FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

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2004 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 2004, progeny from the captive broodstock program were released using three strategies: eyed-eggs were planted in Pettit Lake 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 2004. Population abundances were estimated at 82,258 fish for Redfish Lake, 36,206 fish for Alturas Lake, and 46,065 fish for Pettit Lake.

Angler surveys were conducted from May 30 through August 7, 2004 on Redfish Lake and from May 30 to September 4, 2004 on Stanley Lake to estimate kokanee harvest and to estimate return to creel for hatchery rainbow trout planted in Stanley Lake. On Redfish Lake, we interviewed 150 anglers and estimated that 621 kokanee were harvested. The calculated kokanee catch rate was 0.09 fish/hour. On Stanley Lake, 251 anglers were interviewed who harvested an estimated 102 kokanee at a catch rate of 0.01 fish/hour. We estimated that anglers harvested 3,670 (26%) of the 14,151 rainbow trout planted in Stanley Lake in 2004.

The juvenile out-migrant trap on Redfish Lake Creek was operated from April 13 to June 16, 2004. We estimated that 4,476 wild/natural and 16,289 hatchery-produced sockeye salmon smolts out-migrated from Redfish Lake in 2004. The hatchery-produced component originated from a 2003 fall presmolt direct-release. The juvenile out-migrant traps on Alturas Lake Creek and Pettit Lake Creek were operated by the SBT from April 20 to May 26, 2004 and April 21 to May 28, 2004, respectively. The SBT enumerated 61 wild/natural and 5,227 hatchery-produced sockeye salmon smolts that out-migrated from Pettit Lake and estimated 74 wild/natural and 1,091 hatchery-produced sockeye salmon smolts out-migrated from Alturas Lake in 2004. The hatchery-produced component of sockeye salmon out-migrants originated from presmolt releases made directly to Pettit and Alturas lakes in 2003.

In 2004, the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC) chose to have all Snake River sockeye salmon juveniles (tagged and untagged) transported due to potential enhanced survival. Therefore, mainstem survival evaluations were only conducted to Lower Granite Dam. Unique Passive Integrated Transponder (PIT) tag interrogations from Sawtooth Valley juvenile out-migrant traps to Lower Granite Dam were utilized to estimate detection rates for out-migrating sockeye salmon smolts. Detection rate comparisons were made between smolts originating from Redfish and Pettit lakes and the various release strategies. Redfish Lake wild/natural smolts recorded the highest detection rate of 30.5%.

In 2004, 241 hatchery-produced adult sockeye salmon were released to Redfish Lake for natural spawning. We observed 127 areas of excavation in the lake from spawning events. This was the highest number of redds observed in Redfish Lake since the program was initiated. Suspected redds were approximately 3 m x 3 m in size and were constructed by multiple pairs of adults.

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 seventh consecutive year that the index reaches have been surveyed on these two streams. Adult counts (31 adults) and redd counts (11 redds) in Fishhook Creek were similar to counts conducted since monitoring began in 1998. Bull trout numbers (16 adults) and the number of redds observed (9 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 *(Genus: Oncorhynchus)* in the Columbia River basin currently listed as threatened or endangered under the ESA (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 (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 evolutionarily significant unit of the biological species (Waples 1991). To be considered an evolutionarily significant unit, a stock must satisfy two criteria: 1) it must be reproductively isolated from other conspecific population units, and 2) it must represent an important component in the evolutionary legacy of the biological species (Waples 1991). At the time of listing, the Redfish Lake sockeye salmon population was the only remaining sockeye salmon population of the Snake River sockeye salmon stock. Snake River sockeye salmon are one of three remaining stocks of sockeye salmon in the Columbia River system; the other two stocks, Okanogan Lake sockeye salmon and Wenatchee Lake sockeye salmon, are located in tributaries of the upper Columbia River. Approximately 1,127 river kilometers separate Snake River sockeye salmon from the nearest sockeye salmon populations in the upper Columbia River. Additionally, there has been no reported evidence of straying of sockeye salmon from the upper Columbia River into Redfish Lake (Waples et al. 1991; Winans et al. 1996). Mitochondrial DNA analyses completed in 2003 confirmed the genetic isolation of the upper Columbia River stocks from the Snake River sockeye salmon stock (Faler and Powell 2003).

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

Genetic investigations conducted during and after Snake River sockeye salmon were listed further refined genetic relationships between anadromous sockeye salmon, residual sockeye salmon, and resident kokanee present in Redfish Lake. The presence of all three of these life history strategies of *O. nerka* in Redfish Lake complicated the ESA listing. Anadromous *O. nerka* (sockeye salmon) spawn on the shoals of the lake in October and November. Juveniles out-migrate during the spring from their nursery lake at age-1 or age-2 and remain in the ocean for one to three years before returning to their natal area to spawn. Residual *O. nerka* (sockeye salmon) spawn with anadromous sockeye salmon on the shoals of the lake in October and November. Residual sockeye salmon spend their entire life in their nursery lake. Variable proportions of anadromous and residual progeny may conform to a residual life history pattern. Resident *O. nerka* (kokanee) also complete their lifecycle in freshwater. They remain in Redfish Lake until maturation and spawn in Fishhook Creek, a tributary creek to Redfish Lake, in August and September. Kokanee are nonindigenous to Redfish Lake and were periodically stocked from a range of hatchery sources beginning in 1930 and continuing through 1972 (Bowler 1990). Redfish Lake anadromous sockeye salmon, residual sockeye salmon, and out-migrants were determined to be genetically similar, whereas kokanee were found to be genetically different (Brannon et al. 1992, 1994; Cummings et al. 1997; Waples et al. 1997). Because of their genetic similarity, residual sockeye salmon were added to the ESU listing in 1992.

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) described 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 progeny (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 Sakinaw 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 2,770,467 eyed-eggs from 1991 through 2004 (Table 1). Each year approximately 800 eggs are selected to be reared in the hatchery as an annual captive broodstock; the remaining eggs are utilized for reintroduction into the habitat.

The development of captive broodstock program reintroduction plans follows a “spread-the-risk” philosophy incorporating multiple release strategies and multiple lakes (Hebdon et al. 2004). Progeny from the captive broodstock program are reintroduced to Sawtooth Valley waters at different life stages using a variety of release options including: 1) eyed-egg plants to in-lake incubator boxes in November and December, 2) presmolt releases direct to lakes in October, 3) 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 1,808,177 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% ([1,808,177/2,770,467]*100) for the program.

Release plans are influenced by the life history traits exhibited by wild sockeye salmon and habitat carrying capacity evaluations conducted by the Shoshone-Bannock Tribes (SBT) (Teuscher and Taki 1995, 1996; Taki and Mikkelsen 1997; Taki et al. 1999; Griswold et al. 2000; Lewis et al. 2000; Kohler et al. 2001, 2002). Bjornn et al. (1968) conducted smolt out-migration and adult return monitoring between 1954 and 1966; their work provides a detailed account of sockeye salmon life history in Redfish Lake. Smolt out-migration from Redfish Lake begins in early April, peaks in mid-May, and is complete by mid-June. Smolts out-migrate at either age-1 or age-2; the proportion of age-1 and age-2 smolts varies every year. During their 11-year study, Bjornn et al. (1968) noted that for six out of the 11 years, the out-migration was dominated by age-1 smolts. Age-2 smolts ranged from 2% to 77% of the total out-migration over the course of the early monitoring effort. Age-2 smolts are common in many other sockeye salmon lakes. The reasons for the additional freshwater residence time are unclear (Burgner 1991). Smolt fork length ranges between 45 mm and 120 mm. Adult sockeye salmon begin arriving at Redfish Lake Creek in mid-July and continue escapement through early September. Sockeye salmon spawn over submerged beach substrate of the lake; spawning peaks in mid-October. Returning adults are primarily two-ocean fish (Bjornn et al. 1968).

Efforts to prevent extinction of the Snake River sockeye salmon are coordinated through the 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, addressing recovery guidelines, and providing 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). Currently, as part of NOAA's continuing recovery-planning process, the Interior Columbia Technical Recovery Team is developing draft viability criteria for Snake River sockeye salmon (ICTRT 2005).

PROJECT OBJECTIVES

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

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

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

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

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

Idaho Department of Fish and Game's participation in the Snake River Sockeye Salmon Captive Broodstock Program includes two areas of effort: 1) sockeye salmon captive broodstock culture, and 2) sockeye salmon research and evaluations. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to sockeye salmon captive broodstock culture appears under a separate cover (Baker et al. *in review*). Research and evaluation activities associated with Snake River sockeye salmon are permitted under the ESA (NOAA) Nos. 1120, 1124, and 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; Willard et al. 2003b; Willard et al. 2005). This report details fisheries research information collected between January 1 and December 31, 2004, which includes Sawtooth Valley lakes *O. nerka* population monitoring, sport fishery evaluations on Redfish and Stanley lakes, 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.

2003 and 2004 Captive Broodstock Program Egg and Juvenile Supplementation

All hatchery-produced sockeye salmon released to Sawtooth Valley waters were adipose fin-clipped to distinguish hatchery rearing origin and/or release strategy. A subsample of some release groups were tagged using a Passive Integrated Transponder (PIT) tag prior to release.

In 2003, 77,100 sockeye salmon and 199,666 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 4). All presmolts released in 2003 were age-0 fish from brood year 2001 (BY01) reared at IDFG Sawtooth Fish Hatchery (SFH). 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 Eagle Fish Hatchery [EAG]) were released to Redfish Lake for volitional spawning in September 2003. In November and December 2003, 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).

In 2004, 131,053 sockeye salmon and 49,134 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). All presmolts released in 2004 were BY03 age-0 fish (reared at SFH) and adipose fin-clipped. Redfish Lake received 79,887 presmolts, Alturas Lake received 21,129 presmolts, and Pettit Lake received 29,700 presmolts in October by direct lake releases. Smolts were released to the Salmon River on May 13, 2004. Ninety-six BY02 smolts were released below the Sawtooth Fish Hatchery weir. These fish were part of an experimental group of 200 presmolts that were transferred from Sawtooth Fish Hatchery well water to river water in October of 2003 and reared over winter to smolt stage before release. All 96 fish released were adipose fin-clipped and PIT tagged before release. Two hundred forty-one hatchery-produced adult sockeye salmon (210 reared at NOAA Manchester Marine Lab and 31 reared at NOAA Burley Creek Hatchery) were released to Redfish Lake for volitional spawning in September. In November and December, 49,134 eyed-eggs (40,249 reared at NOAA Burley Creek Hatchery and 8,885 reared at EAG) were planted in Pettit Lake.

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
2004	140,823	135,699
Totals	**1,505,738**	**1,264,729**

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
2004	49,134	130,716	96	241	0
Totals	**576,002**	**1,071,230**	**159,503**	**1,213**	**229**

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

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

Table 4. Sockeye salmon releases to Sawtooth Valley waters in 2003.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Alturas Lake	presmolt (2002)	10/06/2003	2,017	AD	2,017	8.0	SFH
Pettit Lake	presmolt (2002)	10/06/2003	14,961	AD	2,014	10.7	SFH
Redfish Lake	presmolt (2002)	10/07/2003	59,810	AD	1,519	11.0	SFH
Redfish 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	eyed-egg	11/25/2003	11,662	None	NA	NA	NOAA-BC
	(2003)	11/25/2003	70,795	None	NA	NA	EAG
		12/03/2003	45,451	None	NA	NA	EAG
		12/10/2003	22,058	None	NA	NA	EAG
Alturas Lake	eyed-egg						
	(2003)	12/11/2003	41,272	None	NA	NA	NOAA-BC
	(2003)	12/11/2003	8,428	None	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.

Table 5. Sockeye salmon releases to Sawtooth Valley waters in 2004.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Salmon River (below SFH weir)	smolt (2002)	05/13/2004	96	AD	96	20.0	SFH
Alturas Lake	presmolt (2003)	10/06/2004	21,129	AD	1,008	10.3	SFH
Pettit Lake	presmolt (2003)	10/06/2004	29,700	AD	1,013	10.5	SFH
Redfish Lake	presmolt (2003)	10/05/2004	79,887	AD	1,003	10.6	SFH
Redfish Lake	adult						
	(2000)	09/07/2004	44	None	0	2,000.0	NOAA-MML
	(2000)	09/07/2004	12	None	0	2,000.0	NOAA-BC
	(2001)	09/07/2004	139	None	0	2,000.0	NOAA-MML
	(2001)	09/10/2004	19	None	0	2,000.0	NOAA-BC
	(2001)	09/10/2004	27	None	0	2,000.0	NOAA-MML
Pettit Lake	eyed-egg						
	(2004)	11/10/2004	18,146	None	NA	NA	NOAA-BC
	(2004)	11/23/2004	16,065	None	NA	NA	NOAA-BC
	(2004)	11/23/2004	1,146	None	NA	NA	IDFG-EAG
	(2004)	11/30/2004	6,038	None	NA	NA	NOAA-BC
	(2004)	11/30/2004	7,739	None	NA	NA	IDFG-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.

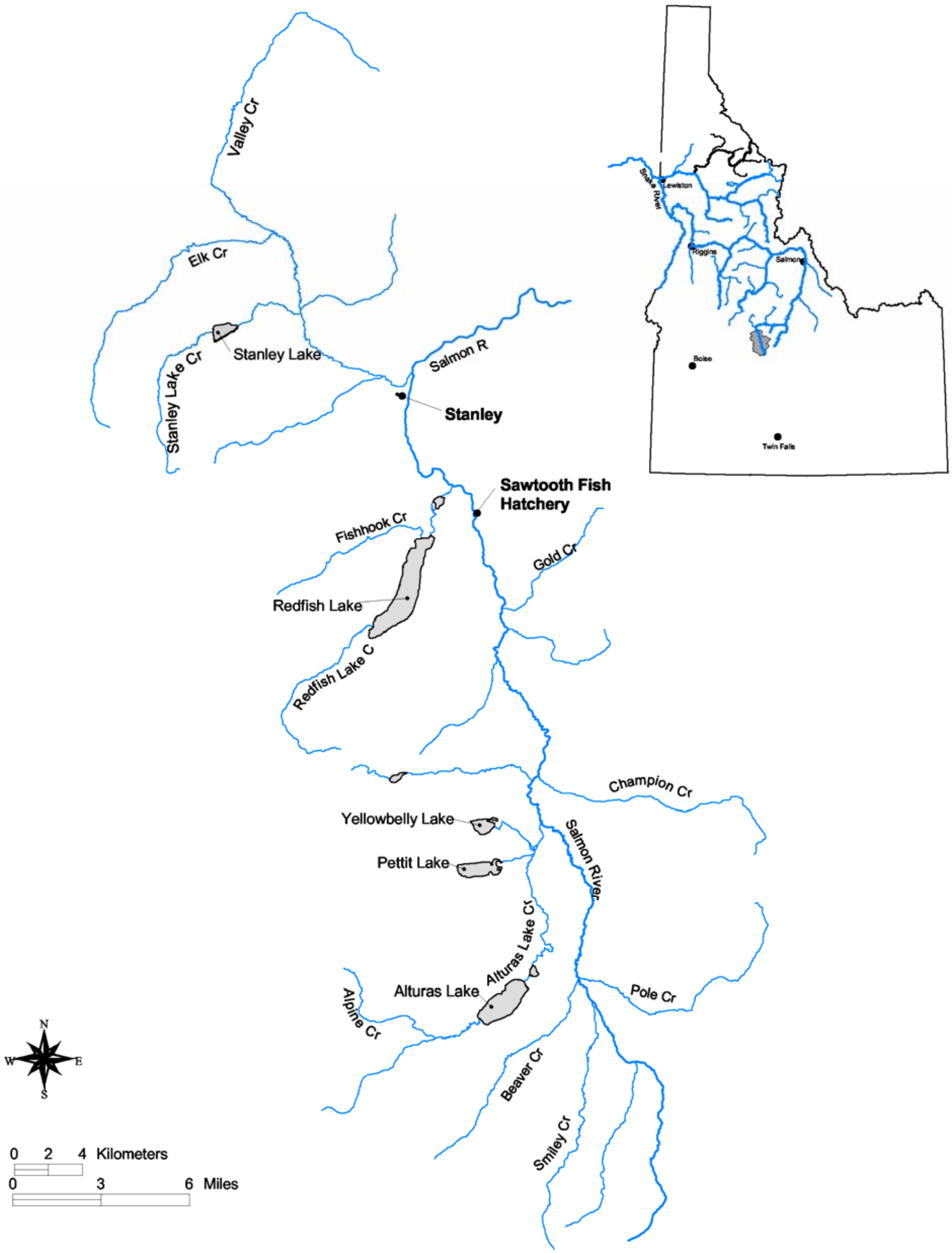


Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

LITERATURE CITED

Baker, D., J. Heindel, J. Redding, and P. A. Kline. In review. Snake River sockeye salmon captive broodstock program, hatchery element, 2004. Project no. 93-72. Bonneville Power Administration, Annual Report. Portland, Oregon.

Baker, D., J. Heindel, J. Redding, and P. A. Kline. 2005a. Snake River sockeye salmon captive broodstock program, hatchery element, 2003. Project no. 93-72. Bonneville Power Administration, Annual Report. Portland, Oregon.

Baker, D., J. Heindel, J. Redding, and P. A. Kline. 2005b. Snake River sockeye salmon captive broodstock program, hatchery element, 1999. Project no. 93-72. 2005. Bonneville Power Administration, Annual Report. Portland, Oregon.

Berejikian, B., T. Flagg, and P. Kline. 2004. Release of captively reared adult anadromous salmonids for population maintenance and recovery: biological tradeoffs and management considerations. Pages 233-245 *in* M. J. Nickum, P. M. Mazik, J. G. Nickum, and D. D. MacKinlay, editors. Propagated fish in resource management. American Fisheries Society, Symposium 44, American Fisheries Society, Bethesda, Maryland.

Bjornn, T. C., D. R. Craddock, and D. R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, sockeye salmon, *Oncorhynchus nerka*. Transactions of the American Fisheries Society 97:360-375.

Bowler, B. 1990. Additional information on the status of Snake River sockeye salmon. Idaho Department of Fish and Game. Boise, Idaho.

Brannon, E. L., A. L. Setter, T. L. Welsh, S. J. Rocklage, G. H. Thorgaard, and S. A. Cummings. 1992. Genetic analysis of *Oncorhynchus nerka*. Project no. 199009300. Bonneville Power Administration, Annual Report. Portland, Oregon.

Brannon, E. L., T. Welsh, R. Danner, K. Collins, M. Casten, G. H. Thorgaard, K. Adams, and S. Cummings. 1994. Genetic analysis of *Oncorhynchus nerka*: Life history and genetic analysis of Redfish Lake *Oncorhynchus nerka*. Project no. 199009300. Bonneville Power Administration, Completion Report. Portland, Oregon.

Burgner, R. L. 1991. Life History of Sockeye Salmon. Pages 3-117 *in* C. Groot, and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press. Vancouver, British Columbia.

Chapman, D. W., W. S. Platts, D. Park, and M. Hill. 1990. Status of Snake River sockeye salmon. Final report for Pacific Northwest Utilities Conference Committee. Don Chapman Consultants Inc. Boise, Idaho.

Cummings, S. A., E. L. Brannon, K. J. Adams, and G. H. Thorgaard. 1997. Genetic analyses to establish captive breeding priorities for endangered Snake River sockeye salmon. Conservation Biology 11:662-669.

Ebenhard, T. 1995. Conservation breeding as a tool for saving animal species from extinction. Trends in Ecology and Evolution 11:438-443.

Evermann, B. W. 1895. A preliminary report upon salmon investigations in Idaho in 1894. Bulletin of the United States Fish Commission 15:253-285.

Evermann, B. W. 1896. A report upon salmon investigations in the headwaters of the Columbia River, in the state of Idaho, in 1895. U.S. Fish Commission Bulletin 16:151-202.

Faler, J. C., and M. S. Powell. 2003. Genetic analysis of Snake River sockeye salmon (*Oncorhynchus nerka*). Bonneville Power Administration Annual Report. Portland, Oregon. *In press*.

Federal Register. 1991. Endangered and threatened species; endangered status for Snake River sockeye salmon-910379-1256. 91. Department of Commerce, National Oceanic and Atmospheric Administration, 50 CFR Part 222.

Fernandez, J., and A. Caballero. 2001. A comparison of management strategies for conservation with regard to population fitness. Conservation Genetics 121-131.

Flagg, T. A. 1993. Redfish Lake sockeye salmon captive broodstock rearing and research, 1991-1992. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.

Flagg, T. A., and W. C. McAuley. 1994. Redfish Lake sockeye salmon captive broodstock rearing and research, 1991-1993. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.

Flagg, T. A., C. V. W. Mahnken, and K. A. Johnson. 1995. Captive broodstocks for recovery of Snake River sockeye salmon. American Fisheries Society Symposium 15:81-90.

Flagg, T. A., W. C. McAuley, M. R. Wastel, D. A. Frost, and C. V. W. Mahnken. 1996. Redfish Lake sockeye salmon captive broodstock rearing and research, 1994. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.

Flagg, T. A., W. C. McAuley, D. A. Frost, M. R. Wastel, W. T. Fairgrieve, and C. V. W. Mahnken. 2001. Redfish Lake sockeye salmon captive broodstock rearing and research, 1995-2000. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.

Frost, D. A., W. C. McAuley, D. J. Maynard, and T. A. Flagg. 2002. Redfish Lake sockeye salmon captive broodstock rearing and research, 2001. Project no. 199204000. Bonneville Power Administration, Annual Report. Portland, Oregon.

Griswold, R., A. Kohler, and D. Taki. 2000. Salmon River sockeye salmon habitat and limnological research: 1999 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., M. Elmer, and P. Kline. 2000. Snake River sockeye salmon captive broodstock program, research element, 1999. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., J. Castillo, and P. Kline. 2002. Snake River sockeye salmon captive broodstock program, research element, 2000. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., J. Castillo, C. Willard, and P. Kline. 2003. Snake River sockeye salmon captive broodstock program, research element, 2001. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., P. A. Kline, D. Taki, and T. A. Flagg. 2004. Evaluating reintroduction strategies for Redfish Lake sockeye salmon captive broodstock progeny. American Fisheries Society Symposium 44: 401-413.

Hedrick, P. W., and P. S. Miller. 1992. Conservation genetics: techniques and fundamentals. Ecological Applications 2:30-46.

Interior Columbia Technical Recovery Team (ICTRT). 2005. http://www.nwfsc.noaa.gov/trt/

Johnson, K. 1993. Research and recovery of Snake River sockeye salmon, 1992. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Johnson, K., and J. Pravecek. 1995. Research and recovery of Snake River sockeye salmon, 1993. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Johnson, K., and J. Pravecek. 1996. Research and recovery of Snake River sockeye salmon, 1994-1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P. 1994. Research and recovery of Snake River sockeye salmon, 1993. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., and J. Younk. 1995. Research and recovery of Snake River sockeye salmon, 1994. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., and J. A. Lamansky. 1997. Research and recovery of Snake River sockeye salmon, 1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., and J. Heindel. 1999. Snake River sockeye salmon captive broodstock program, hatchery element, 1998. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., and C. Willard. 2001. Snake River sockeye salmon captive broodstock program, hatchery element, 2000. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., J. Heindel, and C. Willard. 2003a. Snake River sockeye salmon captive broodstock program, hatchery element, 1997. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., C. Willard, and D. Baker. 2003b. Snake River sockeye salmon captive broodstock program, hatchery element, 2001. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kohler A., B. Griswold, and D. Taki. 2001. Snake River sockeye salmon habitat and limnological research: 2000 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kohler A., D. Taki, and B. Griswold. 2002. Snake River sockeye salmon habitat and limnological research: 2001 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Lewis, B., D. Taki, and R. Griswold. 2000. Snake River sockeye salmon habitat and limnological research: 2000 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

NOAA. National Oceanic and Atmospheric Administration. 2005. Endangered Species Act status review and listing information. www.nwr.noaa.gov/1salmon/salmesa/index.htm.

NMFS. National Marine Fisheries Service. 2002. Interim Abundance Targets. Seattle, Washington, National Oceanic and Atmospheric Administration.

Pravecek, J., and K. Johnson. 1997. Research and recovery of Snake River sockeye salmon, 1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Pravecek, J., and P. Kline. 1998. Research and recovery of Snake River sockeye salmon, 1996. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Ryman, N., and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology 5:325-329.

Taki, D., and A. Mikkelsen. 1997. Salmon River sockeye salmon habitat and limnological research: 1996 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Taki, D., B. Lewis, and R. Griswold. 1999. Salmon River sockeye salmon habitat and limnological research: 1997 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Teuscher, D., and D. Taki. 1995. Salmon River sockeye salmon habitat and limnological research, In Teuscher, D., and D. Taki (ed). Snake River sockeye salmon habitat and limnological research: 1994 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Teuscher, D., and D. Taki. 1996. Salmon River sockeye salmon habitat and limnological research, In Teuscher, D., and D. Taki (ed). Snake River sockeye salmon habitat and limnological research: 1995 annual progress report. Project no. 199107100. Bonneville Power Administration, Annual Report. Portland, Oregon.

Theodorou, K., and D. Couvet. 2004. Introduction of captive breeders to the wild: harmful or beneficial*? Conservation Genetics* 5:1-12.

Wang, J., and N. Ryman. 2001. Genetic effects of multiple generations of supportive breeding. Conservation Biology 15:1619-1631.

Waples, R. S. 1991. Definition of a "species" under the Endangered Species Act: Application to Pacific Salmon. Seattle, Washington, U. S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-F/NWC 194.

Waples, R. S., O. W. Johnson, and R. P. Jones Jr. 1991. Status review for Snake River sockeye salmon. Seattle, Washington, U. S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-F/NWC 195.

Waples, R. S., and C. Do. 1994. Genetic risk associated with supplementation of Pacific salmonids: captive broodstock programs. Canadian Journal of Fisheries and Aquatic Sciences 51:310-329.

Waples, R. S., P. B. Aebersold, and G. A. Winans. 1997. Population genetic structure and life history variability in *Oncorhynchus nerka* from the Snake River Basin. Project no. 93-068. Portland, Oregon, Bonneville Power Administration Annual Report.

Willard, C., D. Baker, J. Heindel, J. Redding, and P. Kline. 2003a. Snake River sockeye salmon captive broodstock program, hatchery element, 2002. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Willard, C., J. L. Hebdon, J. Castillo, J. Gable, and P. Kline. 2003b. Snake River sockeye salmon captive broodstock program, research element, 2002. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Willard, C., K. Plaster, J. Castillo, and P. Kline. 2005. Snake River sockeye salmon captive broodstock program, research element 2003. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Winans, G. A., P. A. Aebersold, and R. S. Waples. 1996. Allozyme variability in selected populations of Oncorhynchus nerka in the Pacific Northwest, with special consideration of populations of Redfish Lake, Idaho. Transactions of the American Fisheries Society 205:645-663.

PART 2—*ONCORHYNCHUS NERKA* POPULATION MONITORING

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. Utilizing multiple release strategies at various life stages allows program managers to design reintroduction plans that take advantage of the nursery lakes' current carrying capacities, which are determined by trawling, hydroacoustic surveys (conducted by the SBT), and limnological surveys (also conducted by the SBT). In years when specific lakes exhibit low productivity and/or high kokanee abundance (as determined using the methods above), program managers design reintroduction strategies that weight releases based estimated lake carrying capacity.

Midwater trawl surveys are also conducted to collect *O. nerka* tissue samples for genetic analysis as well as for whole-body proximate analysis. The results of genetic analyses are used to identify presence/absence of ESA-listed sockeye salmon in the trawl catch.

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 (the program's current trawl 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 13-15, 2004. 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 is presented in Part 6). 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 (six transects, Appendix A) included 102 wild/natural *O. nerka* and zero hatchery-produced sockeye salmon. *Oncorhynchus nerka* abundance was estimated at 82,258 fish (95% CI ± 3,486). Density and biomass were estimated at 133.0 fish/ha and 0.3 kg/ha, respectively (Table 6). Age-0 and age-1 *O. nerka* were captured in the trawl on Redfish Lake. Age-0 fish had the highest density (125 fish/ha) and the highest biomass (0.24 kg/ha) (Table 7). Redfish Lake samples tested negative for *M. cerebralis* in 2004 using both pepsin/trypsin digest (PTD) and polymerase chain reaction (PCR) testing.

Alturas Lake

September trawl catch on Alturas Lake (six transects, Appendix A) included 29 wild/natural *O. nerka* and zero hatchery-produced sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 36,206 fish (95% CI ± 2,579), 107.1 fish/ha, and 1.9 kg/ha, respectively (Table 6). Age-0, age-2, age-3, and age-4 *O. nerka* were captured in the trawl. Age-0 fish had the highest density (81 fish/ha) and contributed 11.79% of the biomass (Table 7). Alturas Lake trawl samples were found to be positive for *M. cerebralis* (1 of 3, 5-fish pools) in 2004 using both PTD and PCR testing methods. Sampling for *M. cerebralis* in 2003 yielded similar results, with parasite detection limited exclusively to Alturas Lake trawl samples.

Pettit Lake

September trawl catch on Pettit Lake (five transects, Appendix A) included 44 wild/natural *O. nerka* and one hatchery-produced (adipose fin-clipped) sockeye salmon. The hatchery-produced sockeye salmon was from an October 2003 presmolt release and was not included in calculations for the population estimate. We estimated *O. nerka* abundance, density, and biomass at 46,065 fish (95% CI ± 3,288), 287.9 fish/ha, and 9.8 kg/ha, respectively (Table 6). Age-0 through age-4 fish were captured in the trawl. Age-0 fish had the highest density (131 fish/ha) and contributed 45.49% of the biomass (Table 7). Pettit Lake samples tested negative for *M. cerebralis* in 2004 using both pepsin/trypsin digest (PTD) and polymerase chain reaction (PCR) testing.

DISCUSSION

Studies have shown that the freshwater survival rate of juvenile *O. nerka* can increase with increasing growth rates (Koenings and Burkett 1987; Sogard 1992; Hyatt et al. 2005). Growth rate is dependent on food intake, which is determined by the availability of optimally sized prey resources such as *Daphnia* spp., *Bosmina* spp. and *Holopedium* spp. (Edmundson and Mazumder 2001; Hyatt et. al 2005). Limnological data collected by Bob Griswold of Biolines, a subcontractor with the SBT, is included in the following discussion in an effort to provide a complete representation of *O. nerka* abundance and food availability in the project lakes.

Redfish Lake

In 2004, the population abundance estimate was the highest (82,258 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 (93%) of the total population abundance estimate in 2004. The age-0 component was produced from either adult kokanee spawning in Fishhook Creek in the fall of 2003, or adult sockeye salmon released for volitional spawning in 2003. Adult kokanee spawner escapement to Fishhook Creek was estimated at 9,679 fish in 2003. This was the second highest adult escapement estimate since the 1993 escapement estimate of 10,800 fish (D. Taki, Shoshone-Bannock Tribes, personal communication) (Table 8). The Redfish Lake kokanee population is potentially limited in spawning habitat. From the mouth of Fishhook to a suspected upstream kokanee passage barrier, only 1.5 km (approximately) of spawning habitat is available. However, this habitat is considered excellent with respect to substrate size, stream morphology, and water depth and velocity.

Following the documented reduction of *O. nerka* biomass in 2000, we theorized that the reduced grazing pressure would allow zooplankton biomass to increase. Based on data from the SBT (November 2002 SBSTOC minutes), mean summer zooplankton biomass (June to October) in Redfish Lake did increase. Mean year 2000 summer zooplankton biomass reached approximately 1,160 mg/m^2 (no lake fertilization was conducted). This was the highest recorded zooplankton biomass recorded since 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 (Table 6) (Figure 2). Lake fertilization was conducted during the summers of 2001 and 2002. During these years, summer zooplankton biomass was comparatively high, similar to the level observed in 2000. Relationships between fish abundance and zooplankton biomass are difficult to identify because fertilization occurred. However, it remains plausible that whole lake fertilization was indeed responsible (at least in part) for the observed increase in zooplankton biomass observed in these two years.

Based on the relationship observed between *O. nerka* and zooplankton biomass in 2000, we expected the zooplankton biomass to decrease in 2003 and 2004 (no lake fertilization was conducted) due to comparatively high *O. nerka* population numbers observed in 2003 and 2004. However, the exact opposite was observed in 2003. Zooplankton biomass during the summer of 2003 was approximately 2,000 mg/m^2, the highest zooplankton biomass recorded for Redfish Lake since monitoring began. Zooplankton biomass slightly decreased in 2004 to approximately 1,170 mg/m^2. However, the zooplankton biomass in 2004 remained higher than levels observed prior to 2000 (Figure 2). The relatively high zooplankton biomasses observed in 2003 and 2004 may be enhancing survival of *O. nerka,* by providing an abundant prey source.

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). In Alturas Lake, as *O. nerka* population size has increased and zooplankton food resources have become limited, population size has typically declined. As food resources recover, *O. nerka* abundance has typically increased (Figure 3).

In 2000, we observed relatively high *O. nerka* abundance in Alturas Lake (125,462 fish). In 2000 and 2001, a sharp decline in zooplankton density was observed. Cyclopoid copepods, *Holopedium spp.,* and *Daphnia spp*. biomass were at a four-year low in 2001. In 2002, zooplankton density began to increase. This trend continued in 2003 and 2004. A high zooplankton density estimate of 883 mg/m^2 was observed in 2004 indicating that food resources are recovering. Concurrently, *O. nerka* population estimates increased in 2002, 2003, and slightly decreased in 2004 (Table 6) (Figure 3).

Kokanee escapement to Alturas Lake Creek in 2004 was estimated at a five-year high of 7,101 kokanee by the SBT (Table 8). The high escapement estimate may indicate another sharp increase of *O. nerka* abundance in Alturas Lake in the near future. The Alturas kokanee population is not spawning habit limited. Several kilometers of good spawning habitat are available in Alturas and Alpine creeks, the lake's two primary inlet tributaries.

Pettit Lake

The 2004 Pettit Lake *O. nerka* abundance estimate represents an increase of approximately 34,000 *O. nerka* from the 2003 abundance estimate (Table 6). The zooplankton biomass in Pettit Lake has been increasing since June 2000 and reached an all-time high in June 2004 (Figure 4). In 2004, zooplankton biomass was at least two times higher than the zooplankton biomasses estimated in Redfish and Alturas lakes. The lake rearing conditions are currently favorable for *O. nerka,* and the 2004 abundance estimate is reflective of the abundant prey source in Pettit Lake.

The abundant food supply in Pettit Lake supports the hypothesis that growth rate is dependent on food intake, which is determined by the availability of optimally sized prey resources such as *Daphnia* spp., *Bosmina* spp. and *Holopedium* spp. (Edmundson and Mazumder 2001; Hyatt et. al 2005). The mean size (e.g., mean fork length and weight) of *O. nerka* by age-class, captured in Pettit Lake trawl samples in 2004 and 2003, was on average larger than that of *O. nerka* captured in Redfish and Alturas Lakes (except age-0 fish) (Table 7) (Willard et al. 2005).

We recommend developing escapement goals for the spawning tributaries on Alturas and Redfish lakes to minimize kokanee population fluctuations. We also recommend that the SBT continue to operate the escapement weir on Fishhook Creek and investigate the possibility of operating a weir on Alturas Lake Creek to help reduce stabilize kokanee populations. By controlling the kokanee populations in the three nursery lakes, we may be able to reduce possible competition between sockeye and kokanee by providing a stabilized and abundant zooplankton population.

RECOMMENDATIONS

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

2. Based on the large proportion of age-0 O. nerka observed in Redfish Lake in 2003 and 2004, we expect kokanee escapement to Fishhook Creek to be high in 2007 and 2008. The Shoshone-Bannock Tribe operates a weir annually on Fishhook Creek to manage escapement and spawning of kokanee migrating into 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 sport-fishery.

3. The SBSTOC should discuss the advantages and disadvantages of adding a program of controlling kokanee spawner escapement in Alturas Lake Creek to further program efforts to stabilize kokanee and zooplankton communities.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, Pettit, and Stanley lakes, 1990 to 2004.

Date	Population (±95% CI)	Density (fish/ha)	Biomass (kg/ha)
	Redfish Lake (615 surface hectares)		
9/15/04	82,258 (3,486)	133.0	0.3
9/24/03	81,727 (2,763)	132.9	1.6
9/06/02	50,204 (4,085)	81.6	1.0
9/17/01	12,980 (2,959)	21.1	<0.1
9/25/00	10,268 (1,605)	16.7	<0.1
9/08/99	42,916 (1,795)	69.7	0.9
9/21/98	31,486 (1,716)	51.2	1.8
9/02/97	55,762 (1,590)	90.7	2.5
9/10/96	56,213 (3,526)	91.4	2.8
9/26/95	61,646 (2,078)	100.2	4.4
9/06/94	51,529 (4,902)	83.8	1.4
9/17/93	49,628[a]	80.7	1.6
9/29/92	39,481 (2,498)	64.2	1.0
8/20/90	24,431[a]	39.7	0.8
	Alturas Lake (338 surface hectares)		
9/13/04	36,206 (2,579)	107.1	1.9
9/26/03	46,234 (5,183)	136.8	5.5
9/04/02	24,374 (2,328)	72.1	2.2
9/19/01	70,159 (1,696)	207.6	2.4
9/25/00	125,462 (1,572)	371.0	2.1
9/09/99	56,675 (4,476)	167.7	0.4
9/23/98	65,468 (2,860)	193.7	1.4
9/04/97	9,761 (933)	28.9	2.1
9/12/96	13,012 (691)	38.5	1.4
9/25/95	23,061 (1,202)	68.2	1.7
9/07/94	5,785 (1,957)	17.1	0.4
9/17/93	49,037 (1,443)	145.1	2.6
9/25/92	47,237 (3,782)	139.8	2.4
9/08/91	125,045 (1,881)	370.0	3.9
8/19/90	126,644 (1,690)	374.7	3.3
	Pettit Lake (160 surface hectares)		
9/14/04	46,065 (3,288)		
9/25/03	11,961 (626)	136.8	5.5
9/05/02	18,328 (384)	114.5	12.1
9/17/01	16,931 (1,311)	105.8	6.1
9/28/00	40,559 (1,317)	253.5	10.2
9/10/99	31,422 (2,515)	196.4	6.3
9/22/98	27,654 (862)	172.8	9.7
9/03/97	21,730 (1,462)	135.8	5.1
9/11/96	71,654 (911)	447.8	15.3
9/24/95	59,002 (1,653)	368.8	14.7
9/08/94	14,743 (1,966)	92.1	3.1
9/18/93	10,511 (640)	65.7	0.8
9/27/92	3,009 (539)	18.8	2.5
	Stanley Lake (81 surface hectares)		
9/17/01	2,472 (812)	35.5	0.2
9/24/98	14,936 (1,118)	184.4	5.0
9/27/95	1,021 (218)	12.6	0.2
9/07/94	2,694 (248)	33.3	0.4
9/16/93	1,325 (183)	16.4	0.5
8/28/92	2,117 (493)	26.1	0.2

[a] Confidence limits not calculated.

Table 7. Estimated 2004 *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	95	7	0	0	0	102
Mean length (mm) (±95 CI)	59.40	95.43	NA	NA	NA	NA
Mean weight (g) (±95 CI)	1.94	8.67	NA	NA	NA	NA
Abundance	76,810	5,448	NA	NA	NA	82,258
95% CI High	80,406	6,704	NA	NA	NA	85,743
95% CI Low	73,214	4,192	NA	NA	NA	78,772
Density (fish/ha)	125	9	NA	NA	NA	133
Biomass (kg/ha)	0.24	0.08	NA	NA	NA	0.32
Alturas Lake (338 surface ha)						
No. captured	22	0	1	1	5	29
Mean length (mm) (±95 CI)	65.31	NA	120.00	157.00	199.60	NA
Mean weight (g) (±95 CI)	2.83	NA	17.10	40.20	82.20	NA
Abundance	27,474	NA	1,273	1,317	6,142	36,206
95% CI High	30,061	NA	3,768	3,899	8,698	38,785
95% CI Low	24,887	NA	0	0	3,586	33,627
Density (fish/ha)	81	NA	4	4	18	107
Biomass (kg/ha)	0.23	NA	0.06	0.16	1.49	1.95
Pettit Lake (160 surface ha)						
No. captured	20	9	5	6	4	44
Mean length (mm) (±95 CI)	55.45	98.22	150.00	198.50	216.25	NA
Mean weight (g) (±95 CI)	2.58	11.02	41.52	101.27	133.65	NA
Abundance	20,939	9,422	5,235	6,282	4,188	46,065
95% CI High	24,566	13,074	8,137	8,724	6,107	49,354
95% CI Low	17,312	5,770	2,333	3,840	2,269	42,777
Density (fish/ha)	131	59	33	39	26	288
Biomass (kg/ha)	0.34	0.65	1.36	3.98	3.49	9.82

Table 8. Estimated kokanee escapement to Fishhook Creek 1991 to 2004 and Alturas Lake Creek 1992 to 2004. Data obtained from the SBT.

Year	Fishhook Creek	Alturas Lake Creek
1991	7,200	No survey data
1992	9,600	60
1993	10,800	200
1994	9,200	3,200
1995	7,000	1,600
1996	10,662	744
1997	8,572	8,492
1998	6,149	15,237
1999	2,336	8,334
2000	60	827
2001	5,853	145
2002	8,626	99
2003	9,679	48
2004	1,508	7,101

Figure 2. Redfish Lake mean summer zooplankton biomass (right Y-axis) and *O. nerka* population estimates (left Y-axis), 1993 to 2004. Zooplankton biomass data obtained from Biolines.

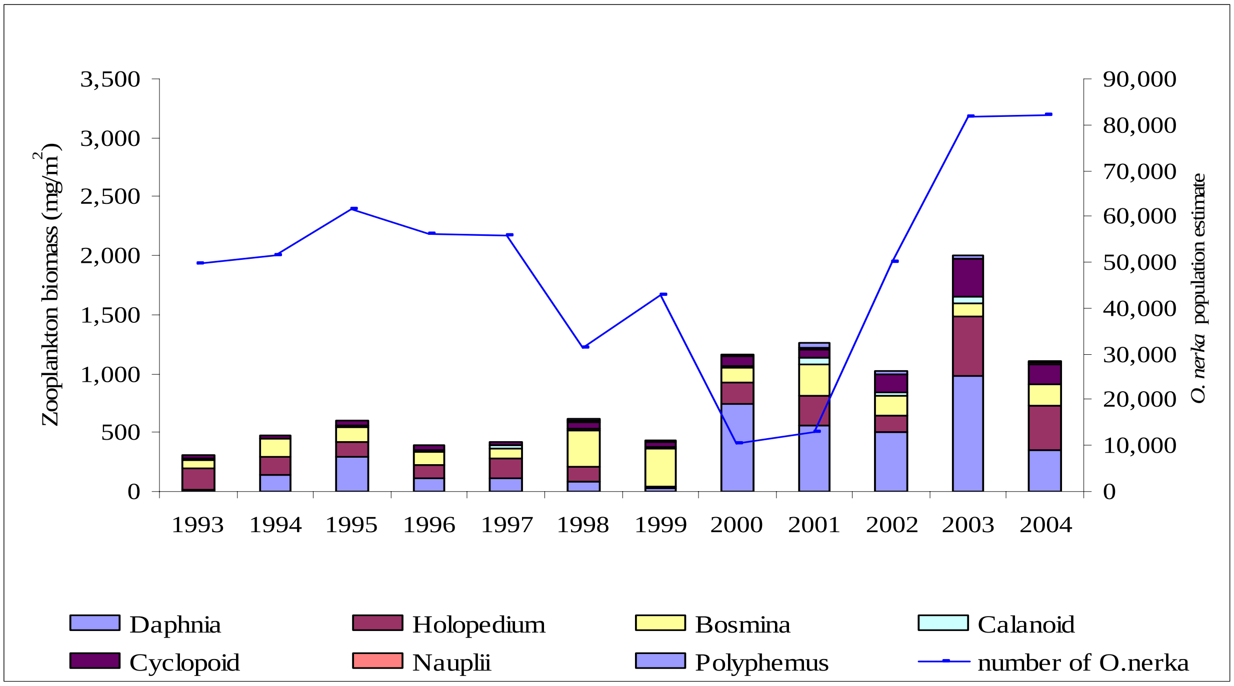


Figure 3. Alturas Lake mean summer zooplankton biomass (right Y-axis) and *O. nerka* population estimates (left Y-axis), 1993 to 2004. Zooplankton biomass data obtained from Biolines.

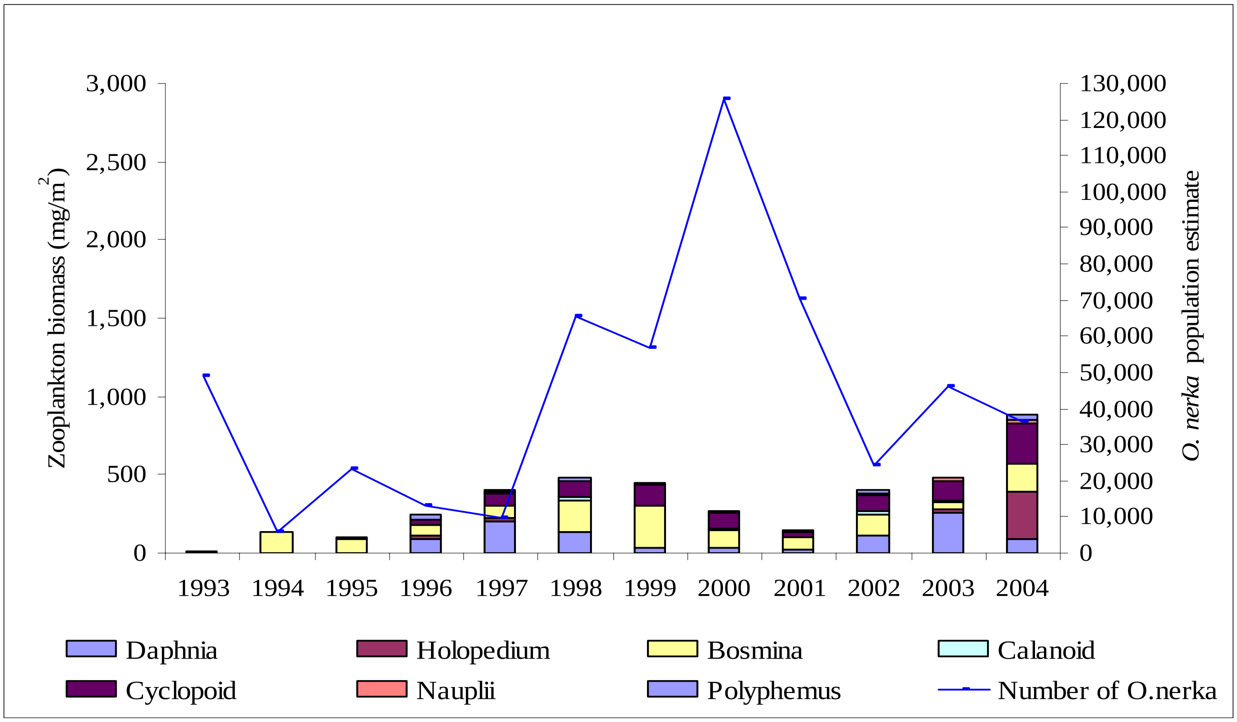
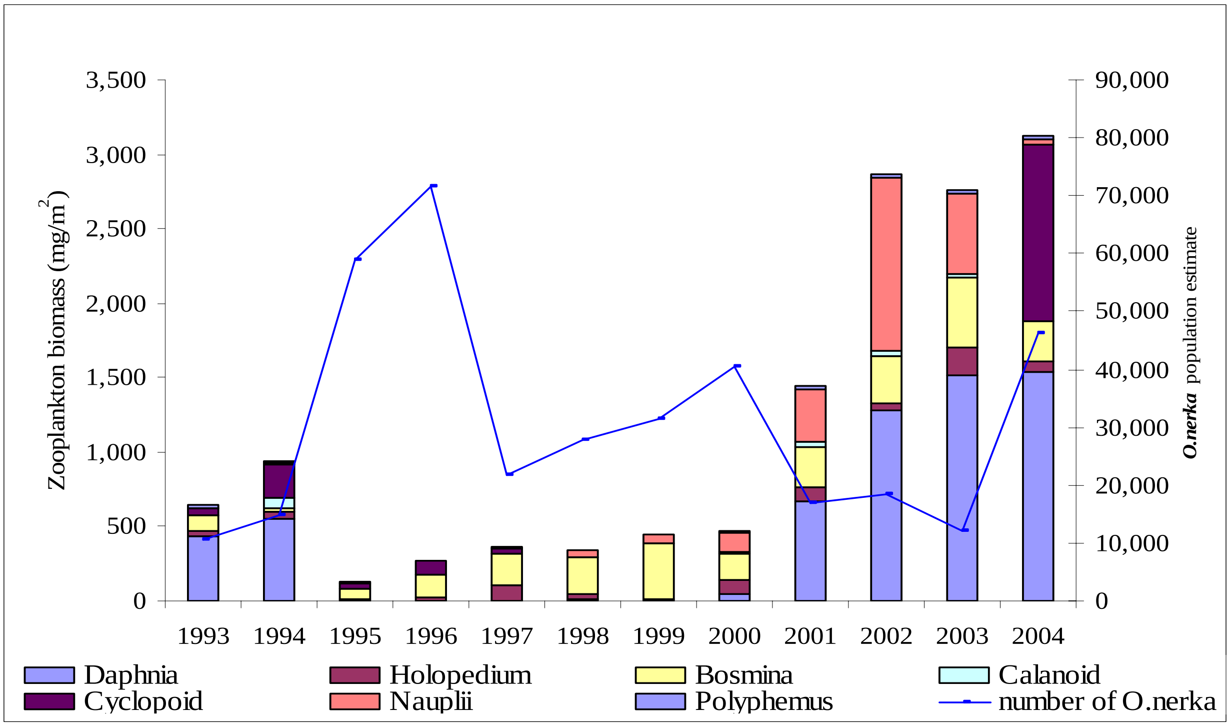


Figure 4. Pettit Lake mean summer zooplankton biomass (right Y-axis) and *O. nerka* population estimates (left Y-axis), 1993 to 2004. Zooplankton biomass data obtained from Biolines.



LITERATURE CITED

Edmundson, J. A., and A. Mazumder. 2001. Linking growth of juvenile sockeye salmon to habitat temperature in Alaskan Lakes. Transactions of the American Fisheries Society 130:644-662.

Hyatt, K. D., K. L. Mathias, D. J. McQueen, B. Mercer, P. Milligan, and D. P. Rankin. 2005. Evaluation of hatchery versus wild sockeye salmon fry growth and survival in two British Columbia lakes. North American Journal of Fisheries Management 25:745-762.

Kline, P. A. 1994. Research and recovery of Snake River sockeye salmon. Idaho Department of Fish and Game. Annual Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-72, Contract No. DE-BI79-91BP21065. Portland, Oregon.

Koenings, J. P., and R. D. Burkett. 1987. Population characteristics of sockeye salmon (*Oncorhynchus nerka*) smolts relative to temperature regimes, euphotic volume, fry density, and forage base within Alaskan Lakes. Pages 216-234 *in* H. D. Smith, L. Margolis, and C. C. Wood, editors. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Canadian Special Publication Fisheries and Aquatic Sciences 96.

Rieman, B. E. 1992. Kokanee salmon population dynamics—kokanee salmon monitoring guidelines. Idaho Department of Fish and Game, Project No. F-73-R-14, Subproject II, Study II. Boise, Idaho.

Sogard, S. M. 1992. Variability in growth rates of juvenile fishes in different estuarine habitats. Marine Ecology Progress Series 85:35-53.

Willard, C., K. Plaster, J. Castillo, and P. Kline. 2005. Snake River sockeye salmon captive broodstock program, research element 2003. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

PART 3—REDFISH AND STANLEY 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 reopened 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 for 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 every year) on Redfish Lake was designed to estimate total kokanee harvest and to collect tissue samples for genetic analysis from angler-harvested kokanee. The tissue samples were collected for genetic analysis to estimate the number of unmarked sockeye salmon harvested incidental to the kokanee fishery.

A roving creel survey was also conducted on Stanley Lake in 2004 to estimate total kokanee harvest, to compare kokanee harvest estimates between Redfish and Stanley lakes, and to collect tissue samples for genetic analysis from angler-harvested kokanee. Additionally, we estimated catch rates and harvest for lake trout, bull trout, and hatchery stocked rainbow trout.

METHODS

Redfish Lake

A roving creel survey was conducted from May 30 through August 7, 2004 (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 (1400 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 collected from kokanee that were checked by creel survey personnel and stored in Lysis buffer solution until they were 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. Formulas used to calculate catch rates and to estimate angler effort and harvest can be found in McArthur (1992).

Stanley Lake

A roving creel survey of Stanley Lake was conducted from May 30 through September 4, 2004. We suspended the survey on September 4, 2004 because fishing pressure typically declines after the Labor Day holiday, even though fishing is open all year on the lake. There is no kokanee fishing/harvest closure on Stanley Lake. We followed the same survey design for Stanley Lake as in Redfish Lake, except we scheduled survey times so they would not overlap. This allowed us to survey both lakes during the same time period with the same personnel.

RESULTS

Redfish Lake

In 2004, we contacted 96 angler parties (150 individual anglers) on Redfish Lake. Idaho residents made up 76% of those interviewed. Most anglers used lures (72%), followed by bait (27%), and flies (1%). Total angler effort was estimated at 2,791 hours (95% CI ± 843). Boat anglers expended more effort (62%) than bank anglers (36%) (Table 9). The average fishing trip lasted 1.7 hours.

The season catch rate for all fish (harvested and released) was 0.90 fish/hour. Kokanee catch rates (harvested and released) averaged 0.37 fish/hour for weekdays and 0.43 fish/hour for weekends. Bull trout catch and release rates averaged 0.31 fish/hour for both weekend and weekdays (IDFG regulations prohibit harvesting bull trout). Other fish (cutthroat, northern pikeminnow, redside shiner, sucker *Catostomus spp*.) accounted for catch rates (harvested and released) of 0.19 fish/hour for the season (Table 10).

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 2,736 fish (95% CI ± 2,201). The majority (77%) of all fish caught were released. Kokanee harvest was estimated at 621 fish (95% CI ± 887), and the number of kokanee released was estimated at 726 (Table 11).

Ten hatchery-produced sockeye salmon (adipose fin-clipped) were caught and released. 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 2004.

Stanley Lake

In 2004, we contacted 161 angler parties (251 individual anglers) on Stanley Lake. Idaho residents made up 84% of those interviewed. Most anglers used lures (65%), followed by bait (30%), and flies (5%). Total angler effort was estimated at 9,641 hours (95% CI ± 1,539). Boat anglers expended more effort (54%) than bank anglers (42%) (Table 9). The average fishing trip lasted 2.8 hours.

The season catch rate for all fish (harvested and released) was 0.66 fish/hour. Catch rates (harvested and released) were 0.02 fish/hour for kokanee, 0.00 fish/hour for bull trout (IDFG regulations prohibit harvesting bull trout), 0.04 fish/hour for lake trout, and 0.60 fish/hour for hatchery stocked rainbow trout. Other fish (cutthroat and brook trout) accounted for catch rates (harvested and released) of 0.01 fish/hour for the season (Table 10).

The total number of fish caught (harvested and released) in Stanley Lake was estimated at 7,947 fish (95% CI ± 2,595; Table 11). Between May 24 and July 27, 2004, 14,151 rainbow trout were planted in Stanley Lake. Twenty-six percent of the rainbow trout planted in Stanley Lake were estimated to have been harvested, and 22% were estimated to have been caught and released. The estimated number of kokanee harvested and released was 102 fish and 96 fish, respectively.

DISCUSSION

Redfish Lake

In addition to providing angler opportunity, the Redfish Lake kokanee fishery provides potential benefits to the sockeye salmon population by removing kokanee (potential competitors) from project lakes. Kokanee escapement to Fishhook Creek during the 2004 spawning season was estimated at 1,508 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 may help to reduce total egg deposition, potentially decreasing kokanee recruitment and competition with sockeye salmon in future years.

In 2004, estimated kokanee harvest was 621 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 (2,791 hours) during the 2004 season was lower than the average effort estimated for 1996 through 2003 (3,525 hours). The 2004 kokanee harvest rate (0.13 fish/hr) was slightly lower than the average kokanee harvest rate estimated for 1996 through 2003 (0.14 fish/hr). However, the estimated number of kokanee harvested (621 kokanee) was the highest since 1999 (Table 12).

As stated earlier, a management reason for conducting the Redfish Lake kokanee fishery is to reduce potential competition between kokanee and juvenile sockeye salmon. In 2004, anglers released an estimated 726 kokanee in Redfish Lake. Increased angler awareness on the importance of harvesting kokanee could increase the number of fish harvested. Future kokanee creel efforts will include a question directed at determining which species anglers are targeting. With this information in hand, managers will be in a better position to determine whether the public is aware of the fact that Redfish Lake offers a kokanee harvest opportunity.

Genetic analysis of fin clips obtained from creeled kokanee has not been completed for 2004. 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 2004 fishery, we estimate an incidental take of two 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 2004, 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.

Estimated bull trout catch rates were higher in 2004 than estimated bull trout catch rates between 1996 and 2003 (Table 12). The average bull trout catch rate for 2000 through 2004 (0.21 fish/hr) was higher than the average bull trout catch rate estimated for 1996 through 1999 (0.13 fish/hr). The observed increase in the bull trout catch rates may be due to an increase in Redfish Lake bull trout abundance. An increase in bull trout abundance may be the result of the implementation of a no-harvest fishing regulation on bull trout in 1994 by the IDFG. 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. Bull trout generally mature at five to six years of age (Leary et al. 1993); therefore, we would expect to see effects of no-harvest regulations become apparent in bull trout abundance after 2000. Bull trout spawners post 2000 represent cohorts completely removed from potential harvest by anglers. A possible increase in bull trout abundance poses a potential risk to sockeye salmon through increased predation. Beauchamp and Van Tassell (2001) concluded that bull trout greater than 450 mm fork length utilized kokanee as a main prey source and removed large fractions of the kokanee population in Lake Billy Chinook, Oregon. It is highly probable that bull trout in Redfish Lake are also effectively utilizing sockeye salmon as a prey source; however, the level of utilization is unknown.

Stanley Lake

The creel survey conducted on Stanley Lake in 2004 was the first creel survey conducted since 1986 (Davis 1987). The 2004 estimated kokanee catch rates and harvest were lower for Stanley Lake than Redfish Lake. The 2004 Stanley Creek kokanee escapement estimate of 228 (survey conducted by the SBT; SBT personal communication) indicated a low abundance of spawning-age kokanee present in the system.

Angler effort at Stanley Lake (9,641 hours ± 1,539) was over three times the effort estimated for Redfish Lake (2,791 hours ± 843). The higher angler effort observed for Stanley Lake is likely the result of the opportunity to fish for hatchery stocked rainbow trout and lake trout. The return rate (the percentage of the stocked hatchery rainbow trout harvested and caught/released) was 48% for Stanley Lake in 2004. This exceeds the desired return rate of 40% outlined in the IDFG 2001 to 2006 Fisheries Management Plan for put-and-take waters. Due to the high angler effort and return to creel rate, we recommend that a creel survey be conducted on Stanley Lake every three years to provide comparative data to facilitate the development of lake management decisions.

RECOMMENDATIONS

1. We recommend that the creel survey on Stanley Lake be repeated every three years to provide comparative data.

2. We recommend that a question be included on the interview form that asks anglers what species (if any) they are targeting while fishing on Redfish Lake. Results from this question will provide insight into whether or not anglers are aware that Redfish Lake is a kokanee fishery. 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. However, if anglers are not typically targeting kokanee, the program may need to increase angler education to inform anglers how to fish for kokanee (e.g., trolling).

Table 9. Estimated angler effort for the 2004 fishing season on Redfish and Stanley Lakes.

	Boat	Bank	Tube	Total
Redfish Lake				
Effort (hours)	1,739	1,009	44	2,791
±95% CI	718	437	65	843
Stanley Lake				
Effort (hours)	5,224	4,050	371	9,641
±95% CI	1,266	848	214	1,539

Table 10. Catch rates (fish/hour) for summer 2004 on Redfish and Stanley Lakes categorized by day type and species.

	Kokanee		Rainbow Trout		Other		Bull Trout	All Fish	
Day Type	Kept	Released	Kept	Released	Kept	Released	Released	Kept	Released
Redfish Lake									
Weekday	0.11	0.26	0.00	0.01	0.00	0.23	0.35	0.11	0.85
Weekend Day	0.16	0.27	0.00	0.00	0.00	0.08	0.22	0.16	0.57
Season Avg.	0.13	0.26	0.00	0.01	0.00	0.19	0.31	0.13	0.77
	Kokanee		**Rainbow Trout**		**Lake Trout**		**Bull Trout**	**All Fish**	
	Kept	**Released**	**Kept**	**Released**	**Kept**	**Released**	**Released**	**Kept**	**Released**
Stanley Lake									
Weekday	0.01	0.01	0.24	0.35	0.02	0.01	0.00	0.28	0.37
Weekend Day	0.01	0.00	0.39	0.23	0.01	0.03	0.00	0.42	0.27
Season Avg.	0.01	0.01	0.28	0.32	0.02	0.02	0.00	0.32	0.34

Table 11. Estimated number of fish harvested and released on Redfish and Stanley lakes during the summer 2004.

	Kokanee	Rainbow Trout	Bull Trout	Other	All Fish ± 95% CI
Redfish Lake					
Harvested	621	0	0	0	621 ± 887
Released	726	28	865	530	2,115 ± 833
	Kokanee	**Rainbow Trout**	**Bull Trout**	**Lake Trout**	**All Fish ± 95% CI**
Stanley Lake					
Harvested	102	3,670	0	172	4,042 ± 1,610
Released	96	3,085	0	193	3,905 ± 791

[a] The creel program does not provide an estimate of fish released by species. Therefore, the number of fish released by species was estimated by multiplying the total number of hours fished by the release rate per species.

Table 12. Historical kokanee catch rates, kokanee harvest estimates, bull trout catch rates, and angler effort for the Redfish Lake fishery.

	Kokanee catch rates (fish/hour)					
	Harvested (fish/hour)	**Released (fish/hour)**	**Kokanee harvested**	**Bull trout catch rate (fish/hr)**	**Angler parties interviewed**	**Estimated hours fished/season**
1996	0.19	0.08	844	0.09	107	3,351
1997	0.19	0.37	466	0.08	117	2,874
1998	0.13	0.17	1,362	0.08	205	7,963
1999	0.38	0.15	1,187	0.28	227	3,951
2000	0.02	0.06	67	0.08	63	3,063
2001	0.00	0.06	0	0.27	88	2,391
2002	0.09	0.16	129	0.16	100	2,127
2003	0.10	0.05	424	0.24	98	2,477
2004	0.13	0.26	621	0.31	96	2,791

LITERATURE CITED

Beauchamp, D. A., and J. J. Van Tassell. 2001. Modeling seasonal trophic Interactions of adfluvial bull trout in Lake Billy Chinook, Oregon. Transactions of the American Fisheries Society 130:204-216.

Davis, J. A. 1987. Regional fishery management investigations, Salmon subregion lowland lakes investigations. Idaho Department of Fish and Game, Project No. F-71-R-11. Salmon, Idaho.

Leary, R. F., F. W. Allendorf, and S. H. Forbes. 1993. Conservation genetics of bull trout in Columbia and Klamath River drainages. Conservation Biology 7:856-865.

McArthur, T. 1992. Statewide angler opinion and harvest surveys. Idaho Department of Fish and Game, Project No. F-71-R-14, Subproject I, Study I. Boise, Idaho.

Rieman, B. E., and M. A. Maiolie. 1995. Kokanee population density and resulting fisheries. North American Journal of Fisheries Management 15:229-237.

PART 4—SOCKEYE SALMON SMOLT MONITORING AND EVALUATION

INTRODUCTION

Monitoring the 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, out-migrant numbers, and smolt sizes. Out-migrant monitoring also 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 decisions regarding the disposition of future captive broodstock progeny.

Out-migrant trapping also provides overwinter survival information for presmolts (fall direct-released) released into the nursery lakes in October the year prior to out-migrant trapping. Hatchery-produced sockeye salmon smolts captured at lake out-migrant traps originated primarily from the October 2003 release of 59,810, 2,017, and 14,961 adipose fin-clipped presmolts to Redfish, Alturas, and Pettit lakes, respectively. All presmolts released in 2003 were reared at the Sawtooth Fish Hatchery.

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 13 to June 16, 2004. The trap can be configured to capture out-migrating smolts as well as returning adult sockeye salmon (Craddock 1958; Bjornn et al. 1968; Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000, 2002, 2003; Willard et al. 2004, 2005). The trap contains nine bays, five of which are fitted with juvenile trap boxes. Personnel checked the trap twice daily in 2004.

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 sub sample of wild/natural and adipose fin-clipped hatchery-reared *O. nerka* (five fish from each 5 mm length group) and returned to the laboratory for aging. In the laboratory, scales were pressed into acetate slides and aged by two experienced program employees. If readers disagreed, a third biologist assisted with the development of a consensus. The proportions of age-1 and age-2 out-migrants were determined by using the MIX computer program developed by MacDonald and Green (1988). MIX software uses known length-at-age information and fits mixture distributions to grouped data by utilizing a maximum likelihood estimator.

To estimate trapping efficiency, up to 30 wild/natural sockeye salmon smolts (determined by presence of an adipose fin) and 30 hatchery-produced sockeye salmon smolts 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 one trapping stratum for wild/natural sockeye salmon smolts and two trapping strata for fall direct-released sockeye salmon smolts. Strata were selected based on stream discharge similarities and the number of PIT-tagged smolts released upstream of the weir that were available for recapture (trap efficiencies). Wild/natural fish typically out-migrate earlier in the season than fall direct-release fish (Figure 5). Stream discharge was measured below the trap approximately two times per week. Out-migrant run size was derived using a modified Bailey estimator with 95% bootstrap confidence intervals using methods described by Steinhorst et al. (2004). Smolt out-migration estimates were generated separately for wild/natural and fall direct-released sockeye salmon smolts. Overwinter survival of presmolts released directly to Redfish Lake in the October (fall direct-release) was calculated by dividing the estimated number of out-migrants by the number of presmolts planted.

Tissue samples were collected from a portion of wild/natural out-migrants and transferred to University of Idaho's Center for Salmonid and Freshwater Species at Risk for genetic and proximate analysis. Fish sampled for genetic analysis were measured for fork length (nearest mm), weighed (nearest 0.1 g), and released unharmed. Fish sampled for whole body proximate analysis were sacrificed.

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 (upstream of the confluence of Pettit Lake Creek and Alturas Lake Creek) and was operated from April 20 to May 26, 2004. 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 fish captured to determine trapping efficiency.

Pettit Lake Creek Trap

Sockeye salmon out-migrant trapping and PIT tagging on Pettit Lake Creek was conducted by the SBT. The Pettit Lake Creek trap is located 1 km downstream from the Pettit Lake outlet at a permanent weir site and was operated from April 21 to May 28, 2004. The Pettit Lake Creek weir traps at 100% efficiency under low spring flow conditions (personal communication, Doug Taki, Shoshone Bannock Tribes); therefore, out-migration run size for Pettit Lake is based on the actual number of smolts trapped. However, during normal to high flow years the trap has to be removed and other means are used to estimate the number of out-migrants, which would be presented under a separate cover provided by the Shoshone Bannock Tribes.

Salmon River Smolt Group

Ninety-six BY02 smolts were released to the Salmon River directly downstream of the Sawtooth Fish Hatchery weir in 2004. These fish were part of an experimental group of 200 fish developed to test overwinter survival on raw winter water and to examine whether fish contracted specific pathogens suspected of being present in the water supply. All fish were adipose fin-clipped and PIT tagged before release. Interrogation data were obtained for this smolt group; however, survival comparisons were not made due to the small number of smolts released. Fish health results are reported separately.

Mainstem Snake and Columbia River Dams

In 2004, the majority of sockeye salmon smolts were transported and released below Bonneville Dam; this included all PIT-tagged fish. As a result, mainstem survival evaluations were only conducted to Lower Granite Dam (LGR). Sockeye salmon smolt survival to LGR was evaluated using PIT tag interrogation data collected at the PIT tag detection facility at LGR. Interrogation data were retrieved from PTAGIS. 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 to LGR. Total survival of wild/natural and hatchery-produced smolts (to LGR) was estimated using the known number of PIT tags released divided by the expanded number of PIT tags detected at LGR. Daily collection efficiencies (DCE) estimated for Chinook salmon smolts (Sandford and Smith 2002) were 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.

Confidence intervals for the difference between two independent proportions were used to compare PIT tag interrogations from out-migrant traps to LGR for selected wild/natural and hatchery-produced sockeye salmon smolt groups (see Table 15 for selected groups) (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 PIT-tagged smolts (leaving the Sawtooth Valley) would be needed, per test group, to achieve an 80% level of power at $\alpha = 0.05$.

RESULTS

Redfish Lake Creek Trap

A total of 7,475 sockeye salmon smolts (1,838 wild/natural and 5,637 fall direct-released) were trapped during the 2004 out-migration season (Figure 5). Fork length of wild/natural and fall direct-released sockeye salmon smolts captured averaged 102 mm (range 78 mm to 167 mm; Figure 6) and 107 mm (range 81 mm to 234 mm; Figure 7), respectively.

Based on observed trapping efficiencies and discharge observations, we determined (to develop out-migration estimates) that a single trapping stratum was most appropriate for wild/natural smolts and two trapping strata were used for fall direct-released smolts. Estimated out-migration information by trapping stratum is presented in Table 13. Figure 5 provides out-migration information by date along with stream discharge information.

Of the 1,838 wild/natural smolts handled in 2004, 861 were marked and released upstream of the weir to estimate trapping efficiency. Trap efficiency was estimated at 41% for one trapping stratum. Total wild/natural sockeye smolt out-migration was estimated at 4,476 fish (95% CI 4,122 to 4,894; Table 13). The proportion of age-1 wild/natural smolts was estimated at 96.6% (95% CI 95.0-98.2) which equals 4,324 smolts (4,476*96.6%); the proportion of age-2 wild/natural smolts was estimated at 3.4% (95% CI 1.8-5.0) which equals 152 smolts.

Of the 5,637 fall direct-released smolts handled in 2004, 1,915 were marked and released upstream of the weir to estimate trap efficiency. To estimate total fall direct-released sockeye salmon smolt out-migration, the trapping season was divided into two periods of similar discharge. Trap efficiency was estimated at 56% and 29% for the two trapping strata. Total fall direct-released smolt out-migration was estimated at 16,289 fish (95% CI 15,208 to 17,402; Table 13). Overwinter survival and out-migration for this group was 27.2% (16,289/59,810) of the number of presmolts planted in 2003. The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated, using the MIX software application, at 99.6% (95% CI 99.4-99.8) which equals 16,224 smolts; the proportion of age-2, adipose-clipped, hatchery-reared smolts was estimated at 0.4% (95% CI 0.2-0.6) which equals 65 smolts.

Alturas Lake Creek Trap

Fifty-five sockeye salmon smolts (4 wild/natural and 51 fall-released) were trapped during the 2004 out-migration season. Fork length of wild/natural and fall direct-released sockeye salmon smolts captured averaged 90 mm (range 78 mm to 96 mm) and 101 mm (range 93 mm to 117 mm), respectively. Scales for ageing were not collected from wild/natural or fall direct-released smolts at the Alturas Lake Creek trap in 2004.

Total wild/natural sockeye smolt out-migration for Alturas Lake was estimated at 74 fish (95% CI not calculated) and fall direct-released smolt out-migration was estimated at 1,091 fish (95% CI not calculated). Overwinter survival and out-migration for the fall direct-release group was 54.1% of the number of presmolts planted in 2003.

Pettit Lake Creek Trap

At the Pettit Lake Creek trap, 61 wild/natural sockeye smolts and 5,227 fall direct-released smolts were enumerated out-migrating from the lake. Overwinter survival and out-migration for fall 2003 direct-released presmolts was 34.9%. Fork length of wild/natural and fall direct-released sockeye salmon smolts captured averaged 86 mm (range 107 mm to 144 mm), and 123 mm (range 107 mm to 144 mm), respectively. The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated, using the MIX software application, at 99.0% (95% CI 98.5-99.5) which equals 5,175 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 1.0% (95% CI 0.5-1.5), which equals 52 smolts. Scales for ageing were not collected from wild/natural smolts at the Pettit Lake Creek trap in 2004.

Salmon River Smolt Group

Ninety-six BY02 smolts were released to the Salmon River below the Sawtooth Fish Hatchery weir on May 13, 2004. Fork length of the Salmon River smolt group averaged 124 mm (range 98 mm to 104 mm).

Mainstem Snake and Columbia River Dams

We estimated smolt out-migration success to LGR for wild/natural and hatchery-produced sockeye salmon smolt groups using PIT tag interrogation data (Table 14;

Appendix B). Estimates reflect numbers of smolts that arrived at LGR adjusted for DCE (Appendix C). Redfish Lake had two groups of smolts for which estimates of out-migration were made: wild/natural and fall direct-released. Estimated numbers were 1,365 (30.5%) wild/natural smolts and 961 (5.9%) fall direct-released smolts arrived at 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 fall direct-released. Zero wild/natural and zero fall direct-released smolts were estimated to have arrived at LGR from Alturas Lake. Pettit Lake had two groups of smolts for which estimates of out-migration were made: wild/natural and fall direct-released. The numbers of smolts estimated to have arrived at LGR from Pettit Lake were two wild/natural smolts (5.9%) and 700 (13.4%) fall direct-released smolts. The number of smolts estimated to have arrived at LGR from the Salmon River smolt group was 23 (23.9%) (Table 14).

Wild/natural and hatchery-produced sockeye salmon smolt PIT tag detections were compared by group from Sawtooth Valley trap sites to the interrogation facility at LGR (Table 15). During the 2004 out-migration year, sockeye salmon smolts were detected between May 3 and June 23; daily collection efficiencies ranged from 44.1% to 89.4%. During this out-migration period, 16 out of 52 days experienced spill at LGR (Appendix C). Two smolt groups (wild/natural and fall direct-released) from Redfish Lake and one smolt group (fall direct-released) from Pettit Lake were used in the comparisons. Alturas Lake wild/natural smolts, Alturas Lake fall direct-released smolts, and Salmon River smolts sample sizes were small, and no comparisons were made. The Redfish Lake wild/natural smolts had the highest detection rate (30.5%) of all smolt groups; the detection rates were statistically higher than the detection rates for the Redfish Lake fall direct-released smolt group and the Pettit Lake fall direct-released smolt group (Table 15).

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 et al. 2004). In 2003, the SBSTOC decided to utilize only the fall-direct release option. Overwinter survival of fall-released presmolts is highly variable among years despite similar early rearing history (Table 16); 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 2004 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 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 that 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 second year that we estimated the proportion of age-1 and age-2 adipose fin-clipped out-migrants and wild/natural out-migrants at the RLCTRP. We observed smaller proportions of age-2 wild/natural out-migrants in 2004 (3.4%) compared to 2003 (10.89%) and adipose fin-clipped hatchery out-migrants (0.4% in 2004 versus 2.6% in 2003). The reasons for this observed difference between the two out-migration years 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. Because of the limited sample size, estimates of daily collection efficiencies for sockeye salmon smolts at Lower Granite Dam are not developed. Due to the lack of these data and the possible difference between species, we must use caution and not overemphasize these results. Date of smolt arrival can also affect the probability of a PIT-tagged fish being detected. For example, during the 2004 out-migration year, PIT-tagged sockeye salmon smolts were detected between May 3 and July 23. 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 PIT-tagged smolts during periods of little or no spill compared to periods of spill. Daily collection efficiencies partially correct for the changes in the probability of detection and facilitate the development of an estimate of passage at LGR. However, this methodology does not permit the development of confidence intervals around the point estimate, and annual emigration estimates are generally not comparable due to observed variability described above. Utilizing the Survival By Proportional Hazards (SURPH) model, developed by the University of Washington, would allow us to estimate survival to Lower Granite Dam and produce confidence bounds around the estimate.

The wild/natural smolt group from Redfish Lake recorded significantly higher interrogation rates than the fall direct-released presmolt groups from Redfish and Pettit lakes. The higher interrogation rates indicate higher survival for the wild/natural smolt group through the mainstem corridor. The higher survival of the wild/natural smolt group has not been consistently higher than fall direct-released presmolt over time and varies from year to year, because of this we are currently 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. Initiate the use of the Survival By Proportional Hazards (SURPH) model developed by the University of Washington to develop sockeye salmon survival estimates (with confidence bounds) to LGR.

Table 13. Mark recapture data for sockeye salmon smolts captured at the Redfish Lake Creek trap from April 13 to June 16, 2004. Fall direct-released smolts were reared at Sawtooth Fish Hatchery.

Wild/natural smolts	Total
Dates	4/13-6/16
Trap efficiency	0.41
Marked	861
Recaptured	353
Total handled	1,838
Estimated total (single trapping stratum estimate)	4,476
95% CI upper bound	4,122
95% CI lower bound	4,894

Fall direct-released smolts	Stratum 1	Stratum 2	Total
Dates	4/13-5/7	5/8-6/16	4/13-6/16
Trap efficiency	0.56	0.29	—
Marked	396	1,519	1,915
Recaptured	221	437	652
Total handled	1,946	3,691	5,637
Estimated total (single trapping stratum estimate)	3,480	12,809	16,289
95% CI upper bound	3,174	10,968	15,208
95% CI lower bound	3,803	14,978	17,402

Table 14. Summary of 2004 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Sawtooth Fish Hatchery (SFH) was the rearing location for the fall-direct released (FDR) presmolts.

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	4,476	861	263	30.5%	1,365	30.5%
FDR presmolt (SFH)	59,810	1,519	120	16,289	1,915	120	5.9%	961	5.9%
Alturas Lake[c]									
Wild/natural smolt	NA	NA	NA	74	0	0	0.0%	0	0.0%
FDR presmolt (SFH)	2,017	2,017	51	1,091	1	0	0.0%	0	0.0%
Pettit Lake[c]									
Wild/natural smolt	NA	NA	NA	61	60	2	3.3%	2	3.3%
FDR presmolt (SFH)	14,961	2,014	551	5,227	203	101	13.4%	700	13.4%
Salmon River									
Smolt (SFH)	96	96	NA	NA	NA	23	23.9%	23	23.9%

[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. The difference between two independent proportions of PIT tag interrogations of sockeye salmon smolts PIT tagged at Sawtooth Valley trap sites and detected at Lower Granite Dam in 2004 (α = 0.05).

Release location	Life-history strategy	Total PIT tags detected at trap	Interrogations	% Detected	Difference between two proportions (95% CI)
Redfish Lake	fall direct-released presmolt	2,035	120	5.9%	24.6%
Redfish Lake	wild/natural	861	263	30.5%	(21.4% - 27.9%) significant
Redfish Lake	fall direct-released presmolt	2,035	120	5.9%	7.5%
Pettit Lake	fall direct-released presmolt	754	101	13.4%	(4.9% - 10.3%) significant
Redfish Lake	wild/natural	861	263	30.5%	17.1%
Pettit Lake	fall direct-released presmolt	754	101	13.4%	(13.1%-21.1%) significant

Table 16. Estimated overwinter survival for Sawtooth Fish Hatchery-reared presmolts released in the fall to Redfish, Alturas, and Pettit lakes.

	Out-migration year				
Release Location	**2000**	**2001**	**2002**	**2003**	**2004**
Redfish Lake	29%	20%	40%	15%	27%
Alturas Lake	34%	75%	30%	NA*	54%
Pettit Lake	46%	29%	29%	59%	35%

*NA = Not Available

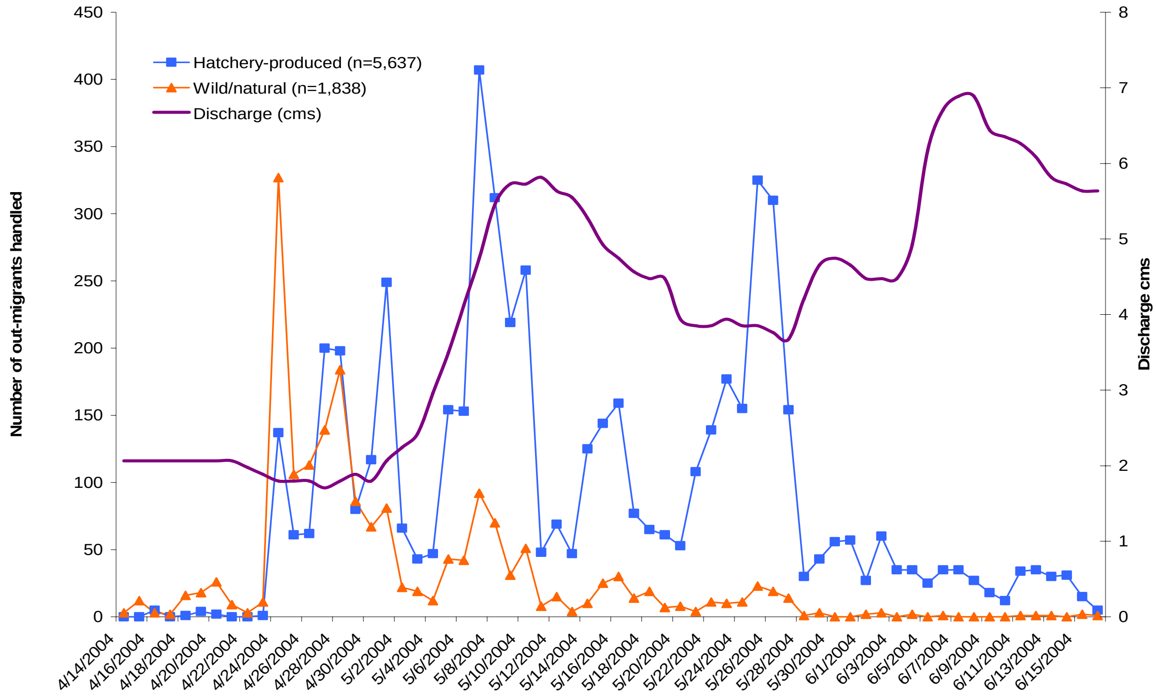


Figure 5. Daily capture of wild/natural and fall direct-released sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2004 out-migration compared to discharge.

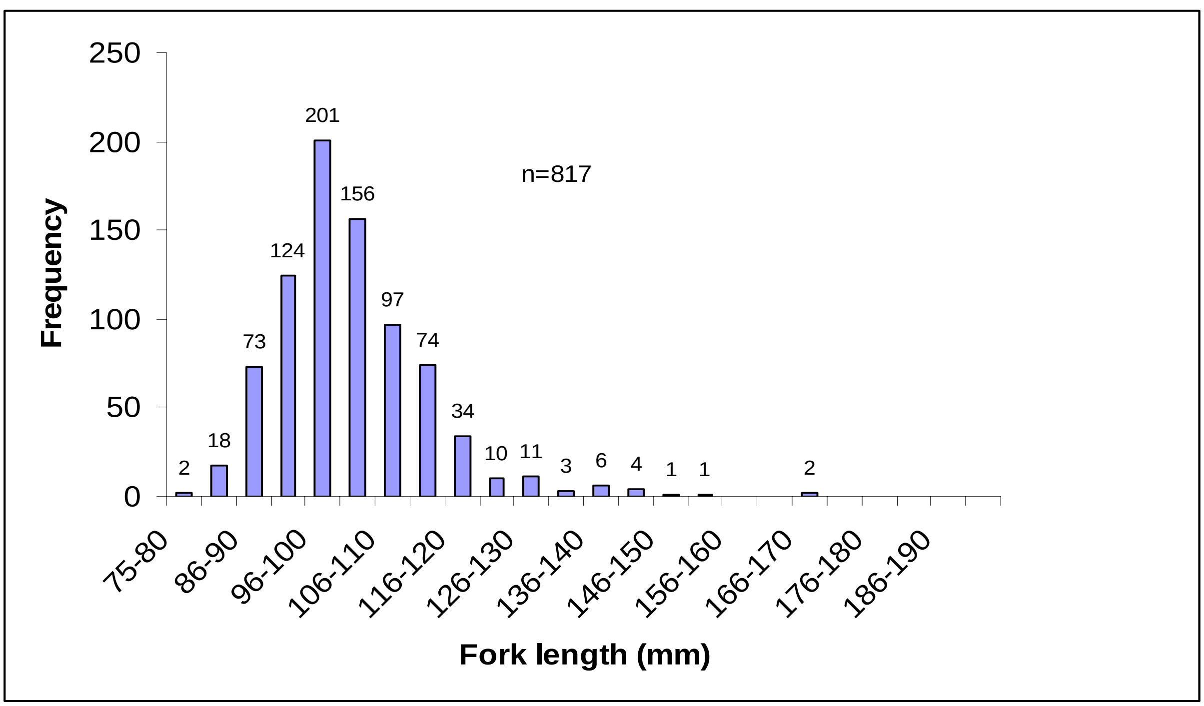


Figure 6. Length frequency of wild/natural sockeye salmon smolts collected at Redfish Lake Creek trap in 2004.

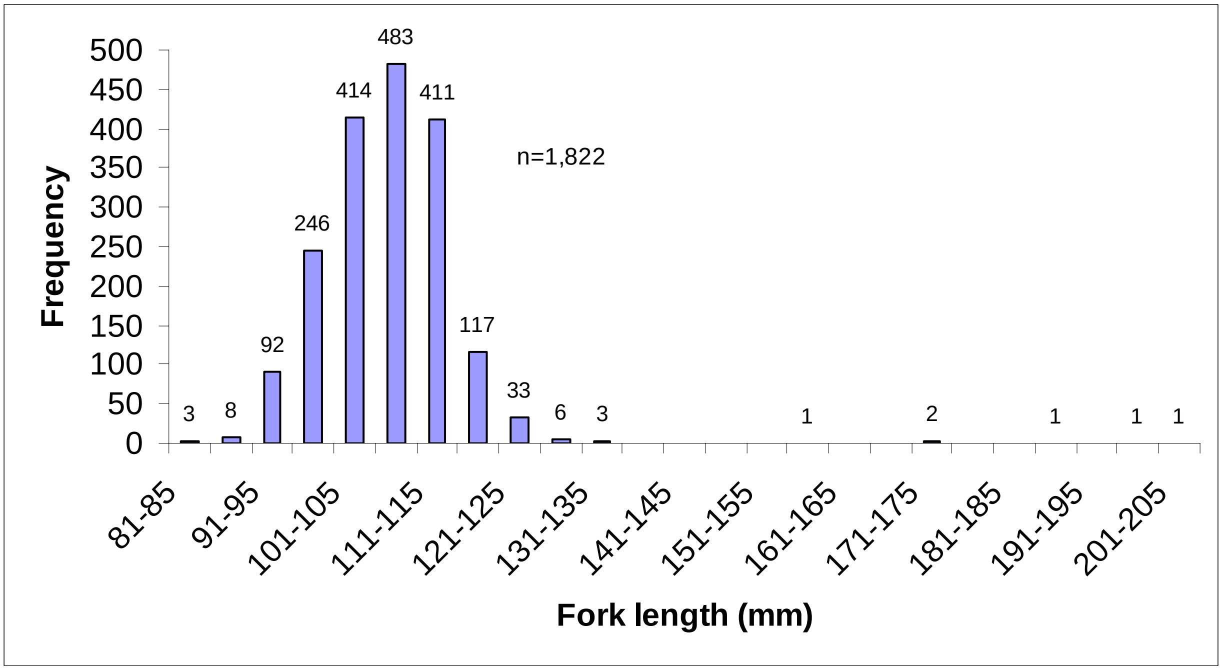


Figure 7. Length frequency of fall-direct released sockeye salmon smolts collected at Redfish Lake Creek trap in 2004.

LITERATURE CITED

Bjornn, T. C., D. R. Craddock, and D. R. Corley. 1968. Migration and survival of Redfish Lake, Idaho sockeye salmon *Oncorhynchus nerka*. Transactions of the American Fisheries Society 97:360-373.

Burgner, R. L. 1991. Life History of Sockeye Salmon. Pages 3-117 *in* Groot, C., and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press. Vancouver, British Columbia.

Craddock, D. R. 1958. Construction of a two-way weir for the enumeration of salmon migrants. The Progressive Fish-Culturist 20:33-37.

Fleiss, J. L., B. Levin, and M. Paik. 2003. Statistical methods for rates and proportions. 3rd edition. John Wiley & Sons, Inc. Hoboken, New Jersey.

Hebdon, J. L., M. Elmer, and P. Kline. 2000. Snake River sockeye salmon captive broodstock program, research element, 1999. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., J. Castillo, and P. Kline. 2002. Snake River sockeye salmon captive broodstock program, research element, 2000. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., J. Castillo, C. Willard, and P. Kline. 2003. Snake River sockeye salmon captive broodstock program, research element, 2001. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Hebdon, J. L., P. A. Kline, D. Taki, and T. A. Flagg. 2004. Evaluating reintroduction strategies for Redfish Lake sockeye salmon captive broodstock progeny. American Fisheries Society Symposium 44:401-413.

Kline, P. 1994. Research and recovery of Snake River sockeye salmon, 1993. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., and J. Younk. 1995. Research and recovery of Snake River sockeye salmon, 1994. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Kline, P., and J. A. Lamansky. 1997. Research and recovery of Snake River sockeye salmon, 1995. Project no. 199107200. Bonneville Power Administration, Annual Report. Portland, Oregon.

Macdonald, P. D. M., and P. E. J. Green. 1988. User's Guide to Program MIX: an interactive program for fitting mixtures of distributions. *Release 2.3, January 1988.* Ichthus Data Systems, Hamilton, Ontario. iv+60 pp. ISBN 0-9692305-1-6.

Newcombe, R. G. 1998. Interval estimation for the difference between two independent proportions: comparison of eleven methods. Statistics in Medicine 17:873-890.

Sandford, B. P., and S. G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River basin anadromous salmonids, 1990-1997. Journal of Agricultural, Biological and Environmental Statistics.

Steinhorst, K., Y. Wu, B. Dennis, and P. Kline. 2004. Confidence intervals for fish out-migration estimates using stratified trap efficiency methods. Journal of Agricultural, Biological, and Environmental Statistics 9:284-299.

Willard, C., J. L. Hebdon, J. Castillo, J. Gable, and P. Kline. 2004. Snake River sockeye salmon captive broodstock program, research element, 2002. Report to Bonneville Power Administration, Contract 5342.

Willard, C., K. Plaster, J. Castillo, and P. Kline. 2005. Snake River sockeye salmon captive broodstock program, research element 2003. Report to Bonneville Power Administration, Contract 5342.

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

INTRODUCTION

In 2004, twenty-seven anadromous sockeye salmon returned to the Sawtooth Valley. Traps on Redfish Lake Creek and the upper Salmon River at the Sawtooth Fish Hatchery intercepted one and four adults, respectively. Additionally, one adult sockeye salmon was collected at the East Fork Salmon River weir, 18 were seined from below the Sawtooth Fish Hatchery weir, one adult sockeye salmon was observed below the Sawtooth Fish Hatchery weir but not captured, and two adult sockeye salmon were observed in Little Redfish Lake but not captured. Fish were collected between July 24 and September 14, 2004. The captured/collected adult sockeye salmon (12 females and 12 males) originated from a variety of release strategies. Only four of the captured adults were unmarked fish (produced naturally within the lake) and 20 adults were from hatchery release strategies (hatchery-origin anadromous) mentioned earlier in the report.

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

Eyed-eggs were first released to valley lakes in 1996. Smolts produced from eyed-egg plants experience the same selection pressure as fish produced from in-lake spawning events. Currently, only Pettit and Alturas lakes receive eyed-egg plants.

The success of the prespawn adult and eyed-egg release strategies is evaluated by estimating the number of age-1 and age-2 unmarked smolts that correspond to specific adult release or egg planting years. While unmarked production could include smolts produced by residual sockeye salmon or even resident kokanee “fallout,” the majority of unmarked production is likely associated with adult spawning events or eyed-egg plants. Future investigations will incorporate the use of genetic methods to associate unmarked production with specific release strategies.

Current evaluations of adult sockeye salmon releases focus on identifying the spawning locations of released sockeye using radio telemetry, enumerating the number of redds produced, estimations of unmarked juvenile out-migrants, and DNA parental exclusion analysis.

METHODS

Sockeye Salmon Spawning Investigations

On September 7 and 10, 2004, 214 and 27 (respectively) adult sockeye salmon were released to Redfish Lake (Table 17). The hatchery-produced adults (129 females and 112 males) were reared at NOAA’s Manchester Marine Laboratory and NOAA’s Burley Creek

Hatchery. Sex was determined by ultrasound, and efforts were made to release fish of equal sex ratios. No anadromous adults were released in 2004.

In order to assist in identifying spawning locations, three male and four female hatchery-produced sockeye salmon were implanted with radio transmitters prior to release. Telemetry investigations of adult locations began September 22, 2004 and continued weekly through November 9, 2004. Fish were tracked by boat using conventional telemetry equipment.

Redd counts were also conducted once a week (coincided with radio telemetry events) beginning on October 13, 2004 and continuing until November 9, 2004. Suspected redds were generally enumerated by two observers on each count date. On the final count date, six observers were used. Areas of excavation (possible redds) were generally 3 m x 3 m in size and likely represented spawning events by multiple parents. As such, we do not know how many parents contributed to the production of natural progeny in spawn year 2004. During redd count surveys, any observed carcasses that could be retrieved were collected to facilitate the collection of biological information (e.g., fish sex and spawning status).

Unmarked Juvenile Out-migrant Monitoring

In 2004, unmarked out-migrants produced from program fish releases to Redfish Lake included age-1 out-migrants produced from 178 hatchery-origin and 12 anadromous fish released for natural spawning in 2002, and age-2 out-migrants produced from 65 hatchery-origin and 14 anadromous fish released for natural spawning in 2001. No program fish or eyed-eggs were released to Alturas Lake in 2001 or 2002 to produce age-1 or age-2 unmarked out-migrants. Unmarked out-migrants produced from program fish releases to Pettit Lake included age-1 out-migrants produced from 30,294 eyed-eggs released in 2002. No program fish or eyed-eggs were released in 2001 to Pettit Lake that would have produced age-2 unmarked out-migrants. The proportions of age-1 and age-2 unmarked out-migration were determined for 2004 Redfish and Pettit 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 13, 2004. Redd counts were finalized with six observers November 9, 2004. During the final count, 127 redds (areas of excavation) were identified. Twenty-three redds were located at the Transfer Camp and 104 redds were located at the south beach area (Table 18; Figure 8). In 2004, we identified approximately 10 small areas of excavation along Sockeye Beach. Due to the small size of these excavations, we did not include them in our final estimate of redds constructed by program adults.

Two completed redds and two test digs were located at the south end of Little Redfish Lake on October 10, 2004. An anadromous male and female were observed near a redd and were exhibiting spawning behavior.

Five carcasses were recovered during the tracking season. Two of the five carcasses were females. One of the female carcasses had been partially consumed by predators, and the other female was fully ovulated and had retained 100% of her eggs.

Unmarked Out-migrant Monitoring

In 2004, 4,476 unmarked smolts (95% CI 4,122 to 4,894) were estimated to have out-migrated from Redfish Lake, 74 unmarked smolts (95% CI not calculated) were estimated to have out-migrated from Alturas Lake, and 1,091 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 96.6% age-1 (95% CI 95.0-98.2) (4,324 smolts produced by brood year 2002) and 3.4% age-2 (95% CI 1.8-5.0) (152 smolts produced by brood year 2001). See table 17 for the number of redds thought to have produced these fish.

Determination of the parental contribution to 2004 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 8). 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 periphyton. This year was the first year that we have documented sockeye spawning in Little Redfish Lake since the program was initiated.

The program began releasing hatchery-reared adults for volitional spawning in 1993. In 2004, the program released 241 prespawn adults (129 females and 112 males) for volitional spawning in Redfish Lake and 127 redds were observed (Table 17). This was the highest number of redds observed in Redfish Lake since the adult release option was initiated. All of the fish released for volitional spawning were reared at NOAA's facilities in Washington. Generally, fish spawned approximately one week earlier than has been observed in the past. While reasons for early spawning are unclear, it is possibly the result of rearing condition changes implemented at the NOAA Burley Creek Fish Hatchery (e.g., longer exposure to natural lighting). This trend in early spawning was also observed by Eagle Fish Hatchery staff while spawning fish from this same NOAA-reared cohort.

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. 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 between the relative individual contribution of adults released to spawn volitionally, and survival comparisons to certain life history stages (e.g., green-egg to smolt and/or fry to smolt survival) for various release strategies. Results would allow program managers to emphasize the release strategy with the highest reproduction potential. Additionally, parental exclusion analysis will allow for evaluation of the reproductive contribution of residuals and estimation of the number of kokanee that fall out.

The analyses for the 2002 and 2003 unmarked out-migrants were completed in 2005. For a complete description, refer to Willard (2005). In summary, we conducted parental analyses using data from seven polymorphic microsatellite loci to associate unmarked smolts produced from prespawn anadromous adult releases, full-term hatchery adult releases, and eyed-egg reintroductions. There were no differences between the relative individual contribution of anadromous and full-term hatchery fish in two out of three evaluations. Green-egg-to-smolt survival comparisons were also not significantly different. However, significant differences in fry-to-smolt survival between anadromous adults that spawn volitionally and eyed-egg reintroductions were observed (fry-to-smolt survival is higher for smolts produced by anadromous adults). All possible spawn cross types between anadromous and full-term hatchery fish were detected among the out-migrants sampled. The percentages of the total out-migration produced from residual parents were 38% for Redfish Lake in 2002, 9% for Redfish Lake in 2003, and 23% for Pettit Lake in 2002. Kokanee dropout from Alturas Lake in 2002 was estimated at 19%.

Our results provided further evidence that adult release strategies can be successful in producing natural smolts. Program managers should feel confident with the decision to allocate both full-term hatchery and anadromous adult-to-adult release strategies. Further investigation of the success of eyed-egg reintroductions is warranted since our data only represented one lake (Pettit Lake) and one year (2002 out-migrants), and there are biological benefits to eyed-egg reintroductions. One such benefit may be natural selection acting on "eyed-egg-produced" fry reared naturally within the lake without hatchery influence.

The SBSTOC believes it is important to utilize reintroduction strategies that produce natural smolts (e.g., prespawn adults released for volitional spawning and eyed-egg reintroductions). This need to produce natural smolts is constantly weighed against the benefit of greater production potential from releasing hatchery-reared presmolts and smolts. However, adult release strategies provide the potential for biological benefits, including the opportunity for natural and sexual selection to occur on the spawning grounds. Offspring produced from adult releases and eyed-egg reintroductions may be less likely to stray, and domestication selection is minimized in comparison to when fish are produced and reared in a hatchery environment (Berejikian et al. 2004).

Table 17. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history.

Lake	Rearing origin	Date released	Number released	Number of suspected redds
Redfish	Full-term hatchery	1993	20	Unknown
Redfish	Full-term hatchery	1994	65	One behavioral observation
Redfish	Full-term hatchery	1996	120	30 suspected redds
Redfish	Full-term hatchery	1997	80	30 suspected redds
Pettit	Full-term hatchery	1997	20	1 suspected redd
Alturas	Full-term hatchery	1997	20	Test digs only
Redfish	Full-term hatchery	1999	18	
Redfish	Hatchery-produced anadromous	1999	3	8 suspected redds
Redfish	Full-term hatchery	2000	36	
Redfish	Hatchery-produced anadromous	2000	120	20 to 30 suspected redds
Pettit	Hatchery-produced anadromous	2000	28	none confirmed
Alturas	Full-term hatchery	2000	25	
Alturas	Hatchery-produced anadromous	2000	52	14 to 19 suspected redds
Redfish	Hatchery-produced anadromous	2001	14	12 to 15 suspected redds
Redfish	Full-term hatchery	2001	65	
Redfish	Hatchery-produced anadromous	2002	12	10 to 12 suspected redds
Redfish	Full-term hatchery	2002	178	
Redfish	Full-term hatchery	2003	312	42 suspected redds
Redfish	Full-term hatchery	2004	241	127 suspected redds
		Total	**1,315**	

Table 18. Summary of sockeye salmon redd observations in Redfish Lake in 2004.

	10/13/2004	10/19/2004	10/26/2004	11/09/2004
Sockeye Beach	10 possible redds			NA[a]
South Beach	2 possible redds	24 possible redds	77 possible redds	104 possible redds
Transfer camp	2 possible redds	8 possible redds	17 possible redds	23 possible redds

[a] It is difficult to observe redds on Sockeye Beach due to the lack of accumulation of periphyton.

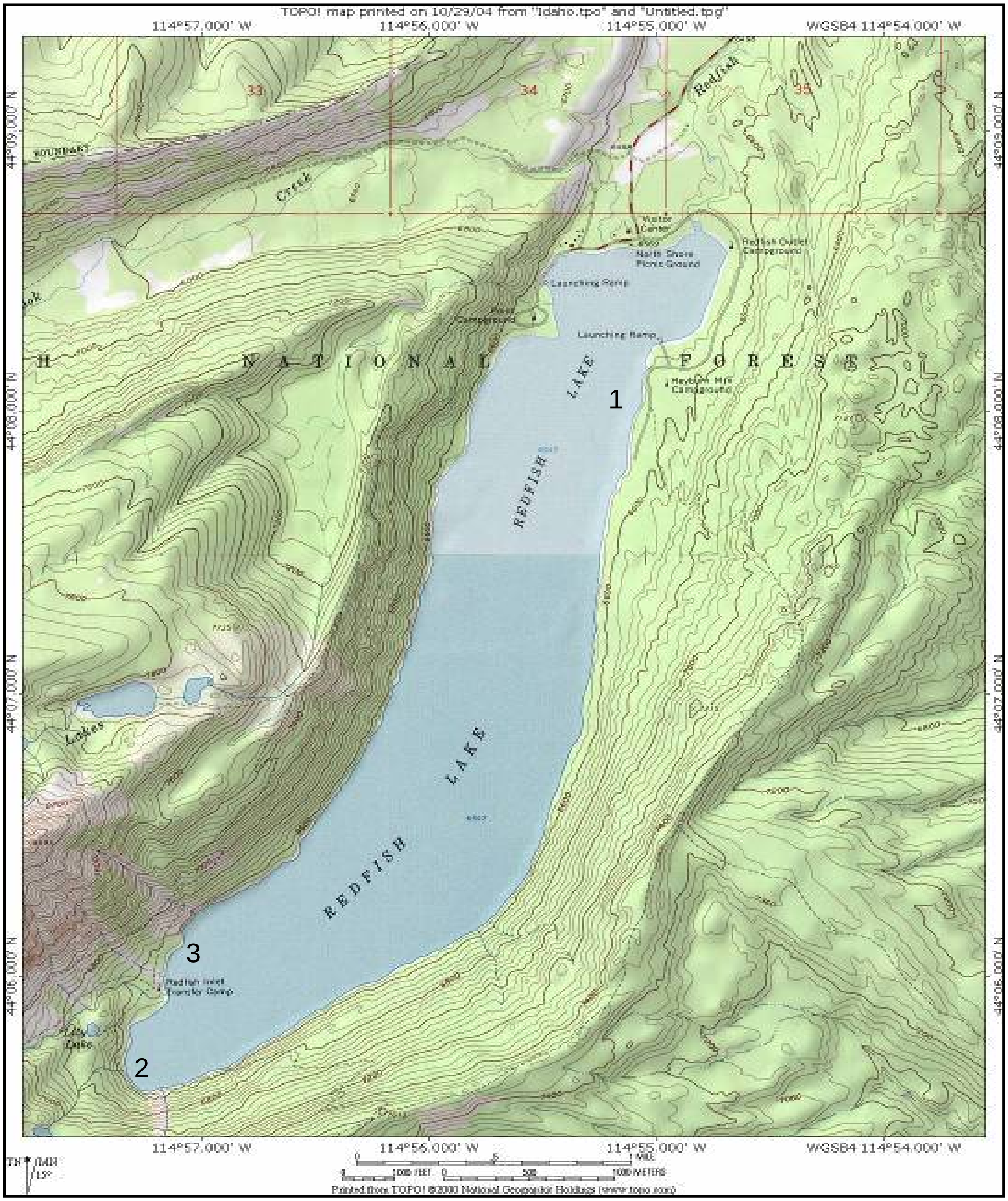


Figure 8. Spawning locations for sockeye salmon in Redfish Lake in 2004: 1) Sockeye Beach, 2) the south beach near the slide, and 3) the area near the U.S. Forest Service transfer camp dock.

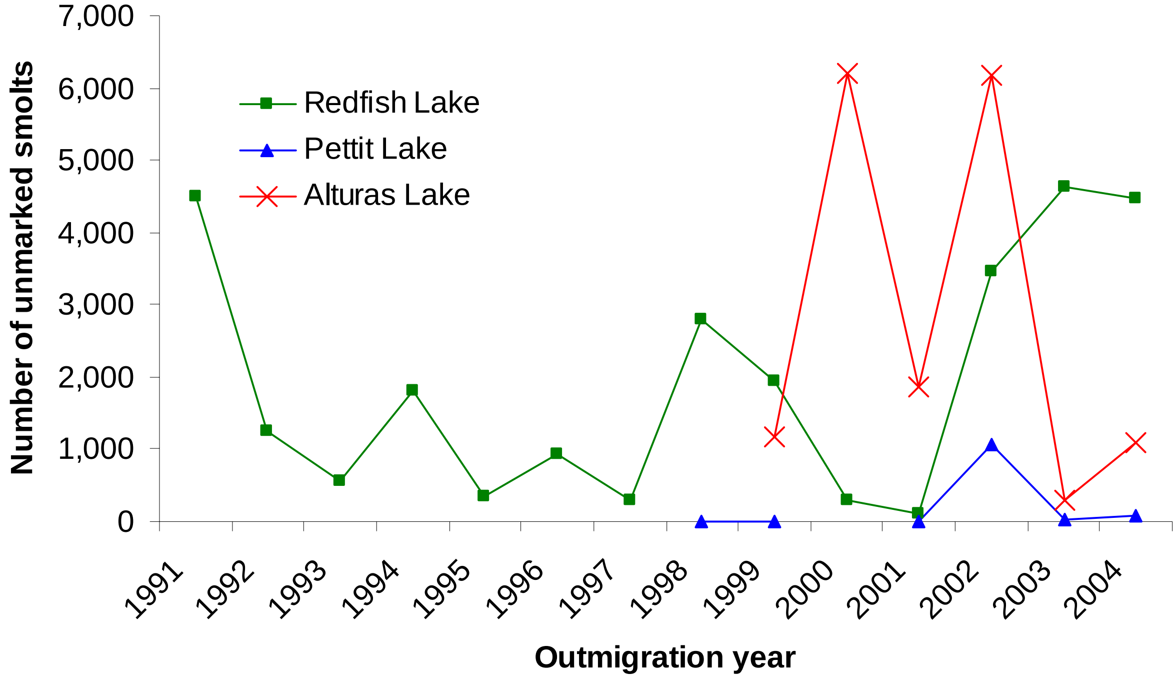


Figure 9. Wild/natural sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2004 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

LITERATURE CITED

Berejikian, B., T. Flagg, and P. Kline. 2004. Release of captively-reared adult anadromous salmonids for population maintenance and recovery: biological trade-offs and management considerations. American Fisheries Society Symposium 44:233-245.

Willard, C. 2005. Utilizing Parental Analyses to Evaluate Natural Smolt Production from the Snake River Sockeye Salmon (*Oncorhynchus nerka*) Captive Broodstock Program. Master of Science thesis. University of Idaho, Moscow.

PART 6—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 2004, *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 19).

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 19. Year 2004 juvenile *O. nerka* proximate body analysis summary.

Sample Date	Sample location	Sampling Method [a]	Number sampled	Mean wt. (g)	Mean FL (mm)	Mean % fat dry weight
6/22/04	Alturas Lake	Hook and line/creel, wild/natural *O. nerka*	10	75.8	188	*pending*
July-2004	Pettit Lake	Hook and line/creel, wild/natural *O. nerka*	4	141.5	237	*pending*
6/03/04	Redfish Lake	Hook and line/creel, wild/natural *O. nerka*	6	127.4	227	*pending*
6/20/04	Redfish Lake	Hook and line/creel, wild/natural *O. nerka*	9	119.7	190	*pending*
August-04	Redfish Lake	Hook and line/creel, wild/natural *O. nerka*	5	88.4	202	*pending*
5/20/04	Pettit Lake Creek	Weir, AD out-migrant	23	22.9	126	*pending*
May-2004	Redfish Lake Creek	Weir, wild/natural out-migrant	20	7.8	100	*pending*
May-2004	Redfish Lake Creek	Weir, AD out-migrant	24	9.1	104	*pending*
9/13/04	Alturas Lake	Trawl, age-0 wild/natural *O. nerka*	12	2.7	65	*pending*
9/13/04	Alturas Lake	Trawl, age-2 wild/natural *O. nerka*	1	17.1	120	*pending*
9/13/04	Alturas Lake	Trawl, age-3 wild/natural *O. nerka*	1	40.2	157	*pending*
9/13/04	Alturas Lake	Trawl, age-4 wild/natural *O. nerka*	2	85.5	205	*pending*
9/14/04	Pettit Lake	Trawl, age-0 wild/natural *O. nerka*	5	6.2	84	*pending*
9/14/04	Pettit Lake	Trawl, age-1 wild/natural *O. nerka*	7	14.9	106	*pending*
9/14/04	Pettit Lake	Trawl, age-2 wild/natural *O. nerka*	1	37.8	149	*pending*
9/14/04	Pettit Lake	Trawl, age-3 wild/natural *O. nerka*	4	98.0	199	*pending*
9/14/04	Pettit Lake	Trawl, age-4 wild/natural *O. nerka*	2	135.0	218	*pending*
9/15/04	Redfish Lake	Trawl, age-0 wild/natural *O. nerka*	45	2.1	60	*pending*
9/15/04	Redfish Lake	Trawl, age-1 wild/natural *O. nerka*	3	7.8	94	*pending*

[a] AD refers to an adipose fin-clip.

PART 7—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.

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 2004, 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.

METHODS

Surveys were conducted on Fishhook Creek (Redfish Lake drainage) August 30 and September 9, 2004 and on Alpine Creek (Alturas Lake drainage) on August 31 and September 9, 2004. No suitable tributary streams feed Pettit Lake and, as such, bull trout spawner surveys were not conducted on this system. We used global positioning satellite (GPS) equipment to verify the index sections. 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 that were obscured over time from the final count. We recorded water temperatures using pocket thermometers.

RESULTS

Fishhook Creek

We observed 31 adult bull trout (13 males, 13 females, and 5 unknown) and seven developing redds on August 30, 2004. Water temperature at 1022 hours was 8.0°C. During our second survey on September 9, we observed 8 adult bull trout (4 males and 4 females) and 11 complete redds (Figure 10). Water temperature was 7.0°C at 1147 hours. Redd counts on the second date included developing redds observed on the previous count (Table 20).

Alpine Creek

We observed 16 adult bull trout (9 males, 3 females, and 4 unknown) and six developing redds during the August 31, 2004 survey. Water temperature was 10.0°C at 1300 hours. On September 9, we observed zero adult bull trout and nine completed redds (Figure 11). Water temperature was 11.0°C at 1601 hours. Redd counts on the second date included developing redds and completed redds observed during the previous count (Table 21).

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).

Index sections were established on Fishhook and Alpine creeks in 1998. Information collected in 2004 represented the seventh 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 seven 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 the number of redds has ranged between 9 and 15 between 2000 and 2004. 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. 2005). As such, it is reasonable to assume that predation pressure by bull trout (produced in the Alturas and Redfish lake drainages) has likely not increased (based on stable redd count trend information).

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). Redd counts are a preferred monitoring technique, 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 area 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 in the system. 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 20. Bull trout adult fish counts and redd counts in trend survey sections of Fishhook Creek from 1998 to 2004.

Year	Dates	Number of bull trout observed	Number of redds
1998	8/22	40	5
	9/10	2	11
1999	8/22	40	0
	8/26	33	15
2000	8/31	16	12
	9/14	2	18
2001	8/28	31	15
	9/11	3	11
2002	9/04	23	6
	9/11	5	17
2003	8/27	40	6
	9/08	15	17
2004	8/30	31	7
	9/9	8	11

Table 21. Bull trout adult fish counts and redd counts in trend survey sections of Alpine Creek from 1998 to 2004.

Year	Dates	Number of bull trout observed	Number of redds
1998	8/23	6	0
	9/11	6	1
1999[a]	8/26	13	3
2000	8/30	18	6
	9/15	5	9
2001	8/28	8	11
	9/11	1	15
2002	8/30	20	8
	9/12	0	14
2003	8/27	27	11
	9/08	0	14
2004	8/31	16	6
	9/9	0	9

[a] Only one count completed.

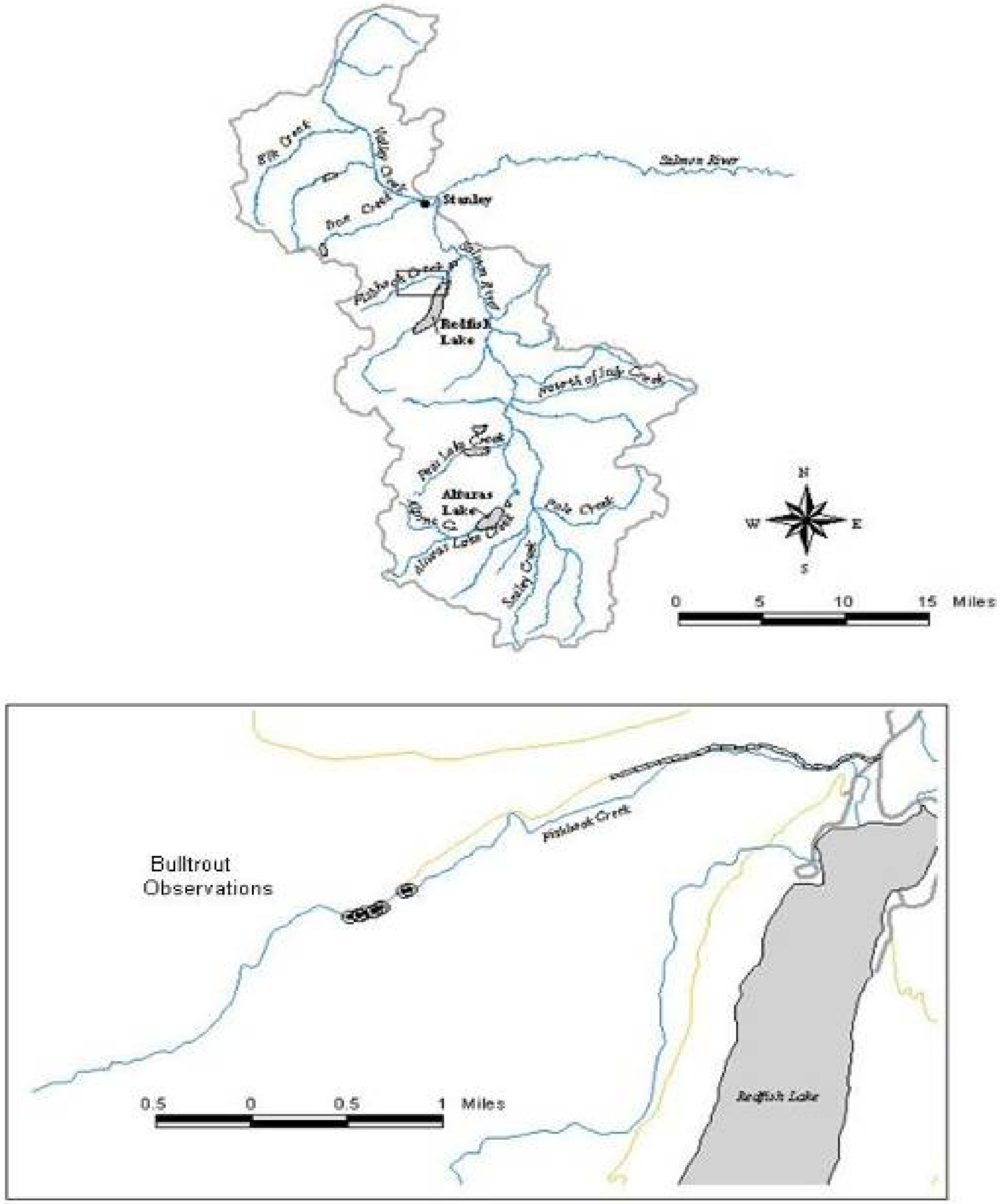


Figure 10. Locations of completed bull trout redds observed in Fishhook Creek in 2004.

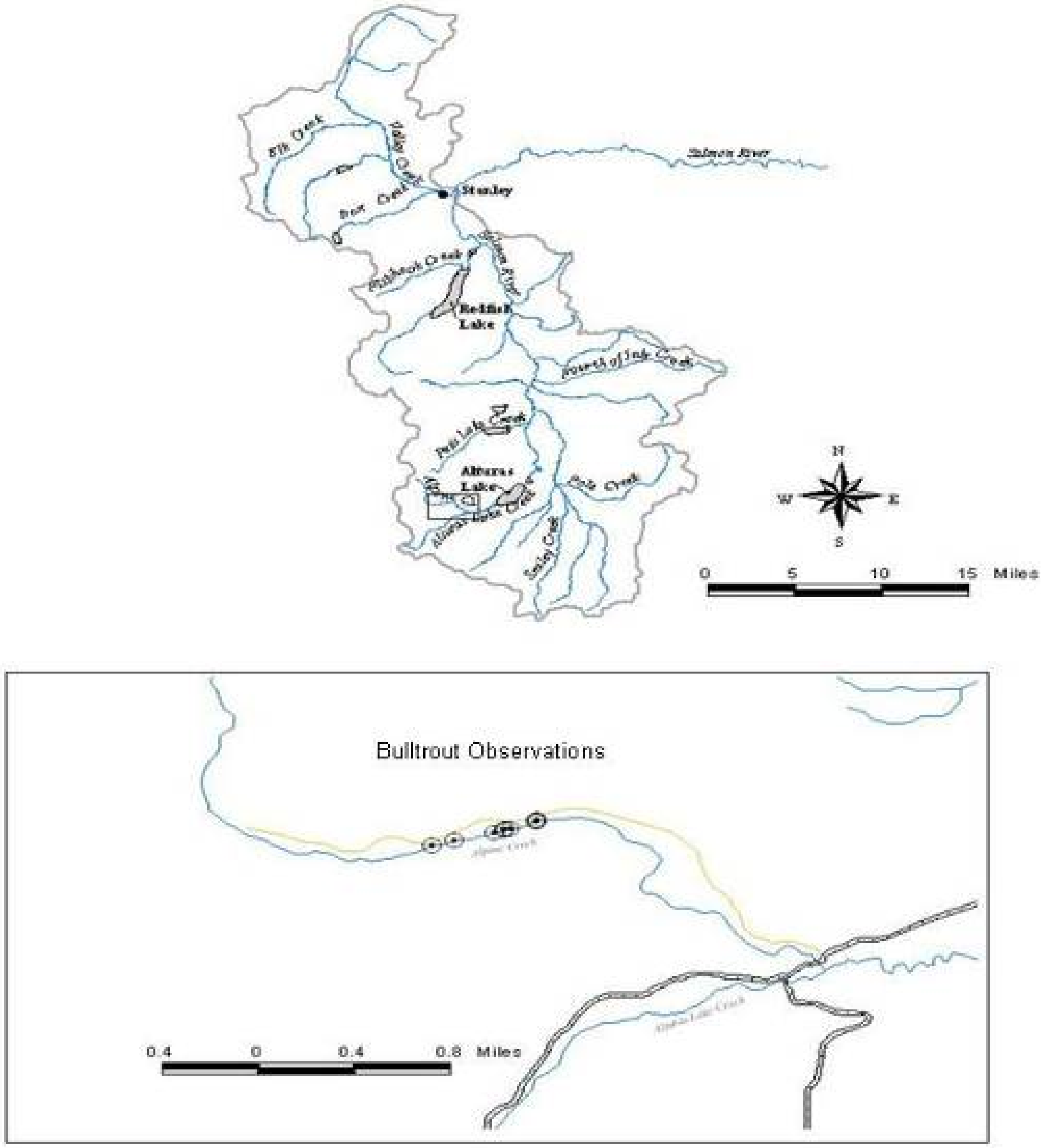


Figure 11. Locations of completed bull trout redds observed in Alpine Creek in 2004.

LITERATURE CITED

Beauchamp, D. A., and J. J. Van Tassell. 2001. Modeling seasonal trophic Interactions of adfluvial bull trout in Lake Billy Chinook, Oregon. Transactions of the American Fisheries Society 130:204-216.

Bjornn, T. C. 1961. Harvest, age, and growth of game fish populations from Priest to Upper Priest Lakes. Transactions of the American Fisheries Society 118:597-607.

Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout. North American Journal of Fish Management 21:343-352.

Fraley, J. J., and B. Shepard. 1989. Life history, ecology and population status of migratory bull trout *Salvelinus confluentus* in the Flathead lake and river systems, Montana. Northwest Science 63:133-142.

High, B., K. A. Meyer, D. J. Schill, and E. R. J. Mamer. 2005. Wild trout investigations. Job performance report 2004. Grant F-73-R-27. Idaho Department of Fish and Game, Boise, Idaho.

Leary, R. F., F. W. Allendorf, S. H. Forbes. 1993. Conservation genetics of bull trout in Columbia and Klamath River drainages. Conservation Biology 7:856-865.

Ratliff, D. E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. *In* Howell, P. J., and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society. Corvallis, Oregon.

Rieman, B. E., and D. L. Meyers. 1997. Use of redd counts to detect trends in bull trout *Salvelinus confluentus* populations. Conservation Biology 11:1015-1018.

Stelfox, J. D., and K. L. Egan. 1995. Bull trout investigations in the Smith-Dorien Creek/Lower Kananaskis Lake system. Alberta Environmental Protection, Fisheries Management Division, and Golder Associates Limited, Calgary, Canada.

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APPENDICES

Appendix A. Fork length, weight (g) and age of *O. nerka* captured during midwater trawls conducted during September 2004 on Redfish, Pettit, and Alturas lakes.

Transect	Length (mm)	Weight (g)	Age
Redfish Lake			
1	45	0.8	0
1	46	0.9	0
1	50	1.3	0
1	52	1.2	0
1	53	1.3	0
1	56	1.8	0
1	56	1.5	0
1	59	2.0	0
1	63	2.6	0
1	61	1.9	0
1	60	2.1	0
1	61	2.2	0
1	59	1.6	0
1	57	1.7	0
1	67	2.8	0
1	65	2.4	0
1	61	2.0	0
1	62	2.5	0
1	68	2.8	0
1	103	9.3	1
2	49	1.1	0
2	59	1.8	0
2	68	2.7	0
2	63	2.2	0
2	62	2.0	0
2	61	2.0	0
2	55	1.4	0
2	63	2.1	0
2	65	2.2	0
2	61	1.9	0
2	58	1.5	0
2	60	2.2	0
2	64	2.4	0
2	65	2.6	0
2	65	2.5	0
2	63	2.0	0
2	83	4.9	1
2	83	5.4	1
2	113	14.8	1
3	107	12.1	1
3	64	2.5	0
3	63	2.4	0
3	47	0.9	0
3	58	1.6	0
3	49	1.0	0
3	66	2.9	0
3	59	1.9	0
3	57	1.4	0
3	56	1.5	0

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
Redfish Lake, continued			
4	56	1.6	0
4	60	2.0	0
4	54	1.3	0
4	52	1.3	0
4	53	1.2	0
4	67	2.7	0
4	63	2.4	0
4	53	1.3	0
4	55	1.5	0
4	57	1.9	0
4	53	1.4	0
4	58	1.6	0
4	62	2.1	0
4	47	0.9	0
4	57	1.5	0
4	56	1.5	0
4	57	1.6	0
4	54	1.3	0
4	62	2.3	0
4	64	2.4	0
4	61	1.9	0
4	54	1.3	0
4	56	1.8	0
4	60	2.0	0
4	57	1.8	0
4	51	1.1	0
4	59	1.8	0
4	69	2.8	0
4	68	2.2	0
4	71	3.8	0
4	66	2.4	0
5	62	1.9	0
5	64	2.3	0
5	46	0.8	0
5	52	1.1	0
5	57	1.5	0
5	53	1.3	0
5	68	3.3	0
5	84	5.7	1
6	55	1.6	0
6	65	2.7	0
6	57	1.6	0
6	65	2.6	0
6	60	1.9	0
6	58	1.6	0
6	68	2.8	0
6	63	2.1	0
6	63	2.2	0
6	60	2.1	0
6	61	2.0	0
6	78	3.8	0
6	95	8.5	1

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
Alturas Lake			
1	63	1.8	0
1	68	3.0	0
1	65	2.9	0
1	157	40.2	3
1	195	79.2	4
2	82	5.2	0
2	63	2.4	0
2	67	2.7	0
2	60	2.1	0
2	208	90.0	4
2	201	80.9	4
4	73	3.9	0
4	78	4.6	0
4	77	4.5	0
4	78	4.6	0
4	58	1.8	0
4	62	2.0	0
4	200	84.1	4
4	194	76.8	4
5	45	0.8	0
5	52	1.5	0
5	56	1.8	0
5	78	4.5	0
5	78	4.2	0
5	120	17.1	2
6	44	0.8	0
6	66	2.7	0
6	64	2.5	0
6	60	2.0	0
Pettit Lake			
1	54	1.4	0
1	65	3.3	0
1	83	5.6	0
1	96	10.1	1
1	94	10.2	1
1	98	10.7	1
1	94	9.9	1
1	98	11.1	1
1	90	8.0	1
1	137	32.9	2
1	144	34.3	2
1	175	66.7	2
1	200	91.6	3
1	195	97.9	3
1	175	62.2	2
2	125	19.1	1
2	149	37.8	2
2	145	35.9	1
2	215	133.6	4
2	203	103.1	3
3	34	0.5	0

Appendix A. Continued.

Transect	Length (mm)	Weight (g)	Age
Pettit Lake, continued.			
3	85	6.9	0
3	200	99.4	3
3	210	117.2	4
3	220	147.6	4
3	198	112.5	3
3	195	103.1	3
4	33	0.4	0
4	50	1.3	0
4	38	0.7	0
4	38	0.6	0
4	48	1.0	0
4	29	0.2	0
4	68	3.3	0
4	86	7.0	0
4	83	5.9	0
4	96	10.7	1
5	30	0.3	0
5	37	0.4	0
5	34	0.4	0
5	49	1.1	0
5	88	6.4	0
5	76	5.0	0
5	93	9.4	1
5	220	136.2	4

Appendix B. Arrival dates for PIT-tagged sockeye salmon smolts at Lower Granite Dam for the 2004 migration year.

	Redfish Lake		Pettit Lake		Salmon River
Date	Wild/natural	Direct fall release (SFH)	Wild/natural	Direct fall release (SFH)	Smolt release (SFH)
5/03/2004	1				
5/04/2004	3				
5/05/2004	3				
5/06/2004	5				
5/07/2004	7				
5/08/2004	17	1		1	
5/09/2004	10	2		0	
5/10/2004	13	2		5	
5/11/2004	13	2	1	5	
5/12/2004	6	1		2	
5/13/2004	7	3		5	
5/14/2004	15	6		11	
5/15/2004	2	3	1	1	
5/16/2004	5	1		6	
5/17/2004	6	4		11	
5/18/2004	3	4		1	
5/19/2004	12	3		7	
5/20/2004	15	6		6	
5/21/2004	13	12		11	6
5/22/2004	4	7		3	5
5/23/2004	7	1		4	5
5/24/2004	2	4		0	
5/25/2004	9	3		0	
5/26/2004	8	2		1	2
5/27/2004	4	1		2	1
5/28/2004	4	2		0	
5/29/2004	3	1		2	
5/30/2004	0	1		1	
5/31/2004	3	1		1	
6/01/2004	0	1			
6/02/2004	1	0			
6/03/2004	2	2			
6/04/2004	1	0			
6/05/2004	1	1			
6/06/2004	1	3			
6/07/2004	2	2			
6/08/2004	0	0			
6/09/2004	4	1			
6/10/2004	0	1			
6/11/2004	0	1			
6/12/2004	1	2			
6/13/2004	0	3			
6/14/2004	0	2			
6/15/2004	0	2			
6/16/2004	0	0			
6/17/2004	0	0			
6/18/2004	0	0			
6/19/2004	0	1			
6/20/2004	0	0			
6/21/2004	0	1			
6/22/2004	0				
6/23/2004	1				
TOTAL	**214**	**96**	**2**	**86**	**19**

Appendix C. Estimates of PIT-tagged sockeye salmon passing Lower Granite Dam for the 2004 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 fall	PET WN	PET fall	Smolt	Cumulative
5/3/2004	0.860	60.9	0	1					1
5/4/2004	0.856	70.4	0	4					5
5/5/2004	0.836	79.1	3.75	4					9
5/6/2004	0.805	85.2	2.62	6					15
5/7/2004	0.831	80.5	0	8					23
5/8/2004	0.838	78.7	0	20	1		1		45
5/9/2004	0.844	75.2	0	12	2				59
5/10/2004	0.863	73.1	0	15	2		6		82
5/11/2004	0.861	72.2	0	15	2	1	6		106
5/12/2004	0.844	72.1	0	7	1		2		116
5/13/2004	0.876	64.1	0	8	3		6		133
5/14/2004	0.883	59.5	0	17	7		12		169
5/15/2004	0.879	57.9	0	2	3	1	1		176
5/16/2004	0.885	55.9	0	6	1		7		190
5/17/2004	0.874	68.2	0	7	5		13		215
5/18/2004	0.879	64.9	0	3	5		1		224
5/19/2004	0.894	67.7	0	13	3		8		248
5/20/2004	0.888	75.5	0	17	7		7		279
5/21/2004	0.885	77.5	0	15	14		12	7	327
5/22/2004	0.877	83.6	0	5	8		3	6	349
5/23/2004	0.855	84.7	0	8	1		5	6	369
5/24/2004	0.846	89.7	0	2	5				376
5/25/2004	0.823	86.8	0	11	4				391
5/26/2004	0.750	84.2	0	11	3		1	3	409
5/27/2004	0.708	92.8	4.44	6	1		3	1	420
5/28/2004	0.628	122.4	29.87	6	3				429
5/29/2004	0.587	132.4	39.46	5	2		3		439
5/30/2004	0.589	125.8	34.23	0	2		2		443
5/31/2004	0.573	120.8	28.41	5	2		2		452
6/1/2004	0.467	114.8	22.23		2				454
6/2/2004	0.444	103.1	11.41	2					456
6/3/2004	0.451	100.4	18.9	4	4				464
6/4/2004	0.445	105.1	22.46	2					466
6/5/2004	0.441	108.9	19.01	2	2				470
6/6/2004	0.488	108.3	20.48	2	6				478
6/7/2004	0.570	110.6	21.74	4	4				486
6/8/2004	0.628	102.0	9.52						486
6/9/2004	0.677	97.6	5.57	6	1				493
6/10/2004	0.765	90.5	0		1				494
6/11/2004	0.808	88.2	0		1				495
6/12/2004	0.847	83.8	0	1	2				498
6/13/2004	0.855	77.2	0		4				502
6/14/2004	0.836	76.5	0		2				504
6/15/2004	0.837	72.6	0		2				506
6/16/2004	0.834	60.7	0						506
6/17/2004	0.813	55.2	0						506
6/18/2004	0.804	53.5	0						506
6/19/2004	0.832	49.3	0		1				507
6/20/2004	0.824	48.7	0						507
6/21/2004	0.848	46.2	0		1				508
6/22/2004	0.816	52.1	0						508
6/23/2004	0.830	48.4	0	1					509
			TOTAL	**263**	**120**	**2**	**101**	**23**	

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