coincided with low *O. nerka* abundance, suggesting that grazing pressure from the resident *O. nerka* population may have been responsible for controlling zooplankton biomass. Lake fertilization was conducted during the summers of 2001 and 2002. During these years, summer zooplankton biomass maintained similar high levels recorded during the summer of 2000. The effects of *O. nerka* abundance on zooplankton biomass could not be determined for 2001 or 2002 due to confounding effects of lake fertilization. Based on the relationship observed between *O. nerka* and zooplankton biomass in 2000, we expected the zooplankton biomass to decrease in 2003 (no lake fertilization was conducted) due to comparatively high *O. nerka* population numbers observed in 2003. However, the exact opposite was observed. Zooplankton biomass during the summer of 2003 was approximately 3,800 mg/m^2, the highest zooplankton biomass recorded for Redfish Lake since 1994. Even though *O. nerka* abundance was high, the population consisted mainly of small, age-0 *O. nerka* that potentially could have a smaller impact on zooplankton biomass than a population consisting mainly of older, larger fish.

Alturas Lake

Abundance of *O. nerka* in Alturas Lake has been highly variable since monitoring began in 1990. Kokanee in Alturas Lake Creek are not spawning habitat limited, which may contribute to the fluctuating *O. nerka* abundance observed (over 120,000 fish in 1990 to less than 6,000 fish in 1994; Table 6). As *O. nerka* population size increases and zooplankton food resources become limited, population size typically declines. As food resources recover, *O. nerka* abundance typically increases. This pattern generally repeats itself every four to six years.

In 2000, we observed relatively high *O. nerka* abundance in Alturas Lake (125,462 fish). In 2001, a sharp decline in zooplankton density was observed (Shoshone Bannock-Tribes personal communication). In fact, cyclopoid copepods, *Holopedium spp.,* and *Daphnia spp*. biomass were at a four-year low (SBSTOC minutes March 2002) in 2001.

In 2002, zooplankton density began to increase. This trend continued in 2003. Concurrently, kokanee estimates increased in 2002 and 2003 (24,374 and 46,234 fish, respectively).

Based on past observations, high kokanee abundance and biomass are typically followed by sharp declines in zooplankton density. Conditions may take several years to recover. Currently, the SBT uses whole lake fertilization to dampen the oscillation observed between “boom and bust” zooplankton cycles. The SBSTOC is also discussing the advantages and disadvantages of adding a program of controlling kokanee spawner escapement to further program efforts to stabilize kokanee and zooplankton communities.

Pettit Lake

Since monitoring began in 1992, Pettit Lake has exhibited the greatest relative fluctuation in *O. nerka* numbers (maximum to minimum range) of the three lakes studied. *Oncorhynchus nerka* abundance increased from 1992 (3,009 fish) to 1996 (71,654 fish), then declined in 1997 (21,730 fish; Table 6). The population increased steadily from 1998 to 2000, reaching a high of 40,559 fish. This was followed by a sharp decline in *O. nerka* abundance to 16,931 fish in 2001. An additional decrease to 11,961 fish was observed in 2003.

We suspect that decreases observed in *O. nerka* abundance may be a result of sampling bias associated with our midwater trawling efforts rather than an actual decrease in abundance. With the exception of this year, during the last four years we have failed to capture age-0 *O. nerka* in Pettit Lake during trawl surveys; however, age-1 and older *O. nerka* have been captured annually. This suggests age-0 *O. nerka* are present but not sampled by our gear. One possible explanation is age-0 *O. nerka* are utilizing nearshore habitat that we do not consistently sample during our trawl surveys. Zooplankton biomass in Pettit Lake has been increasing since June 2000 and reached an all-time high in June 2003; lake rearing conditions are currently favorable for *O. nerka*. These data support our hypothesis that the reported reduction in *O. nerka* abundance is most likely a result of sampling error.

RECOMMENDATIONS

1. Based on the large proportion of age-0 *O. nerka* observed in Redfish Lake in 2003, we expect kokanee escapement to Fishhook Creek to be high in 2007. The Shoshone-Bannock Tribe operates a weir annually on Fishhook Creek to manage escapement and spawning of kokanee in Redfish Lake. We recommend continued operation of the weir on Fishhook Creek based on escapement goals that are beneficial for the sockeye salmon population and the kokanee sportfishery.

2. An increase in zooplankton biomass was observed in Alturas Lake during the summers of 2002 and 2003, reversing the declining trend observed in 2000 and 2001. However, zooplankton biomass is not at the higher levels observed between 1996 and 1999. In an effort to enhance zooplankton biomass, we recommend the fertilization of Alturas Lake. Lake fertilization could dampen the magnitude of the oscillations observed in the zooplankton population, thus creating a more consistently favorable environment for sockeye salmon. However, fertilization should be coupled with managing kokanee escapement to reduce fluctuating, density dependent rearing conditions. A program that includes kokanee spawner escapement and whole lake fertilization is expected to benefit the sockeye salmon population as well as the kokanee sportfishery.

3. We recommend that kokanee escapement goals for tributaries of Alturas and Redfish lakes be developed and provided for the SBSTOC.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, Pettit, and Stanley lakes, 1990 to 2003.

Date	Population (±95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
9/24/03	81,727 (25,995)	132.9	1.6
9/06/02	50,204 (28,485)	81.6	1.0
9/17/01	12,980 (12,080)	21.1	<0.1
9/25/00	10,268 (5,675)	16.7	<0.1
9/08/99	42,916 (13,177)	69.7	0.9
9/21/98	31,486 (11,349)	51.2	1.8
9/02/97	55,762 (13,961)	90.7	2.5
9/10/96	56,213 (28,102)	91.4	2.8
9/26/95	61,646 (27,639)	100.2	4.4
9/06/94	51,529 (33,179)	83.8	1.4
9/17/93	49,628[a]	80.7	1.6
9/29/92	39,481 (10,767)	64.2	1.0
8/20/90	24,431 (11,000)	39.7	0.8
	Alturas Lake (338 surface hectares)		
9/26/03	46,234 (26,442)	136.8	5.5
9/04/02	24,374 (16,968)	72.1	2.2
9/19/01	70,159 (18,642)	207.6	2.4
9/25/00	125,462 (27,037)	371.0	2.1
9/09/99	56,675 (43,536)	167.7	0.4
9/23/98	65,468 (34,284)	193.7	1.4
9/04/97	9,761 (4,664)	28.9	2.1
9/12/96	13,012 (3,860)	38.5	1.4
9/25/95	23,061 (9,182)	68.2	1.7
9/07/94	5,785 (6,919)	17.1	0.4
9/17/93	49,037 (13,175)	145.1	2.6
9/25/92	47,237 (61,868)	139.8	2.4
9/08/91	125,045 (30,708)	370.0	3.9
8/19/90	126,644 (31,611)	374.7	3.3
	Pettit Lake (160 surface hectares)		
9/25/03	11,961 (3,225)	136.8	5.5
9/05/02	18,328 (2,351)	114.5	12.1
9/17/01	16,931 (7,566)	105.8	6.1
9/28/00	40,559 (11,717)	253.5	10.2
9/10/99	31,422 (21,280)	196.4	6.3
9/22/98	27,654 (8,764)	172.8	9.7
9/03/97	21,730 (11,262)	135.8	5.1
9/11/96	71,654 (9,658)	447.8	15.3
9/24/95	59,002 (15,735)	368.8	14.7
9/08/94	14,743 (3,683)	92.1	3.1
9/18/93	10,511 (3,696)	65.7	0.8
9/27/92	3,009 (2.131)	18.8	2.5
	Stanley Lake (81 surface hectares)		
9/17/01	2,472 (2,872)	35.5	0.2
9/24/98	14,936 (7,391)	184.4	5.0
9/27/95	1,021 (702)	12.6	0.2
9/07/94	2,694 (913)	33.3	0.4
9/16/93	1,325 (792)	16.4	0.5
8/28/92	2,117 (1,592)	26.1	0.2

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

Table 7. Estimated 2003 *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	70	8	3	2	2	85
Mean length (mm) (±95 CI)	60.6(1.5)	113.7(7.7)	145.3(5.7)	161.2(38.2)	250(14.1)	NA
Mean weight (g) (±95 CI)	1.9(.6)	13.4(3.0)	35.1(6.9)	250.5(48.6)	170.9(29.6)	NA
Abundance	67,016	8,122	2,821	942	2,826	81,727
95% CI High	90,949	17,060	5,124	2,827	6,594	107,723
95% CI Low	43,082	0	518	0	0	55,732
Density (fish/ha)	109	13	5	2	4	133
Biomass (kg/ha)	.21	.18	.16	.21	.81	1.56
			Alturas Lake (338 surface ha)			
No. captured	5	2	8	10	0	25
Mean length (mm) (±95 CI)	65.6(8.7)	106.0(1.9)	164.1(3.2)	177.7(4.6)	NA	NA
Mean weight (g) (±95 CI)	14.2(14.1)	44.9(2.6)	51.0(2.4)	53.4(13.3)	NA	NA
Abundance	9,238	3,341	17,249	16,046	NA	46,234
95% CI High	15,392	7,439	38,898	3,145	NA	72,676
95% CI Low	3,084	0	0	13,261	NA	19,792
Density (fish/ha)	27	10	51	49	NA	137
Biomass (kg/ha)	.08	.10	2.44	2.89	NA	5.50
			Pettit Lake (160 surface ha)			
No. captured	2	16	0	6	0	24
Mean length (mm) (±95 CI)	44.0(11.7)	129.0(4.7)	NA	203.5(6.9)	NA	NA
Mean weight (g) (±95 CI)	.8(.7)	26.1(2.7)	NA	108.1(16.6)	NA	NA
Abundance	997	7,974	NA	2,990	NA	11,961
95% CI High	2,148	9,602	NA	5,564	NA	15,216
95% CI Low	0	6,346	NA	417	NA	8,706
Density (fish/ha)	6	49	NA	19	NA	75
Biomass (kg/ha)	<.1	1.3	NA	2.0	NA	3.33

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PART 3—REDFISH LAKE SPORT FISHERY INVESTIGATIONS

INTRODUCTION

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 1233). The kokanee fishery was opened based on the recommendation of the SBSTOC to reduce kokanee competition with sockeye salmon by removing spawning age kokanee through angler harvest. Permit 1233 (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, because mature kokanee initiate spawning in Fishhook Creek at this time, 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 analyzed by the University of Idaho's Center for Salmonid and Freshwater Species at Risk to estimate the number of residual sockeye salmon harvested incidental to the kokanee fishery.

METHODS

Redfish Lake

A roving creel survey was conducted from May 25 through August 7, 2003 (kokanee harvest closes on August 7 to protect residual sockeye salmon). The creel census was stratified by 14 d 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 two weekdays and one weekend day during each week of the 14 d 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 were selected randomly, and count times were selected systematically. 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, and the type of gear they used; responses were recorded. Fin clips were taken from creeled kokanee that were checked by creel survey personnel. Fin clips were stored in Lysis buffer solution and delivered to University of Idaho 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

Redfish Lake

In 2003, we contacted 98 angler parties (179 individual anglers) on Redfish Lake. Idaho residents made up 72% of those interviewed. Most anglers used lures (77%), followed by bait (20%), and flies (3%). Total angler effort was estimated at 2,477 hours (95% CI ± 758). Boat anglers expended more effort (82%) than bank anglers (16%) (Table 8). The average fishing trip lasted 2.5 hours.

The season catch rate for all fish (harvested and released) was 0.42 fish/hour (Table 9). Kokanee catch rates (harvested and released) averaged 0.11 fish/hour for weekdays and 0.24 fish/hour for weekends. Bull trout catch and release rates averaged 0.24 fish/hour for both weekend and weekdays (IDFG regulations prohibit harvesting bull trout). Other fish (cutthroat, northern pikeminnow, sucker *catostomus spp*.) accounted for catch rates (harvested and released) of 0.02 fish/hour for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 1,250 fish (95% CI ± 567; Table 10). The majority (63%) of all fish caught were released. Kokanee harvest was estimated at 424 fish (95% CI ± 215).

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 creeled kokanee. Genetic analysis of fin clips obtained from creeled kokanee has not been completed for 2003.

DISCUSSION

Redfish Lake

In addition to providing an important recreational fishery, the Redfish Lake kokanee fishery benefits the sockeye salmon population by removing kokanee from project lakes and reducing competition between sockeye salmon and kokanee. Kokanee escapement to Fishhook Creek during the 2003 spawning season was estimated at 4,025 fish (D. Taki, Shoshone-Bannock Tribes, personal communication). We assume that kokanee anglers on Redfish Lake primarily remove kokanee adults of spawning age from the population. Kokanee become more susceptible to fishing gear and harvest by anglers as they increase in age and length (Rieman and Maiolie 1995). Removal of spawning-age kokanee by sport harvest helps to reduce total egg deposition, potentially decreasing kokanee recruitment and competition with sockeye salmon in future years. In 2003, estimated kokanee harvest was 424 fish. Since 1996, the estimated number of kokanee harvested from Redfish Lake has ranged from 1,362 in 1998 to zero in 2001. Angler effort (2,477 hours) during the 2003 season was lower than the average effort estimated for 1996 through 2002 (3,674 hours). The 2003 kokanee harvest rate (0.10 fish/hr) was also lower than the average kokanee harvest rate estimated for 1996 through 2002 (0.14 fish/hr). However, the estimated number of kokanee harvested was the highest since 1999 (Table 11).

Genetic analysis of fin clips obtained from creeled kokanee has not been completed for 2003. However, of the 378 fin clips collected from creeled kokanee from 1996 through 2001, only one (collected in 1996) was found to exhibit a mitochondrial DNA haplotype unique to residual sockeye salmon. If we apply this proportion to the total number of kokanee harvested during the 2003 fishery, we estimate an incidental take of one ESU fish. Permit 1233 allows for an incidental take of 34 naturally-produced (unmarked) Snake River sockeye salmon associated with the kokanee fishery on Redfish Lake. In 2003, as in past years, the IDFG posted signs at all access locations to Redfish Lake alerting anglers to the fact that ESA-listed sockeye salmon were present in the lake and that adipose fin-clipped sockeye salmon needed to be released immediately if caught.

Table 8. Estimated angler effort for the 2003 fishing season on Redfish Lake.

	Boat	Bank	Tube	Total
Redfish Lake				
Hours fished	2,035	408	34	2,477
±95% CI	699	291	45	758

Table 9. Catch rates (fish/hour) for summer 2003 on Redfish Lake categorized by day type and species.

	Kokanee			Bull Trout	Rainbow Trout		Other		All Fish		
Day Code	Kept	Released	Combined	Released	Kept	Released	Kept	Released	Kept	Released	Combined
Redfish Lake											
Weekday	0.09	0.02	0.11	0.27	0.00	0.00	0.01	0.03	0.10	0.31	0.42
Weekend day	0.12	0.12	0.24	0.17	0.00	0.00	0.01	0.01	0.14	0.31	0.44
Season average	0.10	0.05	0.15	0.24	0.00	0.00	0.01	0.02	0.11	0.31	0.42

Table 10. Estimated number of fish harvested and released on Redfish Lake during the summer 2003.

	Harvested		All Fish		
	Kokanee	Other	Released	Harvested	Combined
Number of fish	424	29	782	468	1,250
±95% CI	215	36	273	227	567

Table 11. Historical kokanee catch rates, kokanee harvest estimates, and angler effort for the Redfish Lake fishery.

	Kokanee catch rate (fish/hr)				
	Harvested (fish/hour)	Released (fish/hr)	Kokanee harvested	Angler parties interviewed	Estimated hours fished/season
1996	0.19	0.08	844	107	3,351
1997	0.19	0.37	466	117	2,874
1998	0.13	0.17	1,362	205	7,963
1999	0.38	0.15	1,187	227	3,951
2000	0.02	0.06	67	63	3,063
2001	0.00	0.06	0	88	2,391
2002	0.09	0.16	129	100	2,127
2003	0.10	0.05	424	98	2,477

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PART 4—SOCKEYE SALMON SMOLT MONITORING AND EVALUATION

INTRODUCTION

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.

METHODS

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 and was operated from April 15 to May 29, 2003. The trap functions as a juvenile trap and with only minor modifications as an adult trap (Craddock 1958; Bjornn et al. 1968; Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000, 2002, 2003; Willard 2004). The trap contains nine bays, five of which are fitted with juvenile trap boxes. Personnel from IDFG checked the trap twice daily in 2003.

Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 45,001 adipose and right ventral fin-clipped presmolts (reared at BFH) and released into the lake in August 2002 (summer direct-released) and 61,500 adipose fin-clipped presmolts (reared at SFH) released directly to the lake in October 2002 (fall direct-released). All sockeye salmon smolts captured at RLCTRP were anesthetized in buffered tricaine methanesulfonate (MS-222), measured for fork length (1 mm) and weight (0.1 g), and scanned for PIT tags. Scales were removed from a subsample of wild/natural and adipose fin (AD)-clipped hatchery-reared *O. nerka* and returned to the laboratory. Scales were pressed into acetate, and three program employees aged the scales. 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 fits mixture distributions to grouped data by the method of maximum likelihood. 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.

To estimate trapping efficiency, up to 30 wild/natural sockeye salmon smolts (determined by presence of an adipose fin) and 60 hatchery-produced sockeye salmon smolts (30 summer direct-released and 30 fall direct-released) were PIT tagged daily and released approximately 250 m upstream of 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 a single time interval for wild/natural, summer direct-released, 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. 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 wild/natural, summer direct-released, and fall direct-released sockeye salmon smolts.

Confidence intervals for the difference between two proportions were used to compare out-migration success by release strategy at the RLCTRP (Newcombe 1998). If the interval included the value zero, a significant difference between the two proportions was not detected (Fleiss et al. 2003). Differential marks per release strategy allowed us to determine interrogation rates at the trap and compare out-migration success of summer direct-released presmolts and fall direct-released presmolts.

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 23 to June 5, 2003. Alturas Lake out-migrant run size was derived using a modified Bailey estimator as described by Steinhorst et al. (2004). Confidence intervals were not calculated due to the low number of recaptures and multiple intervals.

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 25 to June 4, 2003. The Pettit Lake Creek weir traps at 100% efficiency; therefore, out-migration run size for Pettit Lake is based on the actual number of smolts trapped.

As described above for Redfish Lake, confidence intervals for the difference between two proportions were used to compare out-migration success by release strategy. Differential marks per release strategy allowed us to determine interrogation rates at the trap and compare out-migration success of summer direct-released presmolts and fall direct-released presmolts for Pettit Lake.

Mainstem Snake and Columbia River Dams

Sockeye salmon smolt out-migration variables (travel time and date of arrival) were evaluated using PIT tag interrogation data collected at lower Snake and Columbia river dams with fish bypass and PIT tag detection facilities (Lower Granite [LGR], Little Goose [LGJ], Lower Monumental [LMN], and McNary [MCN] dams). Interrogation data were retrieved from the PIT Tag Information System (PTAGIS) maintained by the Pacific States Marine Fisheries Commission (Portland, Oregon). Tagged to untagged ratios of smolts observed at Sawtooth Valley trap locations were used to expand the number of PIT tag interrogations to derive a total out-migration estimate for presmolt release groups at LGR. Total wild/natural and hatchery-produced smolt out-migration was estimated using the known number of PIT tags released and the expanded number of PIT tags detected at LGR. Daily collection efficiency (DCE) estimated for Chinook salmon smolts (Sandford and Smith 2002) was used to expand estimates of PIT tag interrogations for sockeye salmon smolts migrating past LGR (daily collection efficiencies have not been developed for sockeye salmon). Daily collection efficiency takes into account the effect of spill on fish guidance efficiency.

Median travel times to downstream dams with fish detection facilities were calculated for wild/natural and hatchery-produced sockeye salmon smolts. Distribution of arrival times for PIT-tagged fish at LGR were compared for wild/natural and hatchery-produced progeny (by release strategy) using two-sample Kolmogorov-Smirnov tests (α = 0.10) (Sokal and Rohlf 2000). Confidence intervals for the difference between two independent proportions were used to compare cumulative unique PIT tag interrogations from out-migrant traps to LGR, LGJ, LMN, and MCN between selected release strategies (Newcombe 1998).

A priori power analyses for testing equality of proportional data were performed to determine PIT tag sample sizes needed for comparisons (Fleiss et al. 2003). To detect an effect of approximately 10% between test groups (expressed as proportional survival information collected at out-migration monitoring locations), we estimated that approximately 600 observations would be needed, per test group, to achieve an 80% level of power at α = 0.05.

RESULTS

Redfish Lake Creek Trap

A total of 7,334 sockeye salmon smolts (2,611 wild/natural, 2,699 fall direct-released, and 2,024 summer-released) were trapped during the 2003 out-migration season (Figure 2). Fork length of wild/natural, summer direct-released, and fall direct-released sockeye salmon smolts captured averaged 115 mm (range 86 mm to 171 mm; Figure 3), 127 mm (range 97 mm to 161 mm; Figure 4), and 124 mm (range 95 mm to 200 mm; Figure 5), respectively.

Based on observed trapping efficiencies and discharge during out-migration monitoring, we determined that using a single season trapping interval was appropriate for estimating total wild/natural and hatchery-produced sockeye salmon smolt out-migration.

Of the 2,611 wild/natural smolts handled in 2003, 926 were marked and released upstream of the weir to estimate trapping efficiency. Trap efficiency was estimated at 56% for one interval. Total wild/natural sockeye smolt out-migration was estimated at 4,637 fish (95% CI 4,360 to 4,935; Table 12). The proportion of age-1 wild/natural smolts was estimated at 89.11% (95% CI 89.06-89.16) which equals 4,132 smolts; the proportion of age-2 wild/natural smolts was estimated at 10.89% (95% CI 10.84-10.94) which equals 505 smolts. As referenced in the Methods section of this report, age proportions were estimated using the MIX software application. Graphical depictions of age-1 and age-2 frequency distributions, estimated using this application, are presented in Figure 6.

Of the 2,024 summer direct-released smolts handled in 2003, 623 were marked and released upstream of the weir to estimate trap efficiency. Trap efficiency was estimated at 38% for one trapping interval. Total summer direct-released smolt out-migration was estimated at 5,352 fish (95% CI 4,806 to 5,944; Table 12). Overwinter survival and out-migration for this group was 8.7% of the number of presmolts planted in 2002.

Of the 2,699 fall direct-released smolts handled in 2003, 679 were marked and released upstream of the weir to estimate trap efficiency. Trap efficiency was estimated at 39% for one interval. Total fall direct-released smolt out-migration was estimated at 6,874 fish (95% CI 6,252 to 7,618; Table 12). Overwinter survival and out-migration for this group was 15.2% of the number of presmolts planted in 2002. The proportion of age-1, AD-clipped, hatchery-reared smolts was estimated, using the MIX software application, at 97.39% (95% CI 97.37-97.41) which equals 11,907 smolts; the proportion of age-2, AD-clipped, hatchery-reared smolts was estimated at 2.61% (95% CI 2.59-2.63) which equals 319 smolts (Figure 7).

A total of 4,723 hatchery-produced fish were handled at RLCTRP (2,699 fall direct-released and 2,024 summer direct-released). Fall direct-released presmolts overwintered and out-migrated significantly better than summer direct-released presmolts (Table 13).

Alturas Lake Creek Trap

Forty-three sockeye salmon smolts (13 wild/natural and 30 summer-released) were trapped during the 2003 out-migration season. Fork length of wild/natural and summer direct-released sockeye salmon smolts captured averaged 119 mm (range 110 mm to 130 mm) and 112 mm (range 90 mm to 140 mm), respectively.

Total wild/natural sockeye smolt out-migration for Alturas Lake was estimated at 286 fish (95% CI not calculated) and summer direct-released smolt out-migration was estimated at 553 fish (95% CI not calculated). Overwinter survival and out-migration for this group was 9.0% of the number of presmolts planted in 2002.

Pettit Lake Creek Trap

At the Pettit Lake Creek trap, 28 wild/natural sockeye smolts, 1,571 summer direct-released smolts, and 11,758 fall direct-released smolts were enumerated out-migrating from the lake. Fork length of wild/natural, summer direct-released, and fall direct-released sockeye salmon smolts captured averaged 193 mm (range 164 mm to 208 mm), 127 mm (range 101 mm to 157 mm), and 138 mm (range 116 mm to 161 mm), respectively.

Overwinter survival and out-migration for fall 2002 direct-released presmolts and summer 2002 direct-released presmolts was 58.8% and 20.1%, respectively, of the number of presmolts planted in 2002. Fall direct-released presmolts overwintered and out-migrated significantly better than summer direct-released presmolts (Table 13).

Mainstem Snake and Columbia River Dams

We estimated smolt out-migration success to LGR by release strategy using PIT tag interrogation data (Table 14; Appendix B). Estimates reflect numbers of smolts passing LGR adjusted for DCE (Appendix C). Redfish Lake had three groups of smolts for which estimates of out-migration were made: wild/natural, summer direct-released, and fall direct-released. Estimated numbers were 1,465 (31.6%) wild/natural smolts, 1,450 (27.2%) summer direct-released smolts, and 1,828 (26.6%) fall direct-released smolts passing LGR (percentages represent survival from the Redfish Lake Creek weir to LGR). Alturas Lake had two groups of smolts for which estimates of out-migration were made: wild/natural and summer direct-released. Zero wild/natural and summer direct-released smolts were estimated to have passed LGR from Alturas Lake. Pettit Lake had three groups of smolts for which estimates of out-migration were made: wild/natural, summer direct-released, and fall direct-released. The numbers of smolts estimated to have passed LGR from Pettit Lake were zero wild/natural smolts, 825 (52.5%) summer direct-released smolts, and 6,467 (55.0%) fall direct-released smolts.

Median travel times for PIT-tagged smolts were recorded from Sawtooth Valley trap sites to LGR, LGJ, LMN, and MCN (Table 15). Median travel times to LGR for Redfish Lake wild/natural, summer direct-released, and fall direct-released sockeye salmon smolts were 10.6 days, 6.2 days, and 7.1 days, respectively. Alturas Lake wild/natural and summer direct-released sockeye salmon smolts and Pettit Lake wild/natural sockeye salmon smolts were not detected at LGR. Median travel times to LGR for Pettit Lake wild/natural, summer direct-released and fall direct-released sockeye salmon smolts were 14.1 days and 13.6 days, respectively. Significant differences in the distribution of arrival times at LGR were detected for all selected group comparisons except Redfish Lake summer direct-released smolts versus Redfish Lake fall direct-released smolts, and Pettit Lake summer direct-releases smolts versus Pettit Lake fall direct-released smolts (Table 16).

Cumulative unique PIT tag detections were compared by group from Sawtooth Valley trap sites to downstream interrogation facilities (Table 17). During the 2003 out-migration year, sockeye salmon smolts were detected between May 12 and June 12; daily collection efficiencies ranged from 24.4% to 58.5% (Appendix C). Three smolt groups (wild/natural, fall direct-released, and summer direct-released) from Redfish Lake, two smolt groups (fall direct-released and summer direct-released) from Pettit Lake, and one smolt group (summer direct-released) from Alturas Lake were used in the comparisons. Alturas and Pettit lakes wild/natural groups out-migrated at low rates; due to the small sample size, no comparisons were made.

The Pettit Lake fall direct-released smolts had the highest cumulative unique detection rate (37.1%) of all smolt groups; the detection rate was statistically higher than the cumulative unique detection rates for the Pettit Lake summer direct-released smolt group and the Redfish Lake fall direct-released smolt group (Table 17). Significant differences in PIT tag interrogations and arrival times at LGR were observed between Pettit Lake fall direct-released smolts versus Redfish Lake fall direct-released smolts (Table 16). Significant differences in PIT tag interrogations and arrival times at LGR were not observed for any other release strategy comparisons (Table 17). Detections at LGR for the Redfish Lake smolt groups were distributed throughout the one-month out-migration period; detections for the Alturas and Pettit smolt groups were confined within a two-week period (Appendix C). The Alturas Lake summer-direct released smolt group had the lowest cumulative unique detection rate (16.7%); however, it was not statistically lower than the detection rates for Redfish Lake summer direct-released smolts or Pettit Lake summer direct-released smolts (Table 17). The failure to detect a significant difference for Alturas Lake summer direct-released comparisons was due to a small sample size for the Alturas smolt group.

DISCUSSION

Redfish, Alturas, and Pettit Lake Creek Traps

Of the three presmolt release options (summer direct-released, fall direct-released, and net pen-released), the fall direct-lake release option has performed consistently well in Redfish, Alturas, and Pettit lakes (Hebdon 2004). However, overwinter survival of fall-released presmolts is highly variable among years despite similar early rearing history (Table 18); the factors controlling overwinter survival are poorly understood. Since 1998, presmolts destined for direct release back to Sawtooth Valley lakes have been reared at SFH. The 2003 out-migration year is the fifth opportunity to evaluate presmolts reared at SFH and released to the lakes in the fall to overwinter and out-migrate. We are currently working with the University of Idaho to apply assessments of fish quality to hatchery-produced juvenile sockeye salmon in this program to provide additional perspectives on factors that may affect fish survival from out-planting through out-migration. General parameters considered for investigation included: 1) proximate body composition analysis, 2) organosomatic index, and 3) fish health.

Age-2 wild/natural smolts are well documented in the Redfish Lake sockeye salmon population (Bjornn et al. 1968). During the 11-year study beginning in 1956, 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 lakes, although the reasons for the additional freshwater residence time are unclear (Burgner 1991). This was the first year that we estimated the proportion of age-1 and age-2 AD-clipped out-migrants and wild/natural out-migrants at the RLCTRP. We observed a larger proportion of age-2 wild/natural out-migrants (10.89%) compared to age-2 AD-clipped hatchery reared out-migrants (2.6%). The reasons for this observed difference between hatchery-reared and wild/natural out-migration in freshwater residence time is unclear.

Mainstem Snake and Columbia River Dams

We used estimates of survival to LGR as another method of evaluating success of progeny released from the captive broodstock program. This method should be continued, but the results should be viewed carefully in making future release decisions due to the multitude of factors that affect detections of PIT-tagged sockeye salmon. Estimates of daily collection efficiencies for sockeye salmon smolts at Lower Granite Dam are not developed. Due to the lack of these data, we must use caution and not overemphasize these results because of the possible difference between species. Date of smolt arrival can also affect the probability of a PIT-tagged fish being detected. For example, during the 2000 out-migration year, PIT-tagged sockeye salmon smolts were detected between May 1 and July 9. Both flow and percent of flow as spill during the period of sockeye salmon smolt out-migration varied widely, and collection efficiency varied accordingly. This resulted in a greater chance for the detection of a PIT-tagged smolt in July (little or no spill) compared to June (with 25% to 49% spill). Daily collection efficiencies partially correct for the changes in the probability of detection.

Cumulative unique PIT tag interrogations are another measure of smolt survival from release to LGR. Fish detected at facilities downstream of LGR first had to pass LGR successfully; cumulative unique interrogations represent a minimum actual survival to LGR. During the 2003 out-migration, the Pettit fall direct-released presmolt group recorded significantly higher interrogation rates than the Redfish lake fall direct-released presmolt group. As has been the case in recent years, zooplankton density has been greater in Pettit Lake than in Redfish Lake. Differences in food availability could help explain the higher interrogation rates observed downstream for the Pettit Lake fall direct-release group. Currently we are working with the University of Idaho to determine if total body lipid content of smolts captured at Sawtooth Valley trap sites can be correlated with interrogation rates downstream.

RECOMMENDATIONS

1. Collect scale samples from unmarked smolts at the Alturas Lake Creek trap and the Pettit Lake Creek trap. Currently, scales are collected only at the Redfish Lake Creek out-migration monitoring weir. Additional data from Alturas and Pettit lakes would allow us to create a more complete determination of the proportion of age-1 and age-2 out-migrants from all project lakes.

2. Estimate proportions of age-1 and age-2 out-migrants for past out-migration years. Utilization of the MIX computer program to estimate proportions of age-1 and age-2 out-migrants was new in 2003. The information is beneficial when determining carrying capacities for project lakes.

Table 12. Mark recapture data for sockeye salmon smolts captured at the Redfish Lake Creek trap from April 16 to May 29, 2003.

Wild/natural smolts	
Trap efficiency	0.56
Marked	926
Recaptured	521
Total handled	2,611
Estimated total (single interval estimate)	4,637
95% CI upper bound	4,935
95% CI lower bound	4,360
Summer direct-released smolts (reared at Bonneville Fish Hatchery)	
Trap efficiency	0.38
Marked	623
Recaptured	235
Total handled	2,024
Estimated total (single interval estimate)	5,352
Upper bound	5,944
Lower bound	4,806
Fall direct-released smolts (reared at Sawtooth Fish Hatchery)	
Trap efficiency	0.39
Marked	679
Recaptured	266
Total handled	2,699
Estimated total (single interval estimate)	6,874
Upper bound	7,618
Lower bound	6,252

Table 13. The difference between two independent proportions of interrogations of sockeye salmon smolts released to Redfish and Pettit lakes in 2002 and detected at juvenile out-migrant trapping facilities in 2003 ($\alpha = 0.05$).

Release location	Release strategy	Number of presmolts uniquely marked	Number of Estimated out-migrants	% Interrogated	Difference between two proportions (95% CI)
Redfish Lake	summer direct-released presmolt (BFH)	61,500	5,352	8.7%	6.5% (6.2%-7.0%) significant
Redfish Lake	fall direct-released presmolt (SFH)	45,001	6,874	15.2%	
Pettit Lake	summer direct-released presmolt (BFH)	7,805	1,571	20.1%	38.7% (37.5%-39.7%) significant
Pettit Lake	fall direct-released presmolt (SFH)	19,981	11,758	58.8%	

Table 14. Summary of 2003 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Rearing locations are abbreviated as follows: ODFW Bonneville Fish Hatchery (BFH) and IDFG Sawtooth Fish Hatchery (SFH). Release strategies are abbreviated as follows: summer direct release (SDR) and fall-direct release (FDR).

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 PIT tags at LGR[b]**	**% PIT tags from traps to LGR**	**Estimated no. at LGR**	**% at LGR from release**
Redfish Lake									
Wild/natural smolt	NA	NA	NA	4,637	926	293	31.6%	1,465	NA
SDR presmolt (BFH)	61,500	1,002	40	5,352	623	180	27.2%	1,450	2.4%
FDR presmolt (SFH)	45,001	1,015	54	6,874	679	195	26.6%	1,828	4.1%
Alturas Lake[c]									
Wild/natural smolt	NA	NA	NA	286	1	0	0.0%	0	0.0%
SDR presmolt (BFH)	6,123	1,463	6	553	6	3	25.0%	0	0.0%
Pettit Lake[c]									
Wild/natural smolt	NA	NA	NA	28	7	0	0.0%	0	0.0%
SDR presmolt (BFH)	7,805	1,434	358	1,571	21	199	52.5%	825	10.6%
FDR presmolt (SFH)	19,981	2,013	850	11,758	52	496	55.0%	6,467	32.4%

[a] Total released for hatchery presmolts.
[b] Estimated from daily collection efficiency.
[c] Data from Alturas and Pettit lake traps obtained from SBT biologists.

Table 15. Median travel times of PIT-tagged sockeye salmon smolts recorded from outlet creek traps to mainstem Snake and Columbia river dams: Lower Granite (LGR), Little Goose (LGJ), Lower Monumental (LMN), and McNary (MCN) during 2003. Numbers in ( ) are unique PIT tag interrogations.

Release Strategy	LGR	LGJ	LMN	MCN
Redfish Lake				
Wild/natural	10.6 (113)	11.0 (102)	11.2 (27)	17.8 (23)
Summer direct-released (BFH)	6.2 (62)	9.2 (75)	8.6 (17)	12.0 (11)
Fall direct-released (SFH)	7.1 (66)	9.4(86)	7.3(20)	9.8(14)
Alturas Lake				
Wild/natural	NA (0)	NA (0)	NA (0)	NA (0)
Summer direct-released (BFH)	NA (0)	7.29 (1)	7.29 (1)	NA (0)
Pettit Lake				
Wild/natural	NA (0)	NA (0)	NA (0)	NA (0)
Summer direct-released (BFH)	14.1(39)	16.1 (55)	17.2 (7)	19.8 (7)
Fall direct-released (SFH)	13.6 (141)	11.8 (146)	16.4 (28)	18.0 (20)

Table 16. Comparisons of distributions of PIT tag interrogations and arrival times at Lower Granite Dam by release strategy for the 2003 out-migration year based on Kolmogorov-Smirnov two sample tests ($\alpha = 0.10$).

Release location	Release strategy	Test outcome
Redfish Lake Redfish Lake	wild/natural fall direct-released presmolt	Significant
Redfish Lake Redfish Lake	wild/natural summer direct-released presmolt	Significant
Redfish Lake Redfish Lake	summer direct-released presmolt fall direct-released presmolt	Not significant
Pettit Lake Pettit Lake	summer direct-released presmolt fall direct-released presmolt	Not significant
Redfish Lake Pettit Lake	summer direct-released presmolt summer direct-released presmolt	Significant
Redfish Lake Pettit Lake	fall direct-released presmolt fall direct-released presmolt	Significant

Table 17. The difference between two independent proportions of PIT tag interrogations of sockeye salmon smolts PIT tagged at Sawtooth Valley trap sites and detected at Snake and Columbia river dams (Lower Granite, Little Goose, Lower Monumental, and McNary) in 2003 (α = 0.05).

Release location	Release strategy	Total PIT tags detected at trap	Cumulative unique interrogations	% Detected	Difference between two proportions (95% CI)
Redfish Lake	wild/natural	926	265	28.62	3.3% (-1.1% - 7.5%) not significant
Redfish Lake	fall direct-released presmolt	730	185	25.34	
Redfish Lake	wild/natural	926	265	28.62	3.9% (-.6% - 8.2%) not significant
Redfish Lake	summer direct-released presmolt	663	164	24.74	
Redfish Lake	summer direct-released presmolt	663	164	24.74	0.6% (-4.0% - 5.1%) not significant
Redfish Lake	fall direct-released presmolt	730	185	25.34	
Pettit Lake	summer direct-released presmolt	379	114	30.08	7.1% (1.4% - 12.5%) Significant
Pettit Lake	fall direct-released presmolt	902	335	37.14	
Redfish Lake	summer direct-released presmolt	663	164	24.74	8.1% (-20.2% -20.5%) not significant
Alturas Lake	summer direct-released presmolt	12	2	16.67	
Redfish Lake	summer direct-released presmolt	663	164	24.74	5.3% (-.2% - 11.1%) not significant
Pettit Lake	summer direct-released presmolt	379	114	30.08	
Pettit Lake	summer direct-released presmolt	379	114	30.08	13.4% (-15.1% -26.3%) not significant
Alturas Lake	summer direct-released presmolt	12	2	16.67	
Redfish Lake	fall direct-released presmolt	730	185	25.34	11.2% (7.3% - 16.3%) Significant
Pettit Lake	fall direct-released presmolt	902	335	37.14	

Table 18. Estimated overwinter survival for Sawtooth Fish Hatchery-reared presmolts released in the fall to Redfish, Alturas, and Pettit lakes.

	Out-migration year				
Release Location	1999	2000	2001	2002	2003
Redfish Lake	44%	29%	20%	40%	15%
Alturas Lake	30%	34%	75%	30%	NA
Pettit Lake	NA	46%	29%	29%	59%

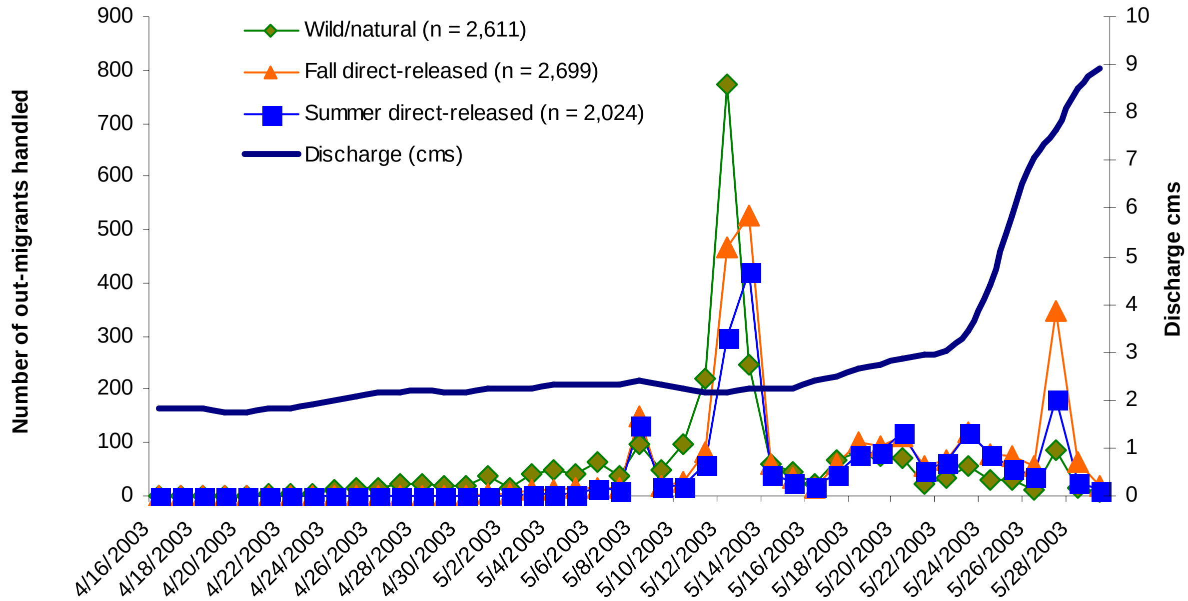

Figure 2. Daily capture of wild/natural, summer direct-released, and fall direct-released sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2003 out-migration.

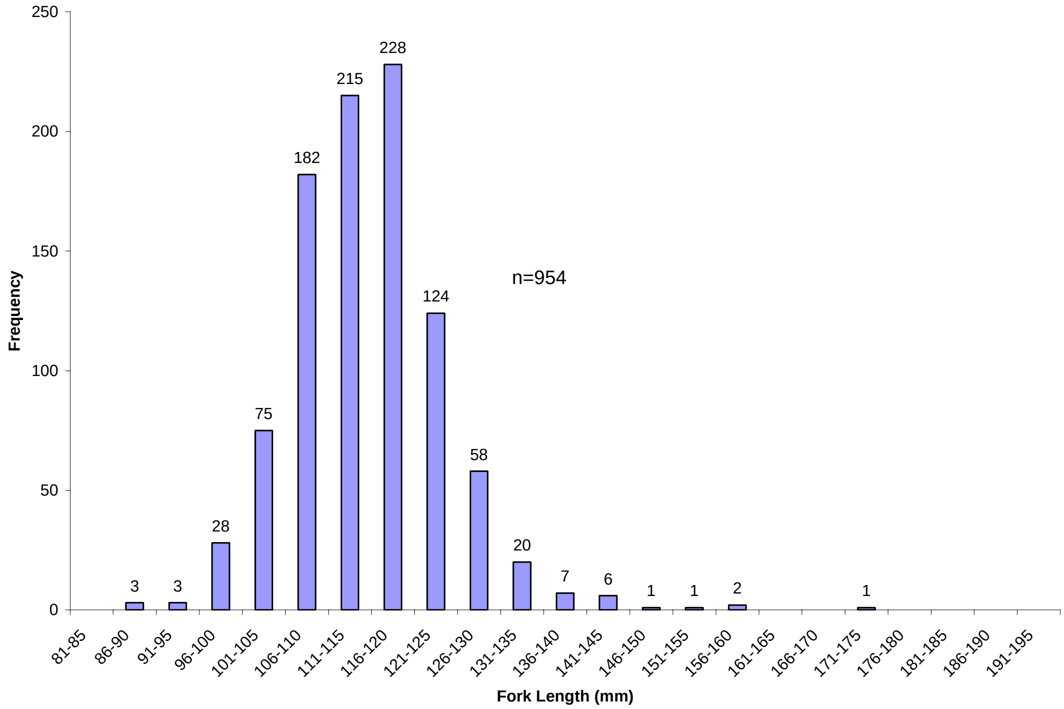

Figure 3. Length frequency of wild/natural smolts collected at Redfish Lake Creek trap in 2003. Total wild/natural out-migration estimated at 4,637 smolts.

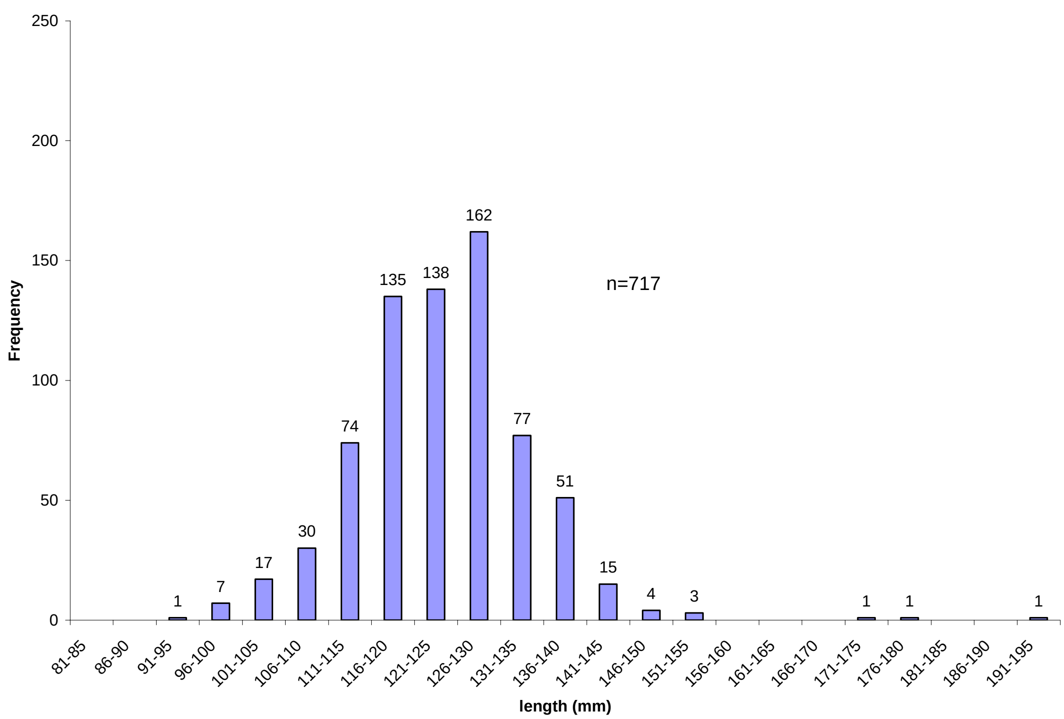

Figure 4. Length frequency of summer direct-released smolts captured at Redfish Lake Creek trap in 2003. Total summer direct-released out-migration estimated at 5,352 smolts.

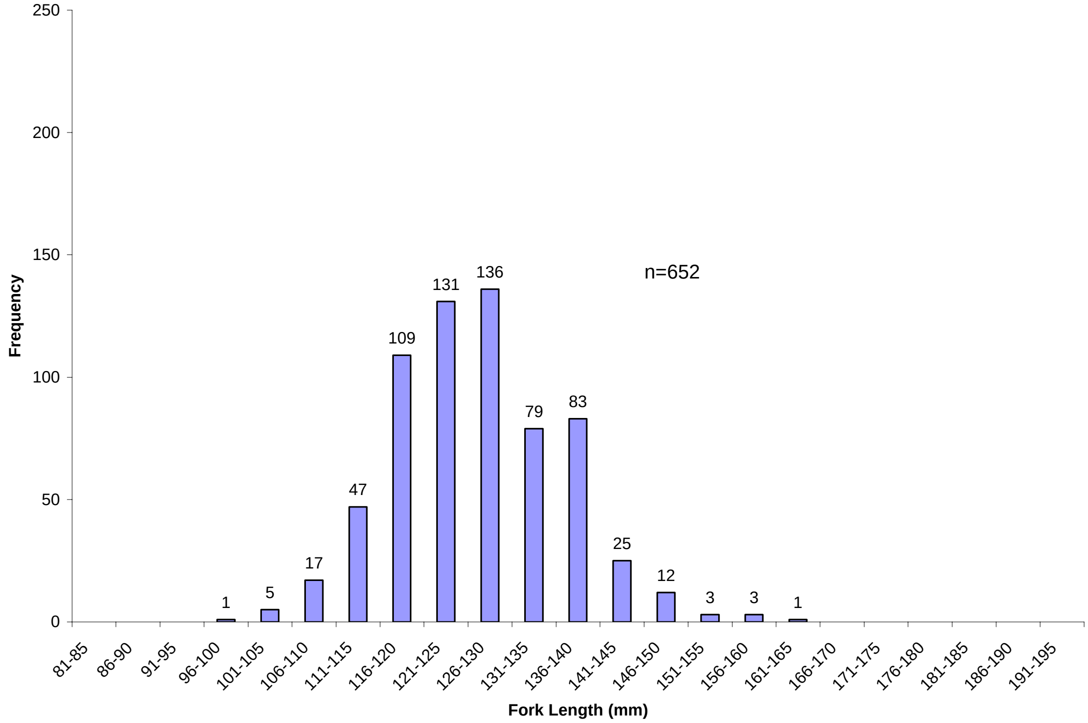

Figure 5. Length frequency of fall direct-released smolts captured at Redfish Lake Creek trap in 2003. Total net pen-released out-migration estimated at 6,874 smolts.

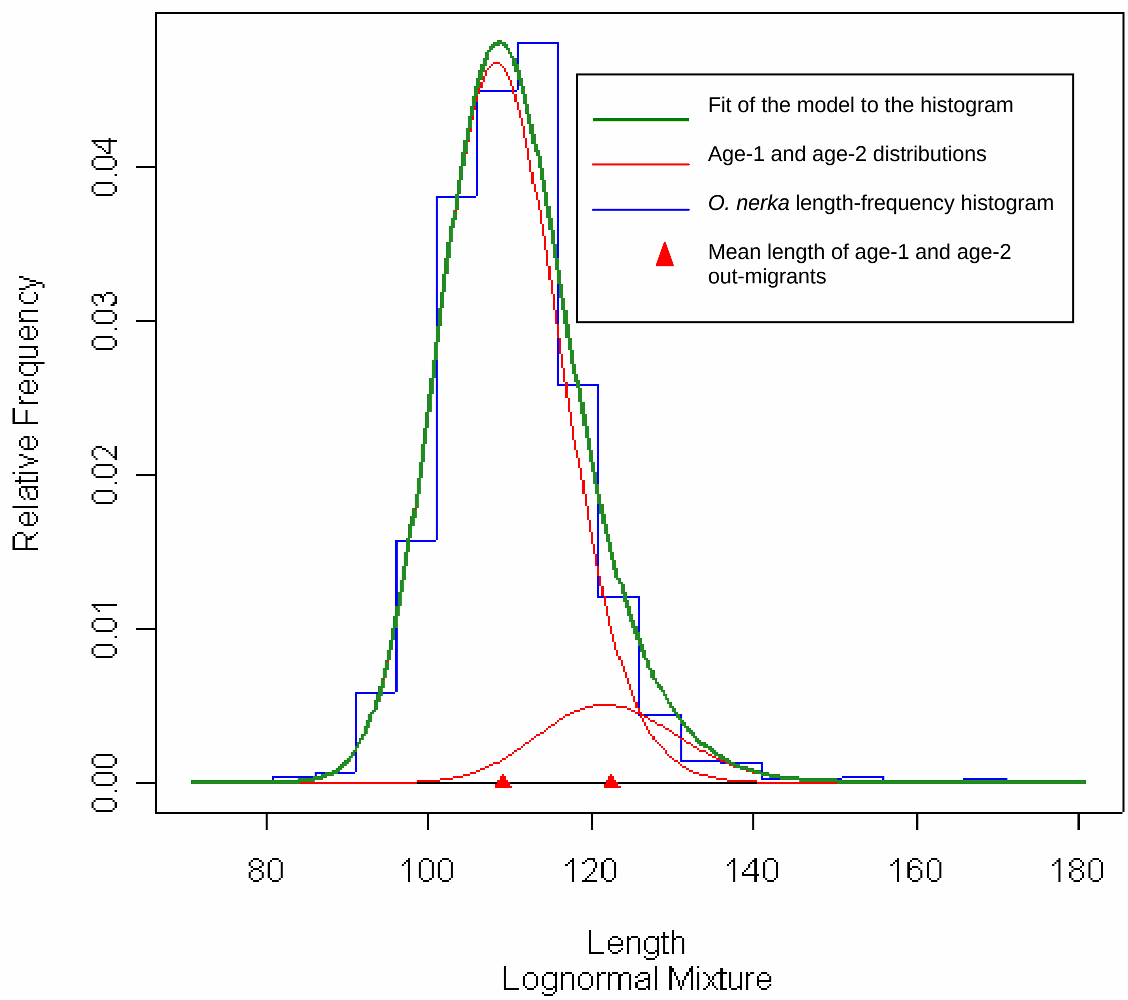

Figure 6. Wild/natural smolt lengths histogram with estimated parameters at Redfish Lake Creek trap in 2003.

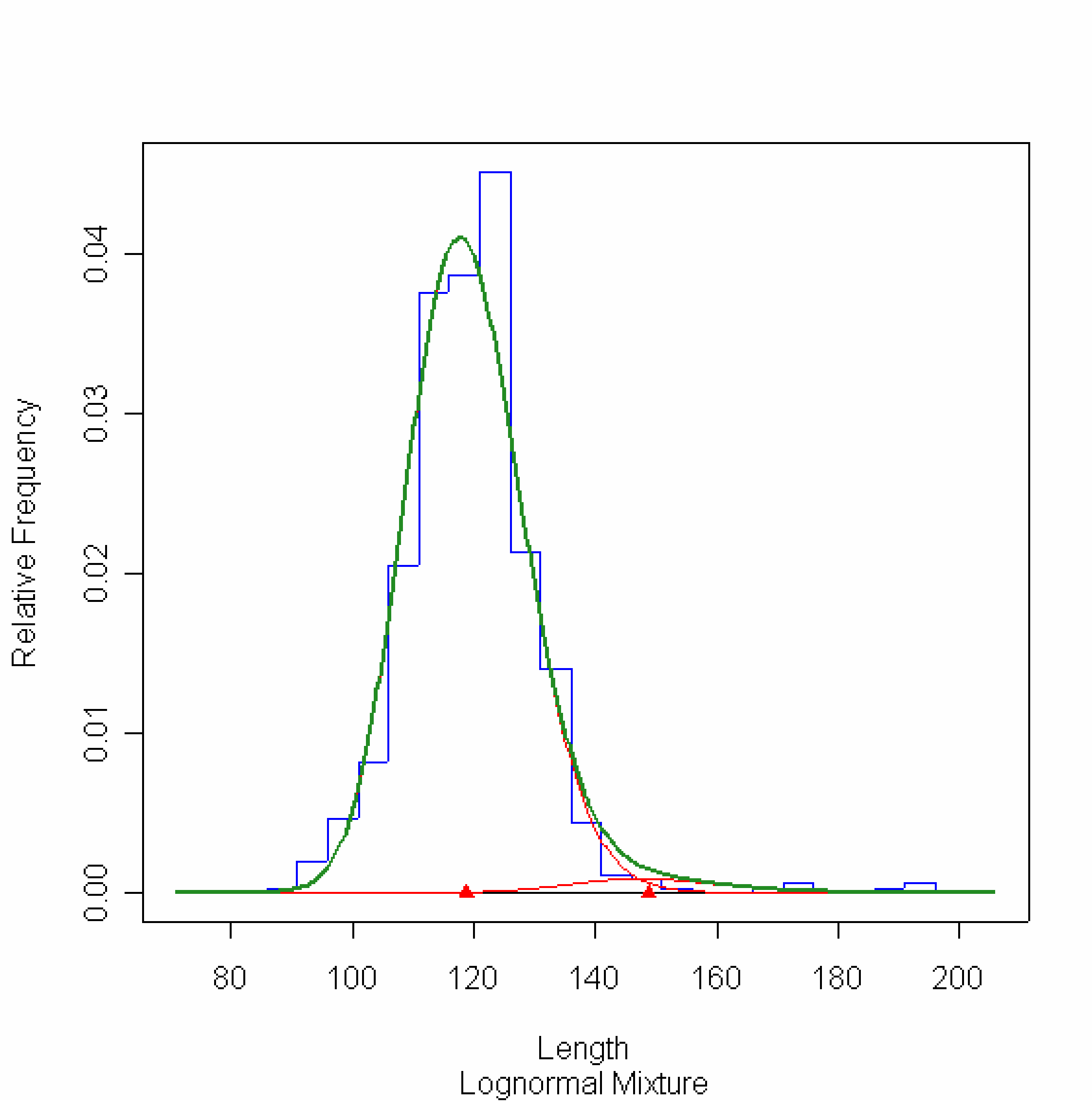

Figure 7. AD-clipped hatchery-reared smolt lengths histogram with estimated parameters at Redfish Lake Creek trap in 2003.

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PART 5—SOCKEYE SALMON SPAWNING INVESTIGATIONS AND UNMARKED JUVENILE OUT-MIGRANT MONITORING

INTRODUCTION

Releasing mature adult sockeye salmon into Sawtooth Valley lakes has been an important part of the "spread-the-risk" philosophy of the SBSTOC since fish from the captive broodstock program 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 along with adult sockeye salmon that were raised to maturity in the hatchery. Current evaluations of adult sockeye salmon releases focus on the number of redds produced, estimations of unmarked juvenile out-migrants, and DNA parental exclusion analysis.

METHODS

Sockeye Salmon Spawning Investigations

On September 15, 16 and 17, 2003, 312 hatchery-reared, BY00 adult sockeye salmon were released to Redfish Lake (Table 19). Hatchery-produced adults were from NOAA Manchester Marine Laboratory (142 females and 135 males) and IDFG Eagle Fish Hatchery (25 females and 10 males). Sex was determined by ultrasound, and efforts were made to release fish of equal sex ratios. No anadromous adults were released in 2003.

In order to assist in identifying spawning locations, six male hatchery-produced (3 EAG reared and 3 NOAA reared) sockeye salmon were implanted with radio transmitters prior to release. Telemetry investigations of adult locations began September 23, 2003 and continued weekly through November 10, 2003. Fish locations were recorded weekly by boat tracking.

Unmarked Juvenile Out-migrant Monitoring

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 Redfish Lake, hatchery-reared prespawn adults released to the lakes for natural spawning, anadromous adults released to the lakes for natural spawning, eyed-egg releases, or misclipped hatchery-reared 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.

In 2002, we began collaboration with the University of Idaho’s Center for Salmonid and Freshwater Species at Risk to utilize DNA microsatellite methods to identify individual parental contribution to unmarked smolt production through parental exclusion analysis. Parental exclusion analysis allows assignment of an individual smolt to parents of a release strategy, allowing comparisons to be made between the relative reproductive successes (in terms of number of smolts produced) of each release strategy. Emphasis can then be placed on the release strategy that produces the highest quality and/or quantity of smolts. Additionally, parental exclusion analysis will allow for evaluation of the reproductive contribution of residuals and misclipped smolts.

In 2003, unmarked out-migrants produced from program fish releases to Redfish Lake included age-1 out-migrants produced from 79 hatchery-origin fish released in 2001 and age-2 out-migrants produced from 46 hatchery-produced adults and 118 hatchery-origin anadromous adults released for natural spawning in 2000. Unmarked out-migrants produced from program fish releases to Alturas Lake included age-2 out-migrants produced from 25 hatchery-produced adults and 52 hatchery-origin anadromous adults released for natural spawning in 2000. No program fish or eyed-eggs were released in 2001 to Alturas Lake that would have produced age-1 unmarked out-migrants. Unmarked out-migrants produced from program fish releases to Pettit Lake included age-2 out-migrants produced from 28 hatchery-origin anadromous adults released for natural spawning in 2000 and 65,200 eyed-eggs released in 2000. No program fish or eyed-eggs were released in 2001 to Pettit Lake that would have produced age-1 unmarked out-migrants. The proportions of age-1 and age-2 unmarked out-migration were determined for 2003 Redfish Lake out-migrants by aging scales. The methods and discussion for this analysis are found in Part 4.

RESULTS

Sockeye Salmon Spawning Investigations

The first redd was observed at the south end of Redfish Lake on October 6, 2003. Redd counts were finalized with four observers November 10, 2003. Forty-two redds (areas of excavation) were identified. Thirty redds were located at the south beach area and 12 redds were located at the Transfer Camp (Table 20; Figure 8). 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 2003.

An additional eight completed redds were observed in Fishhook Creek. On October 21, 10 sockeye salmon were observed in Fishhook Creek exhibiting typical spawning behavior (test digging, redd maintenance, territory defense, etc.).

One radio tag was recovered during tracking efforts. The recovered tag was not associated with a carcass and was found November 4, approximately 3 m inshore along the south beach area. A female carcass was recovered November 4 and was 70% spawned out.

Unmarked Out-migrant Monitoring

In 2003, 4,611 unmarked smolts (95% CI 4,360 to 4,935) were estimated to have out-migrated from Redfish Lake, 286 unmarked smolts (95% CI not calculated) were estimated to have out-migrated from Alturas Lake, and 28 unmarked smolts were enumerated to have out-migrated from Pettit Lake (Figure 9). For Redfish Lake, the proportion of age-1 and age-2 unmarked out-migrants was estimated at 89.11% (95% CI 89.06-89.16) (4,132 smolts) and 10.89% (95% CI 10.84-10.94) (505 smolts), respectively.

Determination of the parental contribution to 2003 unmarked smolt production through parental exclusion analysis is pending.

DISCUSSION

Sockeye Salmon Spawning Investigations

Sockeye salmon spawning in Redfish Lake has been identified in three locations: Sockeye Beach, the south beach near the slide, and the area near the U.S. Forest Service transfer camp dock (Figure 9). Sockeye Beach was named because of the congregations of spawning sockeye salmon that historically spawned there in October. The south beach spawning area was identified during field investigations in 1992 while searching for residual sockeye salmon. The U.S. Forest Service transfer camp dock was first identified as a spawning area associated with hatchery-produced adults released from the captive broodstock program in 1996. It is difficult to obtain an annual final count of redds constructed on Sockeye Beach due to the lack of accumulation of aufwuchs. This year was the first year that we have observed hatchery-reared adult sockeye salmon spawning in Fishhook Creek.

The program began releasing hatchery-reared adults for volitional spawning in 1993. In 2003, the program released 312 prespawn adults for volitional spawning in Redfish Lake. This was the greatest number of adults released since the first program fish were released in 1993. The high number of redds observed in 2003 corresponded with the number of fish released. Forty-two redds were observed in the lake, the most redds observed since the program initiated the adult release option (Table 19).

Unmarked Out-migrant Monitoring

The inability to identify release strategies that produce unmarked out-migrants has confounded investigations since the initiation of this program. The only way to identify the smolt production from an individual release strategy that produces unmarked smolts has been to separate the release strategies among lakes. Although this allows us to estimate smolt production from a given release strategy, it reduces our flexibility relative to applying appropriate treatments to each lake, those with the best rearing environment at the current time (high zooplankton densities, low kokanee biomass). It also does not allow us to determine residual sockeye salmon production. The DNA microsatellite parental analysis will allow us to evaluate unmarked smolt production from hatchery-produced adult outplants, anadromous adults, and residual adults.

Table 19. 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
		Total	**1,188**	

Table 20. Summary of sockeye salmon redd observations in Redfish Lake in 2003.

	Observation date:					
	10/06/2003	**10/14/2003**	**10/15/2003**	**10/21/2003**	**10/29/2003**	**11/10/2003**
Sockeye beach						NA[a]
South beach	1 possible Redd		24 possible redds		35 possible redds	30 redds
Transfer camp			4 possible redds		9 possible redds	12 redds
Fishhook Creek		1 possible redd		2 to 5 possible redds	8 possible redds	NA[b]

[a] It is difficult to observe redds on sockeye beach due to the lack of accumulation of aufwuchs.
[b] Fishhook Creek was iced over by November 10, 2003. A final redd count was not conducted.

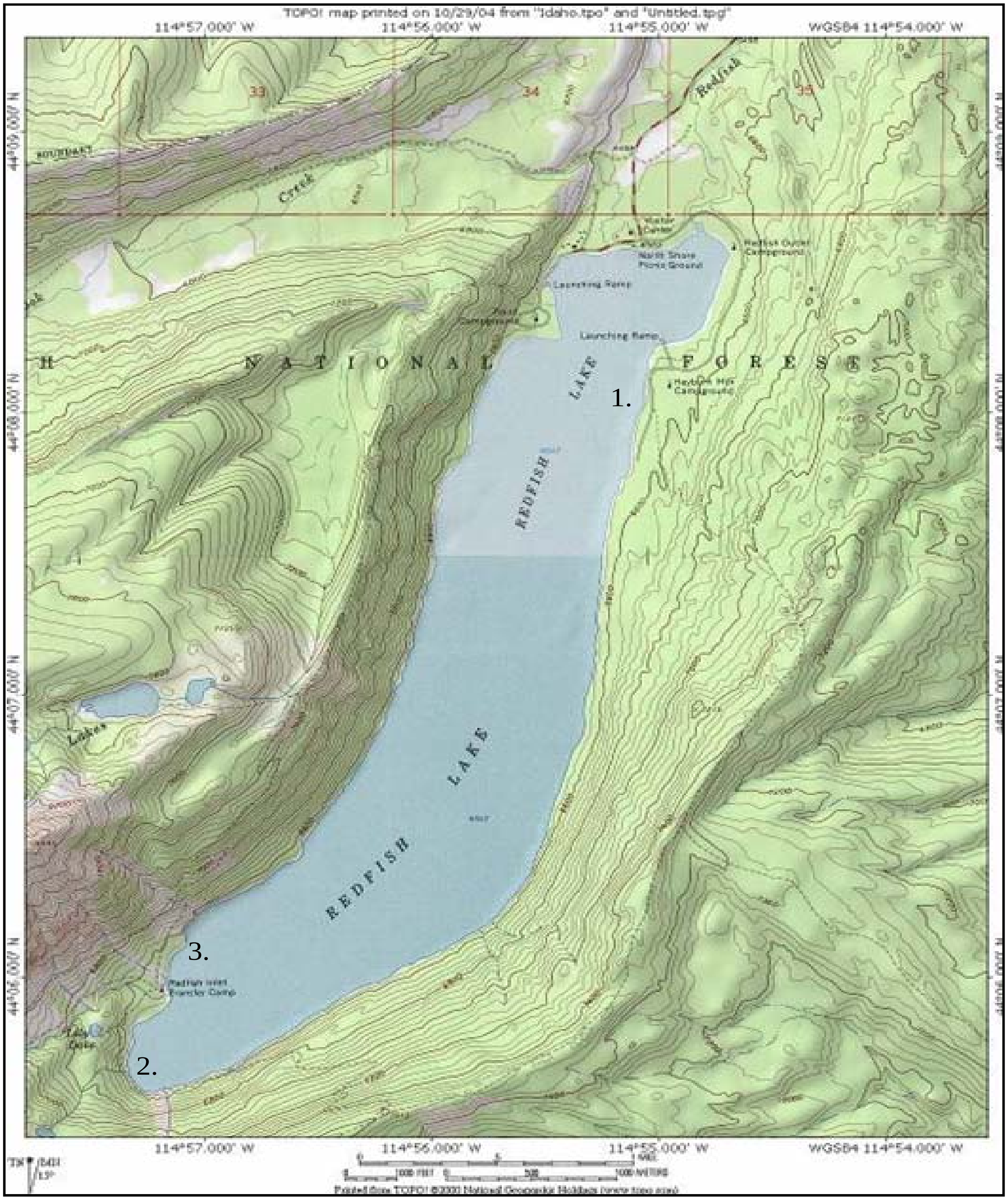

Figure 8. Spawning locations for sockeye salmon in Redfish Lake: 1) Sockeye beach, 2) the south beach near the slide, and 3) the area near the U.S. Forest Service transfer camp dock.

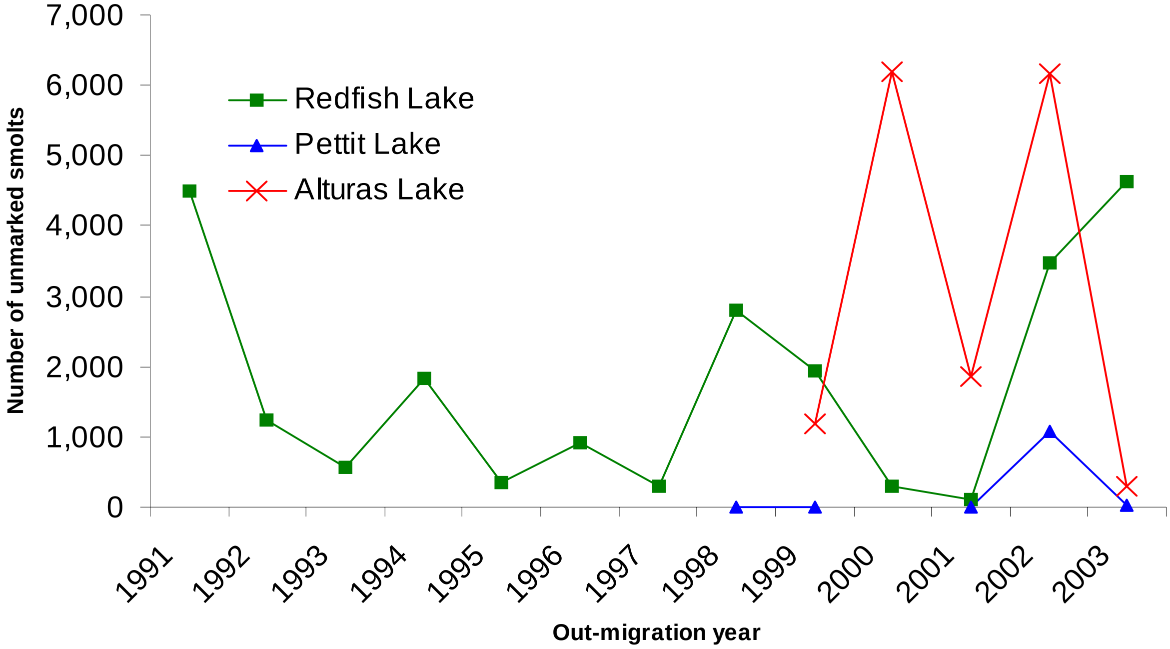

Figure 9. Wild/natural sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2003 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

PART 6—PARENTAL LINEAGE INVESTIGATIONS

INTRODUCTION

When the Snake River Captive Broodstock Program was incorporating founders (anadromous adults, residual adults, and smolts) into the captive broodstock program, the ability to discern the origin of these fish was vital. Early in the captive broodstock program, otolith microchemistry was used to improve our knowledge of the life history of wild sockeye salmon founders that were captured and spawned in the captive broodstock program (Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997). Specifically, otolith microchemistry was used to determine if fish taken into the spawning program were the progeny of anadromous sockeye salmon or residual sockeye salmon as opposed to introduced resident kokanee. However, because extracting an otolith is a lethal process, it is currently only used on anadromous sockeye salmon that are incorporated into the captive broodstock program. This lethal sampling reduces the usefulness of the technique for large application with this endangered stock.

The program continues to collect otoliths from anadromous sockeye salmon incorporated into captive broodstock spawning. However, the parental lineage investigations component of the program has evolved throughout the program's history. Currently, we are working with the University of Idaho's Center for Salmonid and Freshwater Species at Risk to utilize nonlethal genetic techniques to identify the parents of unmarked anadromous adults that return to the Sawtooth Valley. Individual parental contribution to unmarked anadromous adults will be determined by utilizing DNA microsatellite markers for parental exclusion analysis. Analysis of adult anadromous returns will not be conducted until 2004. This will be the first year that we will have the genotypes of possible parents and their offspring (2004 anadromous adult returns) completed. Additionally, we will utilize DNA microsatellite markers to identify the "relatedness" between individual anadromous adults and mature adults in the captive broodstock program. This nonlethal kinship evaluation will allow us to incorporate anadromous adults and captive broodstock adults into hatchery spawn crosses while minimizing inbreeding and the loss of heterozygosity. Additionally, we will use kinship evaluation to develop a spawning matrix for fish in the captive broodstock program. The first spawning matrix developed from kinship evaluation will be available in spawn year 2004.

METHODS

In 2003, all sockeye salmon broodstocks in culture (BY00, BY01, and BY02) had fin tissue collected and archived in Lysis buffer solution for genetic analysis and future development of a spawning matrix. The matrix will be used during the 2004 spawn year. Fin tissue will also be collected from anadromous returns in 2004. Real-time genetic analysis will be completed to determine the relatedness of anadromous fish to individuals within the captive broodstock.

In addition to the fin tissue, during years when anadromous adults are returned to the hatchery and spawned in the captive broodstock program, their otoliths are removed, archived, polished, and mounted according to methods described by Kalish (1990) and Rieman et al. (1993). In 2003, we removed otoliths from two anadromous adults. We can use information obtained from otolith microchemistry analysis to determine the origin of unmarked anadromous returns. Unmarked anadromous adults can be progeny of residual sockeye salmon adults that spawn in Redfish Lake, program prespawn adults released to the lakes for natural spawning, or eyed-egg releases.

RESULTS

Genetic analysis is pending.

Otolith microchemistry analysis is pending.

DISCUSSION

Determination of the parents of unmarked anadromous returns will allow us to establish what release strategy produced adult returns, in addition to identifying the release lake. The program has documented marked fish of known Redfish Lake origin returning to the Sawtooth Trap. The genetic analysis will allow us to determine if an unmarked adult return is homing to its nursery lake.

Utilization of microsatellite markers to conduct parentage analysis has been utilized for determination of parentage and relatedness in aquaculture broodstocks (Norris et al. 2000; Letcher and King 2001; McDonald et al. 2004). Relatedness inferred from microsatellite genotypes can reduce inbreeding and minimize the loss of heterozygosity in mixed aquaculture broodstocks (Blouin 2003; Sekino et al. 2003).

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PART 7—PROXIMATE ANALYSIS FOR JUVENILE FISH QUALITY ASSESSMENT

INTRODUCTION

In 1999, the SBSTOC recommended applying assessments of fish quality to juvenile sockeye salmon produced in this program to provide additional perspective on factors that may affect fish survival from outplanting through out-migration. General parameters considered for investigation included: 1) proximate body composition analysis, 2) organosomatic index, and 3) fish health.

METHODS

In 2003, *O. nerka* fish carcasses were collected and sent to the University of Idaho's Center for Salmonid and Freshwater Species at Risk for proximate analysis (Table 21).

To determine proximate body composition, sampled fish were dried, ground, and analyzed using standardized methods for proximate composition from the Association of Official Analytical Chemists (AOAC) (1990). Sample protein content was analyzed using a LECO FP 28 nitrogen analyzer. Crude lipid content in samples was analyzed using a LECO TFE 2000 supercritical CO^2 extractor (both are from LECO Corporation, St. Joseph, Missouri).

RESULTS

Mean percent fat dry weight calculations are pending.

Table 21. Year 2003 juvenile *O. nerka* proximate body analysis summary.

Sample Date	Sample location	Description of fish sampled[a]	Number sampled	Mean wt. (g)	Mean FL (mm)	Mean % fat dry Weight
01/29/03	Pettit Lake	Gill net, wild/natural *O. nerka*	5	17.1	118	*Pending*
02/19/03	Pettit Lake	Gill net, wild/natural *O. nerka*	21	17.1	120	*Pending*
01/29/03	Pettit Lake	Gill net, AD/RV sockeye salmon	1	19.9	125	*Pending*
02/19/03	Pettit Lake	Gill net, AD/RV sockeye salmon	1	22.0	131	*Pending*
May-2003	Pettit Lake Creek	Weir, AD out-migrant	23	18.8	126	*Pending*
May-2003	Pettit Lake Creek	Weir, AD/RV out-migrant	25	24.8	141	*Pending*
May-2003	Redfish Lake Creek	Weir, wild/natural out-migrant	21	14.7	117	*Pending*
May-2003	Redfish Lake Creek	Weir, AD/RV out-migrant	21	17.5	126	*Pending*
May-2003	Redfish Lake Creek	Weir, AD out-migrant	20	18.4	127	*Pending*
June-2003	Redfish Lake	Hook and line/creel, wild/natural *O. nerka*	9	NA	NA	*Pending*
July-2003	Redfish Lake	Hook and line/creel, wild/natural *O. nerka*	7	NA	NA	*Pending*
July-2003	Alturas Lake	Hook and line/creel, wild/natural *O. nerka*	2	NA	NA	*Pending*
09/24/03	Redfish Lake	Trawl, age-0 wild/natural *O. nerka*	17	4.5	76	*Pending*
09/24/03	Redfish Lake	Trawl, age-1 wild/natural *O. nerka*	3	17.5	122	*Pending*
09/24/03	Redfish Lake	Trawl, age-2 wild/natural *O. nerka*	2	38.3	148	*Pending*
09/24/03	Redfish Lake	Trawl, age-3 wild/natural *O. nerka*	1	136.4	231	*Pending*
09/24/03	Redfish Lake	Trawl, age-4 wild/natural *O. nerka*	1	155.8	240	*Pending*
09/25/03	Pettit Lake	Trawl, age-1 wild/natural *O. nerka*	8	25.1	126	*Pending*
09/25/03	Pettit Lake	Trawl, age-3 wild/natural *O. nerka*	4	108.9	204	*Pending*
09/26/03	Alturas Lake	Trawl, age-0 wild/natural *O. nerka*	5	2.8	66	*Pending*
09/26/03	Alturas Lake	Trawl, age-1 wild/natural *O. nerka*	2	10.1	106	*Pending*
09/26/03	Alturas Lake	Trawl, age-2 wild/natural *O. nerka*	3	49.2	164	*Pending*
09/26/03	Alturas Lake	Trawl, age-3 wild/natural *O. nerka*	5	61.5	181	*Pending*
10/02/03	Sawtooth Fish Hatchery	Prerelease, AD sockeye salmon presmolt	21	106.0	11.7	*Pending*

[a] AD refers to an adipose fin-clip and RV refers to a right ventral fin-clip.

PART 8—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.

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 2003, 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) on August 27 and on September 8, 2003. 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

Fishhook Creek

We observed 40 adult bull trout (28 males, 11 females, and 1 unknown) and six developing redds on August 27, 2003. Water temperature at 1035 hours was 8.5°C. During our second survey on September 8, we observed 15 adult bull trout (10 males and 5 females), 15 complete redds, and two developing redds (Figure 10). Water temperature was 7.0°C at 1230 hours. Redd counts on the second date included developing redds observed on the previous count (Table 22).

Alpine Creek

We observed 27 adult bull trout (18 males, 8 females, and 1 unknown), five developing redds, and six completed redds during the August 27, 2003 survey. Water temperature was 12.0°C at 1511 hours. On September 8, we observed zero adult bull trout, 12 completed redds, and two developing redds (Figure 11). Water temperature was 8.5°C at 1645 hours. Redd counts on the second date included developing redds and completed redds observed during the previous count (Table 23).

DISCUSSION

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).

Final index sections were established on Fishhook and Alpine creeks in 1998. Information collected in 2003 represented the sixth 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 completely removed from potential harvest by anglers.

From the six years of data, it appears that the no-harvest fishing regulation is affecting the bull trout population in Alpine Creek more than in Fishhook Creek. The Alpine Creek population has increased steadily since 1998; one redd was observed in 1998, and a high of 15 redds were observed in 2001. Redd counts in Fishhook Creek have been holding constant since 1998, varying between 11 and 18 redds counted each year. Because bull trout may spawn in alternating or consecutive years (Fraley and Shepard 1989), year-to-year variation would be expected. Our results 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. *in review*).

This effort represented the only attempt to monitor bull trout populations in the upper Salmon River drainage upstream of the Lemhi River (Tom Curet, IDFG, personal communication). Monitoring bull trout populations with redd counts is advantageous, because they are low cost and cause little disturbance to spawning bull trout. However, several sources of error are associated with counting redds. True redds may be missed (omissions) due to location in the stream (associations with depth or cover), or natural channel formations may be counted as redds (false identifications). In addition to the observation error, sampling index sections provide accurate counts only if the distribution of spawning does not change from year to year (Dunham et al. 2001). Despite the potential for error in redd counts, documentation of significant population declines 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.

Table 22. Bull trout adult fish counts and redd counts in trend survey sections of Fishhook Creek from 1998 to 2003.

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

Table 23. Bull trout adult fish counts and redd counts in trend survey sections of Alpine Creek from 1998 to 2003.

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

[a] Only one count completed.

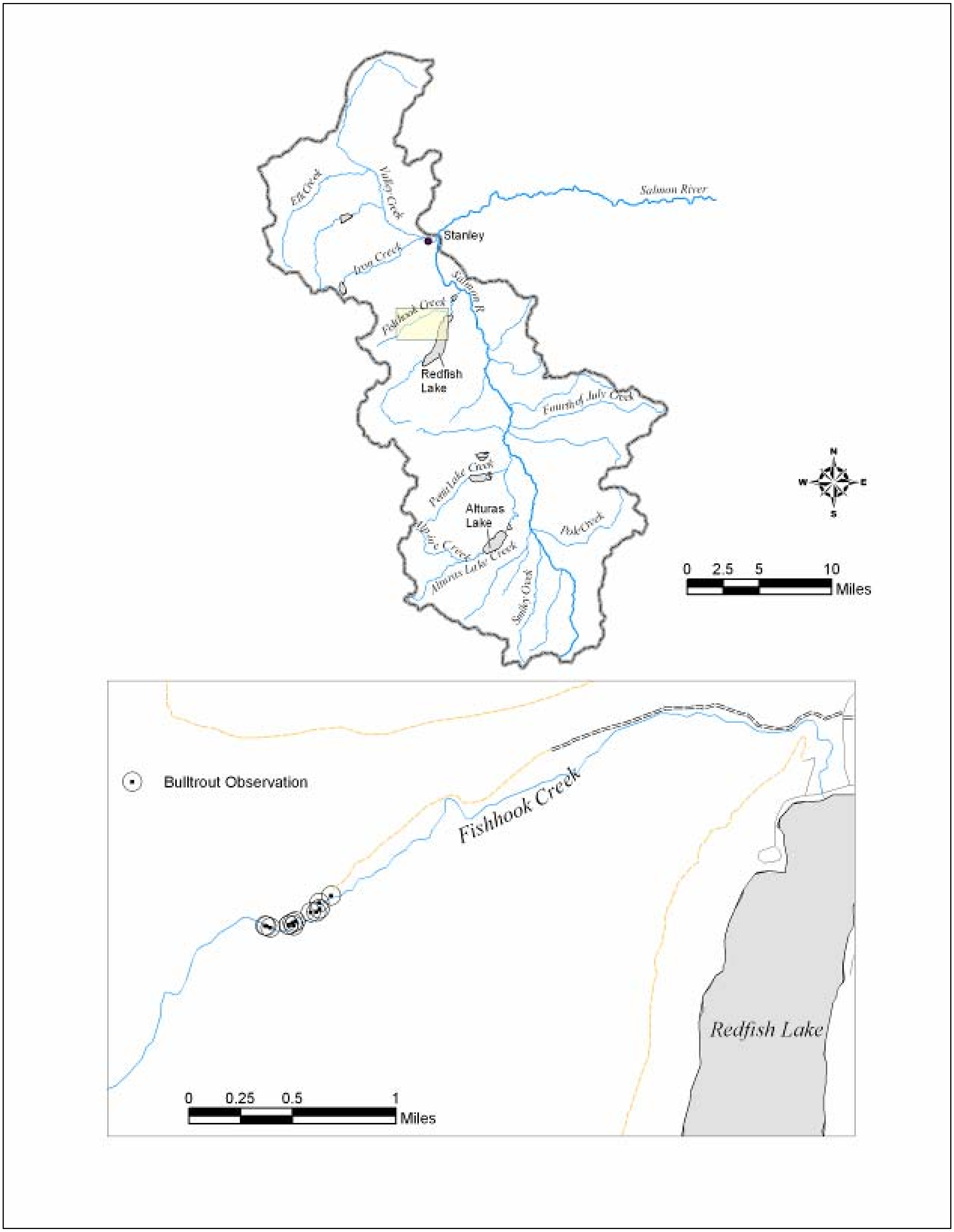

Figure 10. Locations of completed bull trout redds observed in Fishhook Creek in 2003.

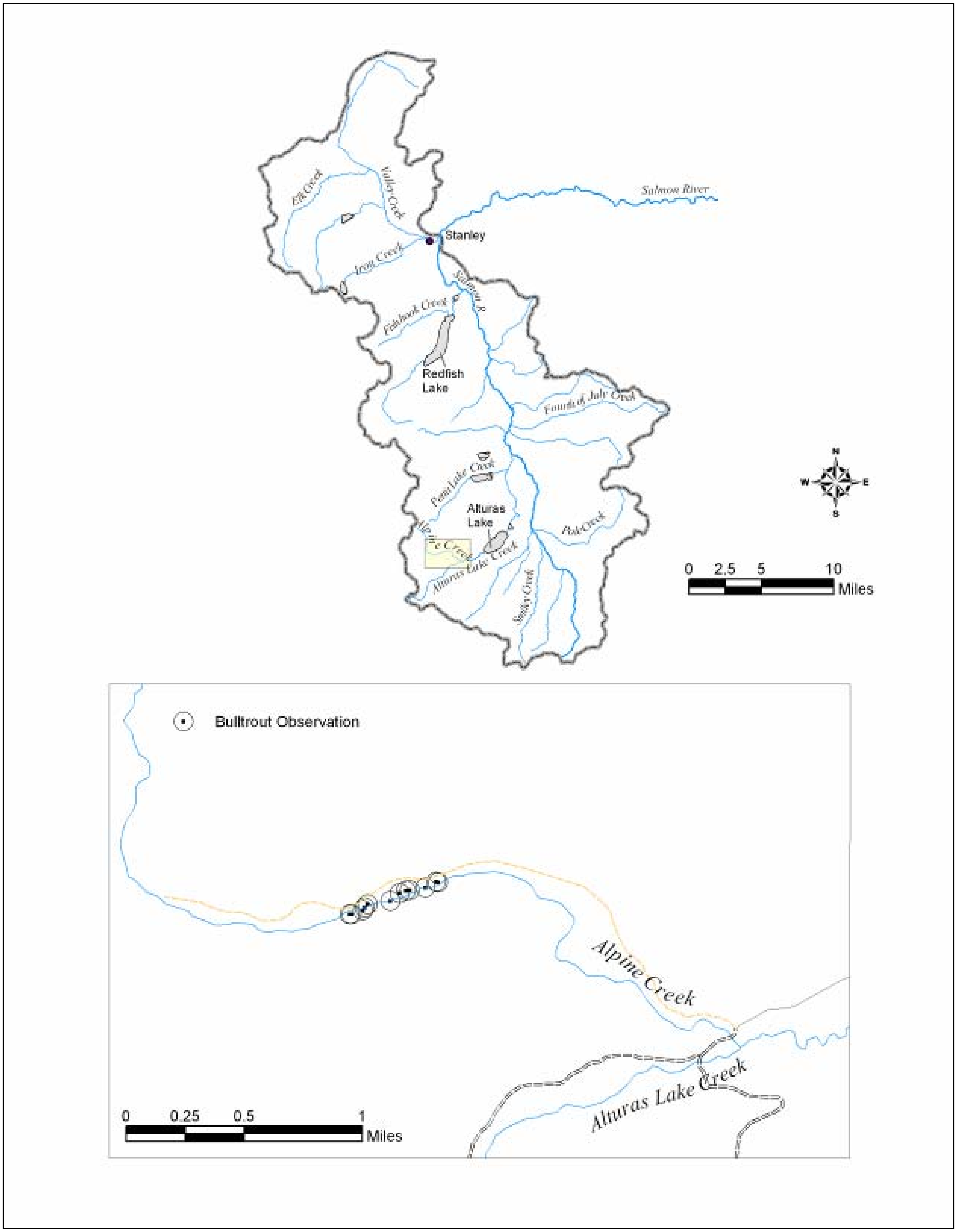

Figure 11. Locations of completed bull trout redds observed in Alpine Creek in 2003.

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APPENDICES

Appendix A. Fork length, weight (g) and age of kokanee captured during midwater trawls conducted during September 2003 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age
Redfish Lake			
1	240	155.8	4
1	146	35.7	2
1	125	16.1	1
1	69	3	0
1	60	1.7	0
1	71	3	0
1	63	2.2	0
1	65	2.5	0
1	270	186	3
1	117	13.3	1
1	109	10.9	1
1	103	9.2	1
1	95	7.8	1
1	65	2	0
1	57	1.8	0
1	55	1.4	0
1	56	1.4	0
1	55	1.4	0
1	53	1.4	0
1	54	1.3	0
1	57	1.6	0
1	46	0.8	0
1	48	0.9	0
2	150	40.9	2
2	62	1.9	0
2	56	1.3	0
2	73	3.2	0
2	64	2.1	0
2	58	1.8	0
2	65	2.3	0
2	63	1.7	0
2	66	2.7	0
2	64	2.1	0
2	65	2.2	0
2	58	1.7	0
2	63	2	0
2	61	1.9	0
2	59	1.8	0
2	56	1.4	0
2	57	1.7	0
2	62	2	0
2	57	1.4	0
2	53	1.2	0
2	51	1	0
3	128	21.4	1
3	114	14.9	1
3	66	2.4	0
3	70	2.8	0
3	65	2.3	0

Appendix A. continued.

Transect	Length (mm)	Weight (g)	Age
Redfish Lake, cont.			
3	59	1.7	0
4	231	136.4	3
4	76	4.5	0
4	76	4.4	0
4	67	2.5	0
4	56	1.6	0
4	54	1.2	0
4	67	2.3	0
4	57	1.6	0
4	56	1.8	0
4	61	1.8	0
4	62	1.9	0
4	46	0.9	0
4	59	2	0
4	65	2.4	0
5	58	1.8	0
5	57	1.4	0
5	63	2	0
5	63	2.1	0
5	63	1.9	0
5	260	186	4
5	140	28.8	2
5	119	13.9	1
5	59	1.8	0
5	57	1.4	0
5	64	2.2	0
5	60	1.8	0
5	67	2.3	0
5	68	2.2	0
5	53	1.2	0
5	62	2	0
5	61	1.6	0
5	64	2	0
5	59	1.5	0
5	70	2.4	0
5	48	0.9	0
Alturas Lake			
2	66	2.9	0
2	105	9.6	1
2	195	72.4	3
2	170	53.1	2
2	180	58.3	3
2	175	55.4	3
3	78	4.7	0
3	72	3.4	0
3	175	54.3	3
3	165	46.6	2
3	179	60.9	3
3	164	46.3	2
3	168	48.6	3
3	176	56.7	3

Appendix A. continued.

Transect	Length (mm)	Weight (g)	Age
Alturas Lake, cont.			
3	160	43.6	2
3	165	51.6	2
3	166	46.4	2
4	59	1.7	0
4	169	52.7	3
4	181	64.3	3
4	168	52	2
5	53	1.4	0
5	107	10.7	1
5	155	42.5	2
5	179	59.8	3
Pettit Lake			
1	133	28.7	1
1	131	26.1	1
1	129	27.6	1
1	124	22	1
1	180	67.3	2
1	210	114.3	3
1	161	55.4	2
1	140	34.4	1
2	111	17.1	1
2	126	24.4	1
2	140	34.8	1
2	117	20.1	1
2	38	0.5	0
3	209	109.6	3
3	195	98.3	3
3	120	24	1
3	138	31.7	1
3	130	237	1
3	148	34.3	1
4	210	145.3	3
4	198	91	3
4	199	89.9	3
4	125	23.4	1
4	121	20	1
4	131	25.4	1
4	50	1.2	0

Appendix B. Arrival dates for PIT-tagged sockeye salmon smolts at Lower Granite Dam for the 2003 migration year.

	Redfish Lake			Pettit Lake	
Date	**Wild/natural**	**Direct summer release (BFH)**	**Direct fall release (SFH)**	**Direct summer release (BFH)**	**Direct-summer release (SFH)**
5/8/2003					
5/9/2003					
5/10/2003					
5/11/2003					
5/12/2003	1		0		
5/13/2003	0		0		
5/14/2003	0		0		
5/15/2003	5		0		
5/16/2003	5		2		
5/17/2003	6		3		
5/18/2003	4		1		
5/19/2003	6		0		
5/20/2003	6	2	1		
5/21/2003	6	4	2		
5/22/2003	12	2	2		
5/23/2003	2	2	3		
5/24/2003	5	2	0		
5/25/2003	6	6	2		
5/26/2003	5	3	5		
5/27/2003	5	4	6	2	13
5/28/2003	7	4	3	9	37
5/29/2003	6	9	10	10	35
5/30/2003	9	6	7	5	19
5/31/2003	3	1	2	4	8
6/1/2003	5	2	4	1	13
6/2/2003	3	6	7	3	2
6/3/2003	2	4	3	2	1
6/4/2003	1	2	1	2	2
6/5/2003	0	1	1	1	0
6/6/2003	0	1			0
6/7/2003	1	1			4
6/8/2003	1				1
6/9/2003	0				
6/10/2003	0				
6/11/2003	0				
6/12/2003	1				
TOTAL	**113**	**62**	**65**	**39**	**135**

Appendix C. Estimates of PIT-tagged sockeye salmon passing Lower Granite Dam for the 2003 migration year. Actual PIT tag interrogations are expanded by Daily Collection Efficiency. Flow and spill are in KCFS. Groups are abbreviated as follows: Redfish Lake wild/natural (RFL WN), Redfish Lake summer direct-release (RFL sum), Redfish Lake fall direct-release (RFL fall), Pettit Lake summer direct-release (PET sum), and Pettit Lake fall direct-release smolts.

Date	DCE	Flow	Spill	RFL WN	RFL sum	RFL fall	PET sum	PET fall	Cumulative
5/8/2003	0.349	70.4	20.4	0	0	0	0	0	0
5/9/2003	0.285	68.0	20.5	0	0	0	0	0	0
5/10/2003	0.274	66.1	25.6	0	0	0	0	0	0
5/11/2003	0.286	34.0	20.5	0	0	0	0	0	0
5/12/2003	0.325	65.2	15.7	3	0	0	0	0	3
5/13/2003	0.326	72.4	20.8	0	0	0	0	0	3
5/14/2003	0.338	78.2	25.5	0	0	0	0	0	3
5/15/2003	0.454	79.1	20.5	11	0	0	0	0	14
5/16/2003	0.541	87.0	15.3	9	0	4	0	0	27
5/17/2003	0.554	89.7	20.4	11	0	5	0	0	43
5/18/2003	0.502	83.8	25.9	8	0	2	0	0	53
5/19/2003	0.510	83.9	20.5	12	0	0	0	0	65
5/20/2003	0.467	72.1	15.4	13	4	2	0	0	84
5/21/2003	0.470	74.4	20.4	13	9	4	0	0	110
5/22/2003	0.401	72.1	25.6	30	5	5	0	0	150
5/23/2003	0.489	79.7	20.5	4	4	6	0	0	164
5/24/2003	0.477	95.7	20.5	10	4	0	0	0	179
5/25/2003	0.492	122.7	30.6	12	12	4	0	0	207
5/26/2003	0.378	146.7	53.8	13	8	13	0	0	242
5/27/2003	0.338	155.2	61.4	15	12	18	6	38	330
5/28/2003	0.299	156.8	63.0	23	13	10	30	124	531
5/29/2003	0.244	172.1	77.9	25	37	41	41	143	818
5/30/2003	0.277	186.2	91.9	32	22	25	18	69	984
5/31/2003	0.324	208.2	114.3	9	3	6	12	25	1039
6/1/2003	0.324	190.8	96.5	15	6	12	3	40	1117
6/2/2003	0.313	165.9	72.2	10	19	22	10	6	1184
6/3/2003	0.418	149.1	55.6	5	10	7	5	2	1212
6/4/2003	0.432	133.0	43.2	2	5	2	5	5	1231
6/5/2003	0.414	118.1	30.1	0	2	2	2	0	1238
6/6/2003	0.418	114.7	27.0	0	2	0	0	0	1241
6/7/2003	0.389	108.7	24.5	3	3	0	0	10	1256
6/8/2003	0.439	111.0	26.0	2	0	0	0	2	1261
6/9/2003	0.459	109.0	31.3	0	0	0	0	0	1261
6/10/2003	0.529	110.5	31.0	0	0	0	0	0	1261
6/11/2003	0.585	109.7	25.8	0	0	0	0	0	1261
6/12/2003	0.565	101.8	20.8	2	0	0	0	0	1262
			TOTAL	**293**	**180**	**193**	**132**	**465**	

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