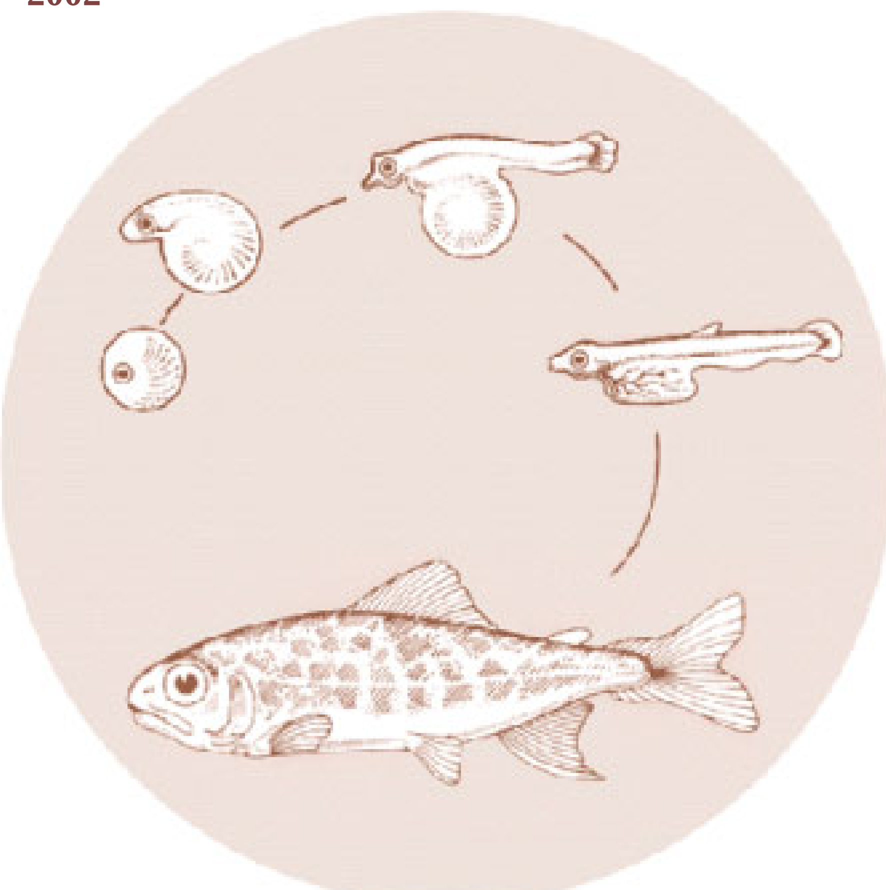
Snake River Sockeye Salmon Captive Broodstock Program

Research Element

Annual Report
2002



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FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

ANNUAL PROGRESS REPORT
January 1, 2002–December 31, 2002

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IDFG Report Number 04-05
January 2004

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

2002 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 and Idaho Department of Fish and Game initiated the Snake River Sockeye Salmon Sawtooth Valley Project to conserve and rebuild populations in Idaho. Restoration efforts are focusing on Redfish, Pettit, and Alturas lakes within the Sawtooth Valley. The first release of hatchery-produced juvenile sockeye salmon from the captive broodstock program occurred in 1994. The first anadromous adult returns from the captive broodstock program were recorded in 1999 when six jacks and one jill were captured at IDFG's Sawtooth Fish Hatchery.

In 2002, progeny from the captive broodstock program were released using four strategies: age-0 presmolts were released to Alturas, Pettit, and Redfish lakes in August and to Pettit and Redfish lakes in October, age-1 smolts were released to Redfish Lake Creek in May, eyed-eggs were planted in Pettit Lake in December, and hatchery-produced and anadromous 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 2002. Age-0, age-1, and age-2 O. nerka were captured in Redfish Lake, and population abundance was estimated at 50,204 fish. Age-0, age-1, age-2, and age-3 kokanee were captured in Alturas Lake, and population abundance was estimated at 24,374 fish. Age-2 and age-3 O. nerka were captured in Pettit Lake, and population abundance was estimated at 18,328 fish.

Angler surveys were conducted from May 25 through August 7, 2002 on Redfish Lake and from May 25 through September 2, 2002 on Pettit Lake to estimate kokanee harvest and to estimate return to creel for hatchery rainbow trout planted in Pettit Lake. On Redfish Lake, we interviewed 147 anglers and estimated 129 kokanee were harvested at a catch rate of .09 fish/hour. On Pettit Lake, 169 anglers were interviewed who harvested an estimated 6 kokanee at a catch rate of .01 fish/hour. We estimated that anglers harvested 3.6% (109) of the 3,004 rainbow trout planted in Pettit Lake in 2002.

The juvenile out-migrant trap on Redfish Lake Creek was operated from April 17 to June 13, 2002. We estimated that 4,951 wild/natural and 25,697 hatchery-produced sockeye salmon smolts out-migrated from Redfish Lake in 2002. The hatchery-produced component included an estimated 19,758 out-migrants produced from presmolt releases made directly to Redfish Lake in 2001 and 5,939 out-migrants produced from presmolt releases made from net pens in 2001. The juvenile out-migrant traps on Alturas Lake Creek and Pettit Lake Creek were operated by the Shoshone-Bannock Tribes from April 23 to May 31, 2002 and April 21 to May 31, 2002, respectively. The SBT enumerated 1,067 wild/natural and 2,155 hatchery-produced sockeye salmon smolts that out-migrated from Pettit Lake and estimated 6,176 wild/natural and 3,602 hatchery-produced sockeye salmon smolts out-migrated from Alturas Lake in 2002. The hatchery-produced component of sockeye salmon out-migrants originated from presmolt releases made directly to Pettit and Alturas lakes in 2001.

Median travel times for passive integrated transponder tagged smolts from the Redfish Lake Creek trap site, the Alturas Lake Creek trap site, and Pettit Lake Creek trap site to Lower Granite Dam were estimated for wild/natural smolts and hatchery-produced smolts. Median travel times for smolts originating from the Redfish Lake Creek trap were 12 d for wild/natural

smolts, 8.9 d for fall direct-released smolts, and 8.7 d for net pen-released smolts. Median travel time for smolts released directly below the Redfish Lake Creek trap was 12 d. Median travel times for smolts originating from the Alturas Lake Creek trap were 12.7 d for wild/natural smolts and 9.5 d for fall direct released smolts. Median travel times for smolts originating from the Pettit Lake Creek trap were 15.5 d for wild/natural smolts and 13.1 d for fall direct release.

Cumulative unique passive integrated transponder tag interrogations from Sawtooth Valley juvenile out-migrant traps to mainstem Snake and Columbia river dams were utilized to estimate detection rates for out-migrating sockeye salmon smolts. Detection rate comparisons were made between smolts originating from Redfish, Alturas, and Pettit lakes and the various release strategies. Redfish Lake fall direct released smolts recorded the highest detection rate of 30.9%.

In 2002, 178 hatchery-produced and 12 anadromous adult sockeye salmon were released to Redfish Lake for natural spawning. We observed 10 to 12 areas of excavation in the lake from spawning events. Suspected redds were approximately 3 m x 3 m in size and were constructed by multiple pairs of adults.

We monitored bull trout spawning in Fishhook Creek, a tributary to Redfish Lake, and in Alpine Creek, a tributary to Alturas Lake. This represented the fifth consecutive year that the index reaches have been surveyed on these two streams. Adult counts (28 adults) and redd counts (17 redds) in Fishhook Creek were similar to previous years. Bull trout numbers (20 adults) and the number of redds observed (22 redds) increased in Alpine Creek compared to previous years.

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PART 1—PROJECT OVERVIEW

Snake River sockeye salmon *Oncorhynchus nerka* were listed as endangered under the Endangered Species Act (ESA) by the National Oceanic and Atmospheric Administration (NOAA) on November 20, 1991. Residual (nonmigratory) sockeye salmon were discovered in Redfish Lake and added to the listing in 1992.

When the petition for listing was filed in 1991, the presence of two populations of *O. nerka* (resident kokanee and anadromous sockeye salmon) in Redfish Lake complicated the decision to list the species as endangered. The population proposed for listing was the sockeye salmon population, an anadromous form of *O. nerka* that spawns on the shoals of the lake in October and November. Juvenile sockeye salmon spend one or two years in the lake before smolting and migrating to the Pacific Ocean although a variable proportion may residualize (see below). Adult sockeye salmon spend one, two, or three years in the ocean before returning to Redfish Lake to spawn. The resident form of *O. nerka* (kokanee) spawns in Fishhook Creek, a tributary to Redfish Lake, in August and September and spends their entire life in Redfish Lake. A third life history form of *O. nerka* was discovered in Redfish Lake in 1992. This form, known as residual sockeye salmon, spawn with the anadromous sockeye salmon on the shoals of the lake in October and November and are genetically similar to the anadromous sockeye salmon. Residual sockeye salmon spend their entire life in Redfish Lake and their progeny spend one or two years in the lake before smolting and migrating to the ocean. A variable portion of residual progeny may conform to a resident life history pattern.

The decision to list Snake River sockeye salmon as endangered required that they meet the definition of a “species” as defined by the ESA. Waples (1991) defined “species” as it pertains to Pacific salmon. The definition of a species is interpreted to include any subspecies of fish or any distinct population segment of any species that interbreeds when mature. Two criteria must be met for a population to be considered an evolutionarily significant unit (ESU) and, therefore, a species. The population must be reproductively isolated, and it must represent an important component in the evolutionary legacy of the species. Reproductive isolation does not have to be absolute, but it must be strong enough to allow evolutionarily important differences to accrue in the different population units (Waples 1991).

Studies conducted after Snake River sockeye salmon were listed as endangered clarified the genetic relationships between anadromous sockeye salmon, residual sockeye salmon, and resident kokanee. Waples et al. (1997) stated that there were two distinct gene pools of *O. nerka* in Redfish Lake: one consisting of Redfish Lake kokanee, the other of anadromous and residual sockeye salmon. Because of the new information, the Snake River sockeye salmon ESU was defined to specifically exclude the Fishhook Creek kokanee population from ESA protection.

In Idaho, only the lakes of the upper Salmon River (Sawtooth Valley) remain as potential sources of production for sockeye salmon. Historically, five Sawtooth Valley lakes (Redfish, Alturas, Pettit, Stanley, and Yellowbelly) supported sockeye salmon (Bjornn et al. 1968). Current recovery efforts are focused on Redfish, Pettit, and Alturas lakes. Since 1991, 16 wild and 302 hatchery-produced adult Snake River sockeye salmon have returned to the Sawtooth Valley from the Pacific Ocean.

The Snake River Salmon Sawtooth Valley Project was started in 1991 as a cooperative effort between the Shoshone-Bannock Tribes (SBT), NOAA, and IDFG with the goal of conserving and rebuilding sockeye salmon populations in Idaho. Bonneville Power Administration (BPA) provides funding for the project. Coordination and guidance for the recovery effort are provided by the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC) composed of biologists representing the agencies involved in the recovery and management of Snake River sockeye salmon. Research and recovery activities associated with Snake River sockeye salmon are permitted under the ESA (NOAA) Nos. 1120, 1124, and 1233).

Idaho Department of Fish and Game participation in the Snake River Salmon Sawtooth Valley Project includes two areas of effort: 1) the sockeye salmon captive broodstock program, and 2) Sawtooth Valley fisheries research. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to the captive broodstock program appears under a separate cover (Willard et al. 2003). This report details fisheries research information collected between January 1 and December 31, 2002, including Sawtooth Valley lakes O. nerka population monitoring, sport fishery evaluation on Redfish and Pettit 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.

PROJECT GOAL

The ultimate goal of the IDFG captive broodstock development and evaluation efforts is to recover sockeye salmon runs in Idaho waters. Recovery is defined as reestablishing sockeye salmon runs and providing for utilization of sockeye salmon and kokanee resources by anglers. The immediate project goal is to maintain this unique sockeye salmon population through captive broodstock technology and avoid species extinction.

PROJECT OBJECTIVES

1. Develop captive broodstocks from Redfish Lake anadromous sockeye salmon.

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 supplementation efforts.

4. Refine our ability 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, providing written activity reports and participation in essential program management and planning activities.

STUDY AREA

Recovery efforts for Idaho sockeye salmon focus on Redfish, Alturas, and Pettit lakes in the Sawtooth Valley (Figure 1) located within the Sawtooth National Recreation Area. Valley lakes are glacial-carved, ranging in elevation from 1,985 m to 2,138 m (Table 1), and receive runoff from the Sawtooth and Smokey mountains. Lakes in the Sawtooth Valley are considered ultra oligotrophic. The lakes are part of the upper Salmon River watershed. The Salmon River flows into the Snake River and then the Columbia River, which drains into the Pacific Ocean. The Sawtooth Valley is approximately 1,450 river km from the mouth of the Columbia River.

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. clarki 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. Sport fishing 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 12 kokanee per day with no seasonal closures (IDFG 2002). Sportfishing regulations on Redfish Lake restrict kokanee fishing/harvest to January 1 through August 7 to protect residual sockeye salmon. No trout have been stocked in Redfish Lake since 1992.

Captive Broodstock Program Egg and Juvenile Supplementation

Reintroduction plans for captive broodstock progeny have followed a "spread-the-risk" philosophy incorporating multiple release strategies and lakes. 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, 2) presmolt releases direct to lakes (a transport barge is used to release presmolts at mid lake locations), 3) presmolt transfers to net pens for in-lake rearing and release in Redfish Lake, 4) smolt releases to the outlet of Redfish Lake and to the upper Salmon River, and 5) prespawn adult releases direct to lakes.

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

In 2001, 120,150 sockeye salmon were released into Sawtooth Valley waters from the captive broodstock program (Table 2). All presmolts released in 2001 were age-0 fish from brood year (BY) 2000. Redfish Lake received 41,529 adipose fin-clipped presmolts released directly to the lake in October and 41,474 adipose and left ventral fin-clipped presmolts reared in net pens and released into the lake in October. Presmolts released directly to the lake were reared at the IDFG's Sawtooth Fish Hatchery (SWT); presmolts released to net pens were reared at the IDFG's Eagle Fish Hatchery (EAG). Fifty-five hatchery-produced adult sockeye salmon (BY97) and 14 anadromous (hatchery-origin) adult sockeye salmon (seven males and seven females) were released to Redfish Lake in September for volitional spawning. Alturas Lake received 6,123 presmolts (3,059 reared at SWT and 3,064 reared at EAG) in July and 5,990 presmolts (reared at SWT) in October by direct lake releases. Pettit Lake received 6,057 presmolts (2,998 reared at SWT and 3,059 reared at EAG) in July and 4,993 presmolts (reared at SWT) in October by direct lake releases. Redfish Lake Creek received 13,915 age-1 smolts (BY99), reared at the Oregon Department of Fish and Wildlife's (ODFW) Bonneville Fish Hatchery, in May; the smolts were released directly below the Redfish Lake Creek juvenile out-migrant trap.

In 2002, 179,272 sockeye salmon and 30,924 sockeye salmon eyed-eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 3). All presmolts released in 2002 were age-0 fish from BY01. Redfish Lake received 61,500 adipose and right ventral fin-clipped presmolts (reared at ODFW) in August and 45,001 adipose fin-clipped presmolts (reared at SWT) in October by direct lake releases. Twelve anadromous adult sockeye salmon (hatchery-origin) and 178 BY99 hatchery-produced adult sockeye salmon (131 reared at NOAA Manchester Marine Lab and 47 reared at EAG) were released to Redfish Lake for volitional spawning in September. Alturas Lake received 6,123 adipose and right ventral fin-clipped presmolts (reared at ODFW) from a direct lake release in August. Pettit Lake received 7,805 adipose and right ventral fin-clipped presmolts in August (reared at ODFW) and 19,981 adipose fin-clipped and coded wire-tagged presmolts in October (reared at SWT) by direct lake releases. In November, 30,924 eyed-eggs (BY02, reared at NOAA Burley Creek Hatchery) were planted in Pettit Lake. Redfish Lake Creek received 38,672 adipose fin-clipped and coded wire-tagged age-1 smolts (BY00, reared at SWT) in May; the smolts were released directly below the Redfish Lake Creek juvenile out-migrant trap.

Table 1. Physical and morphometric characteristics of five study lakes located in the Sawtooth Valley, Idaho.

Surface Area (ha)	Elevation (m)	Volume (m^3 x 10^6)	Mean Depth (m)	Maximum Depth (m)	Drainage Area (km^2)
		Redfish Lake			
615	1,996	269.9	44	91	108.1
		Alturas Lake			
338	2,138	108.2	32	53	75.7
		Pettit Lake			
160	2,132	45.0	28	52	27.4
		Stanley Lake			
81	1,985	10.4	13	26	39.4
		Yellowbelly Lake			
73	2,157	10.3	14	26	30.4

Table 2. Sockeye salmon releases to Sawtooth Valley waters in 2001.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks[a]	Number PIT-tagged	Mean Release Weight (g)	Rearing[b] Location
Redfish Lake Creek (below trap)	smolt (1999)	05/02/2001	13,915	AD/CWT	1,000	49.4	ODFW
Redfish Lake (direct lake)	presmolt (2000)	10/08/2001	41,529	AD	0	10.8	SFH
Redfish Lake (net pen)	presmolt (2000)	10/10/2001	41,474	AD/LV	0	30.0	EAG
	adult						
	(1997)	09/09/2001	33	AD	0	2,522	NOAA-MML
Redfish Lake	(1997)	09/10/2001	32	AD	0	2,522	Anadromous
(boat ramp)	(1997)	09/10/2001	14	None	0	2,522	Anadromous
	presmolt						
	(2000)	07/27/2001	3,064	AD/LV	0	14.5	EAG
Alturas Lake	(2000)	07/31/2001	3,059	AD/RV	0	4.0	SFH
(direct lake)	(2000)	10/09/2001	5,990	AD	0	14.0	SFH
	presmolt						
	(2000)	07/27/2001	3,059	AD/LV	0	14.4	EAG
Pettit Lake	(2000)	07/31/2001	2,998	AD/RV	0	4.0	SFH
(direct lake)	(2000)	10/09/2001	4,993	AD	0	15.4	SFH

[a] AD = adipose fin-clip; LV = left ventral fin-clip; RV = right ventral fin-clip; and CWT = coded-wire tagged.
[b] ODFW = Oregon Department of Fish and Game Bonneville Hatchery; SFH = Idaho Department of Fish and Game Sawtooth Hatchery; EAG = Idaho Department of Fish and Game Eagle Hatchery; NOAA-MML = National Oceanic and Atmospheric Administration Manchester Marine Lab.

Table 3. Sockeye salmon releases to Sawtooth Valley waters in 2002.

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

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

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

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

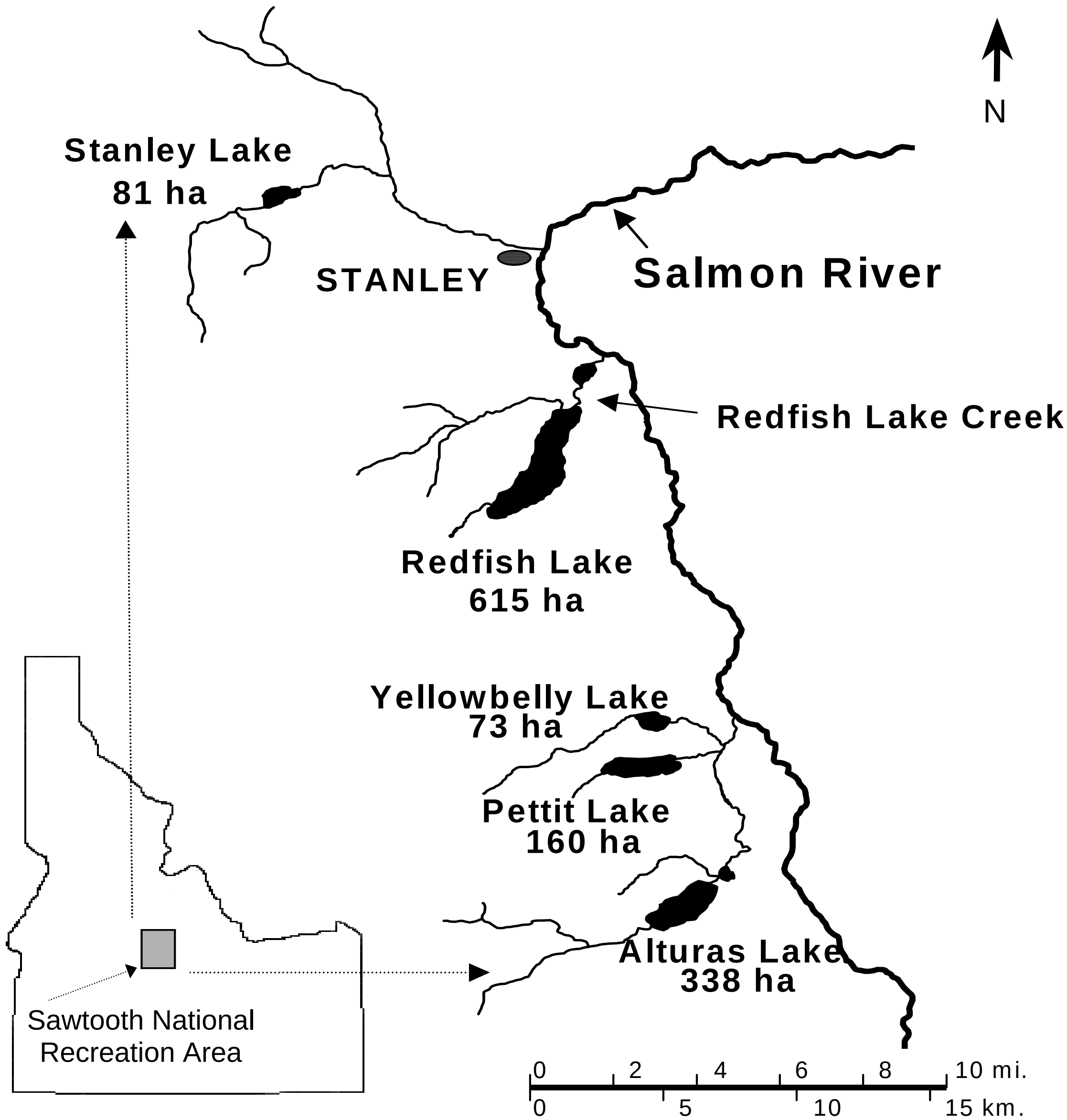

Figure 1. Location of the Sawtooth Valley in Idaho.

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PART 2—*ONCORHYNCHUS NERKA* POPULATION MONITORING

INTRODUCTION

Understanding the dynamics of *O. nerka* populations in the Sawtooth Valley lakes is a vital part of sockeye salmon restoration efforts. Knowledge of *O. nerka* abundance, coupled with limnology data (collected by the SBT) is necessary for making responsible decisions regarding the reintroduction of sockeye salmon juveniles from the captive broodstock program.

METHODS

To estimate *O. nerka* abundance, density, and biomass in Sawtooth Valley lakes, midwater trawling was conducted at night during the dark (new) phase of the moon in September. Our sampling gear does not effectively sample fish >250 mm fork length. 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. 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 4-6, 2002. 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, where three program employees aged them to determine length ranges for age classification. Scales were pressed into acetate before aging. Tissue samples were collected and sent to the University of Idaho's Center for Salmonid and Freshwater Species at Risk for genetic analysis. Stomachs were removed and preserved for diet analysis by SBT biologists. Heads were removed and submitted to IDFG's Eagle Fish Health Lab for whirling disease testing.

RESULTS

<u>Redfish Lake</u>

September trawl catch (four transects, Appendix A) included 44 wild/natural *O. nerka*, five hatchery-produced sockeye salmon (right ventral fin-clipped), two redside shiners, and two sculpin. The hatchery-produced sockeye salmon were from an August presmolt (reared at ODFW) release. *Oncorhynchus nerka* abundance was estimated at 50,204 fish (95% CI ± 28,485). Density and biomass were estimated at 81.6 fish/ha and 0.95 kg/ha (Table 4). Age-0, age-1, age-2 *O. nerka* were captured in the trawl on Redfish Lake; however, only one age-1 fish and three age-2 fish were captured (Table 5). Age-0 *O. nerka* abundance was estimated at 45,417 fish (95% CI ± 28,800) and contributed 17% of the biomass.

Alturas Lake

September trawl catch on Alturas Lake (five transects, Appendix A) included 51 wild/natural *O. nerka* and zero hatchery-produced sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 24,374 fish (95% CI ± 16,968), 72.1 fish/ha, and 2.2 kg/ha (Table 4). Age-0, age-1, age-2, and age-3 *O. nerka* were captured in the trawl. Age-2 fish had the highest density (59 fish/ha) and contributed 92% of the biomass (Table 5).

Pettit Lake

September trawl catch on Pettit Lake (four transects, Appendix A) included 36 wild/natural *O. nerka* and zero hatchery-produced sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 18,328 fish (95% CI ± 2,351), 114.5 fish/ha, and 12.1 kg/ha respectively (Table 4). Only age-2 and age-3 fish were captured in the trawl; age-2 fish contributed 71.9% of the biomass (Table 5).

DISCUSSION

Redfish Lake

Although Redfish Lake has the largest surface area of the three lakes studied, spawning habitat is thought to limit kokanee population abundance. Because kokanee spawning is limited to a short reach of Fishhook Creek, the kokanee population has been relatively stable from 1990 to 1999 and has maintained moderate densities compared to the other lakes in the valley. Prior to 2000, year-to-year *O. nerka* population abundance estimates varied less than 40%. Abundance decreased in 2000 to the lowest recorded value (10,268 fish). In 2002, we documented an increase in abundance (50,204 fish), compared to 12,980 fish observed in 2001. Adult kokanee spawner escapement to Fishhook Creek increased from 60 fish in the fall of 2000 to 5,853 fish during the fall of 2001 (D. Taki, Shoshone-Bannock Tribes, personal communication).

Following the documented reduction of *O. nerka* biomass in 2000, we theorized that the reduced grazing pressure would allow zooplankton biomass to increase. According to data from the SBT (November 2002 SBSTOC minutes), mean summer zooplankton biomass (June to October) in Redfish Lake reached an all-time high during the summer of 2000 (no lake fertilization was conducted). *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 and suggested grazing pressure from the resident *O. nerka* population may control zooplankton biomass. Lake fertilization was conducted during the summers of 2001 and 2002; 2001 summer zooplankton biomass maintained similar high levels recorded during the summer of 2000. The effects of *O. nerka* abundance on zooplankton biomass cannot be determined for 2001 or 2002 due to confounding effects of lake fertilization.

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 4). As the population size increases and food resources become limited, the population size declines, creating a "boom and crash" population growth cycle. We observed a continued decline in the 2002 abundance estimate (24,374 fish) from the 2000 and 2001 estimates (125,462 fish and 70,159 fish, respectively). This decrease may have contributed to low spawner escapement of only 827 adult kokanee during the fall of 2000 and 145 adult kokanee during the fall of 2001 compared to a spawner escapement of 8,334 adults in 1999. The observed reduction in escapement could have negatively effected age-0 recruitment (D. Taki, Shoshone-Bannock Tribes, personal communication).

The high *O. nerka* abundance observed in 2000 may have caused a decline in the zooplankton resources of the lake in 2001. Cyclopoid copepods, *Holopedium spp.,* and *Daphnia spp*. biomass were at a four-year low (SBSTOC minutes March 2002) in 2001. Based on past observations of high *O. nerka* abundance (1990 and 1991), all zooplankton except *Bosmina spp.* were scarce for several years following high *O. nerka* abundance. The summer 2002 data indicated an increase in zooplankton biomass is occurring, reversing the declining trend seen in previous years and improving the desirability of the lake for sockeye salmon restoration activities.

Pettit Lake

Since monitoring began in 1992, Pettit Lake has exhibited the greatest relative fluctuation in *O. nerka* numbers (maximum to minimum range) of the three lakes studied. *Oncorhynchus nerka* abundance increased from 1992 (3,009 fish) to 1996 (71,654 fish), then declined in 1997 (21,730 fish; Table 4). The population increased steadily from 1997 to 2000, reaching a high of 40,559 fish. This was followed by a sharp decline in *O. nerka* abundance to 16,931 fish in 2001; only a moderate increase to 18,328 fish was observed in 2002.

We suspect that the decrease in *O. nerka* abundance may be a result of sampling bias associated with our midwater trawling efforts rather than an actual decrease in abundance. For the last four years, we have failed to capture age-0 *O. nerka* in Pettit Lake during trawl surveys; however, age-1 and older *O. nerka* have been captured annually. This suggests age-0 *O. nerka* are present but not sampled by our gear. One possible explanation is age-0 *O. nerka* are utilizing near-shore habitat that we do not sample during our trawl surveys. Zooplankton biomass in Pettit Lake has been increasing since June 2000 and reached an all-time high in June 2002; lake rearing conditions are currently favorable for *O. nerka*. These data support our hypothesis that the reported reduction in *O. nerka* abundance is most likely a result of sampling error.

Table 4. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, Pettit, and Stanley lakes, 1990 to 2002.

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

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

Table 5. Estimated 2002 *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**	**Total**
			Redfish Lake (615 surface ha)		
# captured	40	1	3	0	44
Length range (mm)	0-90	91-199	200-240	NA	NA
Mean length (mm)	61.3	116	224.7	NA	NA
Mean weight (g)	2.2	16.8	130.5	NA	NA
Abundance	45,417	1,195	3,592	NA	50,204
95% CI High	74,217	3,585	5,987	NA	78,689
95% CI Low	16,618	0	1,197	NA	21,719
Density (fish/ha)	73.9	1.9	5.8	NA	81.6
Biomass (kg/ha)	0.16	0.03	0.75	NA	0.95
			Alturas Lake (338 surface ha)		
# captured	3	4	38	6	51
Length range (mm)	0-60	61-105	106-165	166-230	NA
Mean length (mm)	57.7	93.5	143.7	168.2	NA
Mean weight (g)	1.8	7.5	34.2	53.9	NA
Abundance	1,476	1,968	19,947	984	24,374
95% CI High	3,443	3,808	36,656	2,189	41,342
95% CI Low	0	127	3,237	0	7,406
Density (fish/ha)	4.4	5.8	59.0	2.9	72.1
Biomass (kg/ha)	0.01	0.04	2.02	0.16	2.2
			Pettit Lake (160 surface ha)		
# captured	0	0	28	8	36
Length range (mm)	NA	NA	101-210	211-250	NA
Mean length (mm)	NA	NA	195.3	215.9	NA
Mean weight (g)	NA	NA	97.7	136.8	NA
Abundance	NA	NA	14,255	4,073	18,328
95% CI High	NA	NA	15,918	5,736	20,679
95% CI Low	NA	NA	12,592	2,410	15,977
Density (fish/ha)	NA	NA	89.1	25.5	114.5
Biomass (kg/ha)	NA	NA	8.7	3.5	12.1

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PART 3—REDFISH AND PETTIT LAKES SPORT FISHERY INVESTIGATIONS

INTRODUCTION

The kokanee fishery on Redfish Lake was closed in 1993 due to the presence of ESA listed residual sockeye salmon but was reopened in 1995 (NOAA Permit 1233). The kokanee fishery was opened based on the recommendation of the SBSTOC to reduce kokanee competition with sockeye salmon by removing spawning age kokanee through angler harvest. Permit 1233 (NOAA) requires IDFG to monitor angler harvest of listed sockeye salmon in Redfish Lake during the kokanee fishing season. The kokanee season on Redfish Lake opens on January 1 and closes on August 7 because mature kokanee initiate spawning in Fishhook Creek at this time, while residual sockeye salmon remain in the lake.

The roving creel survey conducted on Redfish and Pettit lakes was designed to estimate total kokanee harvest and to collect tissue samples for genetic analysis from angler-harvested kokanee. The tissue samples were analyzed by the University of Idaho's Center for Salmonid and Freshwater Species at Risk to estimate the number of residual sockeye salmon harvested incidental to the kokanee fishery.

METHODS

Redfish Lake

A roving creel survey was conducted from May 25 through August 7, 2002 (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) 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 count. Anglers were asked how many fish they had harvested and/or released by species, how many hours they had fished, and the type of gear they used; responses were recorded. Fin clips were taken from creeled kokanee that were checked by creel survey personnel. Fin clips were stored in Lysis buffer solution and delivered to University of Idaho personnel for DNA analysis. Creel data were analyzed using the Creel Census System computer program developed by McArthur (1992) and used to estimate angler effort, catch rates, and harvest.

Pettit Lake

A roving creel survey of Pettit Lake was conducted from May 25 through September 2, 2002 following the same procedures described above for Redfish Lake. There is no kokanee fishing/harvest closure on Pettit Lake.

RESULTS

Redfish Lake

In 2002, we contacted 100 angler parties (147 individual anglers) on Redfish Lake. Idaho residents made up 85% of those interviewed. Most anglers used lures (61%), followed by bait (37%), and flies (1%). Total angler effort was estimated at 2,127 hours (95% CI ± 615). Boat anglers expended more effort than bank anglers (Table 6). The average fishing trip lasted 2.3 hours.

The season catch rate for all fish (harvested and released) was 0.52 fish/hour. Season catch rates (all fish) were higher for weekdays (0.56 fish/hour) than for weekends (0.42 fish/hour; Table 7). Kokanee catch rates (harvested and released) averaged 0.25 fish/hour for weekdays and weekends. Bull trout catch rates averaged 0.16 fish/hour (IDFG regulations prohibit harvesting bull trout). Other fish (northern pikeminnow, sucker *catostomus spp*., redside shiner) accounted for catch rates of 0.10 fish/hour for the season.

Total number of fish caught (harvested and released) at Redfish Lake was estimated at 1,227 fish (95% CI ± 540; Table 8). The majority (87%) of all fish caught were released. Kokanee harvest was estimated at 129 fish (95% CI ± 179). Bull trout and kokanee comprised the majority of the fish released by anglers.

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. Of the 378 fin clips collected from creeled kokanee since 1996, 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 2002 fishery, we estimate an incidental take of one ESU fish. Permit 1233 allows for an incidental take of 34 naturally-produced (unmarked) Snake River sockeye salmon associated with the kokanee fishery on Redfish Lake. In 2002, 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.

Pettit Lake

In 2002, we contacted 112 angler parties (169 individual anglers) on Pettit Lake. Idaho residents made up 76% of those interviewed. Most of the angling was done with lures (59%), followed by bait (23%) and flies (17%). Total angler effort was estimated at 791 hours (95% CI ± 354); boat anglers fished 401 hours (95% CI ± 260), bank anglers fished 341 hours (95% CI ± 234), and tube anglers fished 48 hours (95% CI ± 56; Table 6). The average angling trip lasted 2.2 hours.

The season catch rate for all fish (harvested and released) was 0.37 fish/hour (Table 7). Seasonal catch rates (all fish) were higher for weekdays (0.42 fish/hour) than for weekends (0.23 fish/hour). Kokanee catch rates (harvested and released) averaged 0.02 fish/hour for the season. Bull trout catch rates averaged 0.02 fish/hour. Catch rates for rainbow trout were higher on weekdays (0.32 fish/hour) than weekends (0.15 fish/hour). Other fish species (hatchery-produced sockeye salmon, brook trout, northern pikeminnow, redside shiners) accounted for catch rates of 0.05 fish/hour for the season.

The total number of fish caught (harvested and released) at Pettit Lake was estimated at 299 fish (95% CI ± 174); the majority (87.5%) were rainbow trout (Table 8). Of the 3,004 rainbow trout planted in Pettit Lake, anglers harvested approximately 3.6%. An estimated six kokanee (95% CI ± 9) were harvested from Pettit Lake during the 2002 season and 20 hatchery-produced sockeye salmon were reportedly caught (18 released, two harvested). Pettit Lake was posted (as described above for Redfish Lake) to alert anglers on the presence of ESA-listed sockeye salmon.

DISCUSSION

Redfish Lake

In addition to providing an important recreational fishery, the Redfish Lake kokanee fishery benefits the sockeye salmon population by reducing competition between sockeye salmon and kokanee. Kokanee escapement to Fishhook Creek during the 2002 spawning season was estimated at 8,626 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. Removal of spawning-age kokanee by sport harvest helps to reduce total egg deposition, potentially decreasing kokanee recruitment and competition with sockeye salmon in future years. In 2002, estimated kokanee harvest was 129 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 (2,127 hours) during the 2002 season was lower than the average effort estimated for 1996 through 2001 (3,982 hours). Despite average catch rates for kokanee (0.25 fish/hour), the observed decrease in angler effort could explain the low estimated kokanee harvest observed in 2002.

Pettit Lake

The last creel survey conducted on Pettit Lake was in 1999. Estimated angler effort in 2002 increased to 791 hours from 455 hours estimated in 1999; kokanee catch rates in 2002 decreased to 0.02 fish/hour from 0.08 fish/hour estimated in 1999; estimated kokanee harvest decreased slightly from 11 fish in 1999 to six fish in 2002. However, rainbow trout catch rates increased from 1999. Although not reported, the majority of the 2002 angler effort was most likely devoted to the pursuit of hatchery rainbow trout. The combination of anglers targeting the rainbow fishery, unimproved boat ramp facilities, and limited access compared to Redfish Lake may have contributed to the low kokanee harvest in 2002.

Table 6. Estimated angler effort for the 2002 fishing season on Redfish and Pettit lakes.

	Boat	Bank	Tube	Total
Redfish Lake				
Hours fished	1,254	872	0	2,127
±95% CI	473	392	0	615
Pettit Lake				
Hours fished	401	341	48	791
±95% CI	260	234	56	354

Table 7. Catch rates (fish/hour) for summer 2002 on Redfish and Pettit lakes categorized by day type and species.

	Kokanee			Bull Trout	Rainbow Trout		Other		All Fish		
Day Code	Kept	Released	Combined	Released	Kept	Released	Kept	Released	Kept	Released	Combined
Redfish Lake											
Weekday	0.12	0.23	0.35	0.19	0.01	0.00	0.01	0.01	0.13	0.43	0.56
Weekend day	0.00	0.01	0.01	0.07	0.00	0.01	0.00	0.33	0.00	0.42	0.42
Season average	0.09	0.16	0.25	0.16	0.01	0.00	0.01	0.10	0.10	0.43	0.52
Pettit Lake											
Weekday	0.01	0.01	0.02	0.03	0.08	0.24	0.00	0.06	0.09	0.34	0.42
Weekend day	0.00	0.02	0.02	0.01	0.05	0.10	0.01	0.04	0.07	0.16	0.23
Season average	0.01	0.01	0.02	0.02	0.08	0.20	0.00	0.05	0.08	0.29	0.37

Table 8. Estimated number of fish harvested and released on Redfish and Pettit lakes during the summer 2002.

	Harvested			All Fish		
	Kokanee	Rainbow Trout	Other	Released	Harvested	Combined
Redfish Lake						
Number of fish	129	11	29	1,066	161	1,227
±95% CI	179	28	35	411	190	540
Pettit Lake						
Number of fish	6	109	5	183	117	299
±95% CI	9	80	11	108	82	174

LITERATURE CITED

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PART 4—SOCKEYE SALMON SMOLT MONITORING AND EVALUATION

INTRODUCTION

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

METHODS

Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) is located 1.4 km downstream from the lake outlet at a permanent weir site and was operated from April 18 to June 12, 2002. The trap functions as a juvenile trap and with only minor modifications as an adult trap (Craddock 1958; Bjornn et al. 1968; Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000, 2002, 2003). The trap contains nine bays, five of which are fitted with juvenile trap boxes. Personnel from IDFG checked the trap twice daily in 2002.

All sockeye salmon smolts captured at RLCTRP were anesthetized in buffered MS-222 (tricaine methanesulfonate), measured for fork length (1 mm) and weight (0.1g), and scanned for PIT tags. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 41,529 adipose fin-clipped presmolts (reared at SWT) released directly to the lake in October 2001 and 41,474 adipose and left ventral fin-clipped presmolts reared in net pens and released into the lake in October 2001.

To estimate trapping efficiency, up to 30 wild/natural sockeye salmon smolts (determined by presence of an adipose fin) and 60 hatchery-produced sockeye salmon smolts (30 fall direct-released and 30 net pen-released) were PIT tagged daily and released approximately 250 m upstream of the weir one-half hour after sunset. Flow-through live boxes with locking lids were used to hold fish until the evening release.

Trapping efficiencies were calculated for three time periods for wild/natural, fall direct-released, and net pen-released sockeye salmon smolts. Intervals were selected based on stream discharge similarities and the number of PIT-tagged smolts released upstream of the weir that were available for recapture. Out-migrant run size and 95% confidence intervals were estimated using methods described by Steinhorst et al. (In review). Smolt out-migration estimates were generated separately for wild/natural, fall direct-released, and net pen-released sockeye salmon smolts.

Contingency tables (2 x 2) and Fisher's exact tests ($\alpha = 0.10$) were used to compare out-migration success by release strategy at RLCTRP (Motulsky 1995). Differential marks per release strategy allowed us to determine interrogation rates at the trap and compare out-migration success of fall direct-released presmolts and net pen-released presmolts.

Alturas Lake Creek and Pettit Lake Creek Traps

Sockeye salmon out-migrant trapping and PIT tagging on Alturas Lake Creek and Pettit Lake Creek was conducted by SBT. The Alturas Lake Creek screw trap is located 13 km downstream from the Alturas Lake outlet and was operated from April 23 to May 31, 2002. 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 31, 2002. The methods utilized by the SBT were consistent with the methods described above for the RLCTRP. Alturas Lake out-migrant run size and 95% confidence intervals were estimated using methods described by Steinhorst et al. (In review). The Pettit Lake Creek weir traps at 100% efficiency; therefore, out-migration run size for Pettit Lake is based on the actual number of smolts trapped.

Contingency tables (2 x 2) and Fisher's exact tests ($\alpha = 0.10$) were used to compare out-migration success by release strategy at the Alturas Lake Creek and Pettit Lake Creek traps (Motulsky 1995). Differential marks per release strategy allowed us to determine interrogation rates at the traps and compare out-migration success of fall direct-released presmolts, summer direct-released presmolts (reared at SWT), and summer direct-released presmolts (reared at EAG) for Alturas and Pettit lakes.

Mainstem Snake and Columbia River Dams

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

Median travel times to downstream dams with fish detection facilities were calculated for wild/natural and hatchery-produced sockeye salmon smolts. Distribution of arrival times for PIT-tagged fish at LGR were compared for wild/natural and hatchery-produced progeny (by release strategy) using two-sample Kolmogorov-Smirnov tests ($\alpha = 0.10$) (Sokal and Rohlf 2000). Contingency tables (2 x 2) and Fisher's exact tests ($\alpha = 0.10$) were used to compare cumulative unique PIT tag interrogations from out-migrant traps to LGR, LGJ, LMN, and MCN between selected release strategies (Motulsky 1995).

A priori power analyses for testing equality of proportional data were performed to determine PIT tag sample sizes needed for comparisons (Cohen 1988). To detect an effect of approximately 10% between test groups (expressed as proportional survival information collected at out-migration monitoring locations), we estimated that approximately 600 observations would be needed (combined for both test groups) to achieve an 80% level of power.

RESULTS

Redfish Lake Creek Trap

A total of 13,352 sockeye salmon smolts (2,319 wild/natural, 9,724 fall direct-released, and 1,309 net pen-released) were trapped during the 2002 out-migration season (Figure 2). Fork length of wild/natural, fall direct-released, and net pen-released sockeye salmon smolts captured averaged 123 mm (range 104 mm to 171 mm; Figure 3), 126 mm (range 103 mm to 203 mm; Figure 4), and 147 mm (range 107 mm to 191 mm; Figure 5), respectively.

To estimate total wild/natural and hatchery-produced sockeye salmon smolt out-migration, the trapping season was divided into three periods of similar discharge. Trapping intervals ran from April 18 to May 4, May 5 to May 13, and May 14 to June 12.

Of the 2,319 wild/natural smolts handled in 2002, 630 were marked and released upstream of the weir to estimate trapping efficiency. Trap efficiency was estimated at 46%, 53%, and 31% for the three trapping intervals. Total wild/natural sockeye smolt out-migration was estimated at 4,951 fish (95% CI 4,524 to 5,471; Table 9).

Of the 9,724 fall direct-released smolts handled in 2002, 1,179 were marked and released upstream of the weir to estimate trap efficiency. Trap efficiency was estimated at 58%, 59%, and 30% for the three trapping intervals. Total hatchery-produced, fall direct-released smolt out-migration was estimated at 19,758 fish (95% CI 18,485 to 21,101; Table 9). This out-migration represents a 48% overwinter survival and out-migration for October 2001 direct-released presmolts.

Of the 1,309 net pen-released smolts handled in 2002, 586 were marked and released upstream of the weir to estimate trap efficiency. Trap efficiency was estimated at 8%, 49%, and 24% for the three trapping intervals. Total net pen-released smolt out-migration was estimated at 5,939 fish (95% CI 4,424 to 8,815; Table 9). This out-migration represents a 14% overwinter survival and out-migration for October 2001 net pen-released presmolts.

A total of 11,033 hatchery-produced fish were handled at RLCTRP (1,309 net pen-released and 9,724 fall direct-released). Fall direct-released presmolts overwintered and out-migrated significantly better ($P < 0.001$) than net pen-released presmolts (Table 10).

Alturas Lake Creek and Pettit Lake Creek Traps

Total wild/natural sockeye smolt out-migration for Alturas Lake was estimated at 6,176 fish (95% CI 4,115 to 22,229), fall direct-released smolt out-migration was estimated at 3,505 fish (95% CI 2,449 to 12,940), summer direct-released (reared at SWT) smolt out-migration was estimated at 58 fish (95% CI 14 to 19,853), and summer direct-released (reared at EAG) smolt out-migration was estimated at 39 fish (95% CI 8 to 27,660).

At the Pettit Lake Creek trap, 1,067 wild/natural sockeye smolts, 1,451 fall direct-released smolts, 200 summer direct-released (reared at SWT), and 152 summer direct-released (reared at EAG) smolts were enumerated out-migrating from the lake.

A total of 502 hatchery-produced fish were handled at Alturas Lake Creek trap (482 fall direct-released, 12 summer direct-released [reared at SWT], and eight summer direct-released [reared at EAG]). Fall direct-released presmolts overwintered and out-migrated significantly better (P <0.001) than summer direct-released presmolts reared at SWT and EAG. A significant difference in overwinter survival and out-migration was not observed (P = 0.382) between summer direct-released presmolts reared at SWT and summer direct-released presmolts reared at EAG (Table 10).

A total of 1,803 hatchery-produced fish were handled at Pettit Lake Creek trap (1,451 fall direct-released, 200 summer direct-released [reared at SWT], and 152 summer direct-released [reared at EAG]). Fall direct-released presmolts overwintered and out-migrated significantly better (P <0.001) than summer direct-released presmolts reared at SWT and EAG. Summer direct-released presmolts reared at SWT overwintered and out-migrated significantly better (P = 0.005) than summer direct-released presmolts reared at EAG (Table 10).

Mainstem Snake and Columbia River Dams

We estimated smolt out-migration success to LGR by release strategy using PIT tag interrogation data (Table 11; Appendix B). Estimates reflect numbers of smolts passing LGR adjusted for DCE (Appendix C). Redfish Lake had four groups of smolts for which estimates of out-migration were made: wild/natural, fall direct-released presmolts, net pen-released presmolts, and smolts released below the RLCTRP in May. Estimated numbers were 1,500 (30.3%) wild/natural, 6,678 (33.8%) fall direct-released, 730 (12.3%) net pen-released, and 1,372 (3.5%) Redfish Lake Creek-released smolts passing LGR. Alturas and Pettit lakes also had four groups of smolts for which estimates of out-migration were made: wild/natural, fall direct-released presmolts, summer direct-released presmolts (reared at SWT), and summer direct-released presmolts (reared at EAG). The numbers of smolts estimated to have passed LGR from Alturas Lake were 1,723 (27.9%) wild/natural, 729 (20.8%) fall direct-released fish, zero summer direct-released (reared at SWT) fish, and zero summer direct-released (reared at EAG) fish. The numbers of smolts estimated to have passed LGR from Pettit Lake were 334 (31.3%) wild/natural fish, 238 (16.4%) fall direct-released fish, 28 (18.2%) summer direct-released (reared at SWT) fish, and 43 (21.4%) summer direct-released (reared at EAG) fish.

Median travel times for PIT-tagged smolts were recorded from Sawtooth Valley trap sites to LGR, LGJ, LMN, and MCN (Table 12). Median travel times to LGR for Redfish Lake wild/natural, fall direct-released, and net pen-released sockeye salmon smolts were 11.4 days, 9.0 days, and 8.7 days, respectively. Median travel time for smolts released directly below the RLCTRP was 12 d. Median travel times to LGR for Alturas Lake wild/natural and fall direct-released sockeye salmon smolts were 12.7 d and 9.5 d, respectively. Alturas Lake summer direct-released sockeye salmon smolts (reared at SWT) and summer direct-released sockeye salmon smolts (reared at EAG) were not detected at LGR. Median travel times to LGR for Pettit Lake wild/natural, fall direct-released, summer direct-released (reared at SWT), and summer direct-released (reared at EAG) sockeye salmon smolts were 15.5 days, 13.1 days, 13.5 days, and 11.6 days, respectively. Significant differences in the distribution of arrival times at LGR were detected for all selected groups except Redfish Lake net pen-released smolts versus Redfish Lake direct-released smolts, Alturas Lake wild/natural smolts versus Alturas Lake fall direct-released smolts, Pettit Lake wild/natural smolts versus Pettit Lake fall direct-released smolts, and Redfish Lake wild/natural smolts versus Alturas Lake wild/natural smolts (Table 13).

Cumulative unique PIT tag detections were compared by group from Sawtooth Valley trap sites to downstream interrogation facilities (Table 14). During the 2002 out-migration year, sockeye salmon smolts were detected between May 5 and June 24; daily collection efficiencies ranged from 9% to 48% (Appendix C). Four smolt groups from Redfish Lake (wild/natural, fall direct-released, net pen-released, and Redfish Lake Creek) and two smolt groups from Alturas Lake and Pettit Lake (wild/natural and fall direct-released) were used in the comparisons. The summer release groups in Alturas and Pettit lakes overwintered and out-migrated at low rates; due to the small sample size, no comparisons were made.

The Redfish Lake fall direct-released smolts had the highest cumulative unique detection rate (30.9%) of all smolt groups; the detection rate was significantly higher than the cumulative unique detection rates for the other three Redfish Lake smolt groups and fall direct-released smolts from Pettit and Alturas lakes (Table 14). Significant differences in PIT tag interrogations and arrival times at LGR were observed between Redfish Lake fall direct-released fish versus Pettit and Alturas lake fall direct-released fish (Table 13). Detections at LGR for the Redfish Lake fall direct-released group were distributed throughout the two-month out-migration period; detections for the fall Alturas and Pettit lake fall direct-released groups were confined within a two-week period.

The Redfish Lake Creek smolt group had the lowest cumulative unique detection rate (10.6%); it was significantly lower ($P < 0.001$) than the detection rates for the other three Redfish Lake groups (Table 14). Significant differences in PIT tag interrogations and arrival times at LGR were observed between the Redfish Lake Creek smolt group versus the other three Redfish Lake smolt groups (Table 13). Detections at LGR for the Redfish Lake smolt group were confined to a five-day period; detections for the other three Redfish Lake smolt groups were distributed throughout the two-month out-migration period.

The Redfish Lake wild/natural smolt group cumulative unique detection rate (25.1%) was the highest compared to the Alturas Lake wild/natural smolt group (23.4%) and Pettit Lake wild/natural smolt group (18.7%). The difference was not significant between Redfish Lake wild/natural versus Alturas Lake wild/natural smolt groups ($P = 0.757$); however, it was significant between Redfish Lake wild/natural versus Pettit Lake wild/natural smolt groups ($P = 0.023$) (Table 14). Significant differences in PIT tag interrogations and arrival times at LGR were observed between the Pettit Lake wild/natural smolt group versus Redfish and Alturas lake smolt groups (Table 13).

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. in review). However, overwinter survival of fall-released presmolts is highly variable among years despite similar early rearing history (Table 14); the factors controlling overwinter survival are poorly understood. Beginning in 1998, presmolts destined for direct release back to Sawtooth Valley lakes have been reared at SWT. The 2002 out-migration year is the fourth opportunity to evaluate presmolts reared at SWT 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.

In three (1998, 1999, and 2002) of the five (1998 through 2002) years of investigation, out-migrants produced from the fall direct-lake release option overwintered and out-migrated significantly better to the RLCTRP than net pen-released presmolts. The net pen fish were reared in 12 m deep enclosures during the summer months and released to Redfish Lake in the fall. We hypothesized that subjecting the fish to variable lake conditions (e.g., temperature, photoperiod, etc.), while protecting them from predators and supplementing a natural diet with a commercial diet would provide an advantage over the fall direct-released group in terms of overwinter survival and out-migration. However, multiple years of interrogation data from RLCTRP has not shown a significant increase in overwinter survival and out-migration for net pen-released fish. It is possible that the difference in out-migration success reflects differences in early rearing locations of the two release groups. The net pen-released presmolts were reared at EAG until they were released into the net pens; the fall direct-released presmolts were reared at SWT until they were released into the lake. Our work with the University of Idaho to apply assessments of fish quality to hatchery-produced fish will provide additional perspectives on factors that may affect fish survival from out-planting through out-migration.

In 2000 and 2001, presmolts reared at EAG and SWT were released to Pettit and Alturas lakes in the summer. In 2002, there was no detectable difference in overwinter survival and out-migration between Alturas Lake summer direct-released presmolts reared at EAG versus presmolts reared at SWT. The results are not consistent with 2001 and 2002 Pettit Lake and 2001 Alturas Lake overwinter and out-migration comparisons; significant differences were observed between the two rearing locations. Different hatchery temperature profiles and fish culture protocols applied to compensate for water temperature differences are likely responsible to some degree for the observed differences in out-migration success. However, the exact mechanisms for the observed performance differences are unknown. The Sawtooth Fish Hatchery is considered by the SBSTOC as the preferred rearing location for presmolt release groups (Hebdon et al. in review).

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. There are no estimates of daily collection efficiencies for sockeye salmon smolts at Lower Granite Dam; because of this lack of data, we must use caution and not overemphasize these results because of the possible difference between species. Date of smolt arrival can also affect the probability of a PIT-tagged fish being detected. For example, during the 2000 out-migration year, PIT-tagged sockeye salmon smolts were detected between May 1 and July 9. Both flow and percent of flow as spill during the period of sockeye salmon smolt out-migration varied widely, and collection efficiency varied accordingly. This resulted in a greater chance for the detection of a PIT-tagged smolt in July (little or no spill) compared to June (with 25 to 49% spill). Daily collection efficiencies partially correct for the changes in the probability of detection.

Cumulative unique PIT tag interrogations are another measure of smolt survival from release to LGR. Fish detected at facilities downstream of LGR first had to successfully pass LGR; cumulative unique interrogations represent a minimum actual survival to LGR. During the 2002 out-migration, the Pettit and Alturas lake fall direct-released presmolt groups recorded significantly lower interrogation rates than the Redfish lake fall direct-released presmolt group. We suspect that overwintering conditions in the lakes will affect a smolt's "fitness" and ability to survive out-migration, which could affect interrogation rates. This may explain the reduced interrogation rates of the Pettit and Alturas lake fall groups. Currently we are working with the University of Idaho to determine if total body lipid content of smolts captured at Sawtooth Valley trap sites can be correlated with interrogation rates downstream.

Table 9. Mark recapture data for sockeye salmon smolts captured at the Redfish Lake Creek trap (by efficiency periods) from April 18 to June 12, 2002. Data are organized by efficiency period.

Wild/natural smolts				
Dates	04/18 – 05/04	05/05 – 05/13	05/14 – 06/12	Total
Trap efficiency	0.46	0.53	0.31	NA
Marked	157	257	216	630
Recaptured	73	136	68	277
Total handled	813	1,206	300	2,319
Estimated total	1,736	2,271	944	4,951
95% CI upper bound	2,057	2,640	1,210	5,471
95% CI lower bound	1,475	1,966	731	4,524
Fall direct-released smolts				
Dates	04/18 – 05/04	05/05 – 05/13	05/14 – 06/12	Total
Trap efficiency	0.58	0.59	0.30	NA
Marked	185	263	731	1,179
Recaptured	107	156	222	485
Total handled	2,553	5,108	2,063	9,724
Estimated total	4,397	8,589	6,772	19,758
Upper bound	4,989	9,757	8,577	21,101
Lower bound	3,883	7,623	5,421	18,485
Net pen-released smolts				
Dates	04/18 – 05/04	05/05 – 05/13	05/14 – 06/12	Total
Trap efficiency	0.08	0.49	0.24	NA
Marked	88	226	274	586
Recaptured	7	111	64	182
Total handled	275	673	361	1,309
Estimated total	3,059	1,364	1,516	5,939
Upper bound	6,079	1,712	2,270	8,815
Lower bound	1,602	1,102	1,056	4,424

Table 10. Fisher's exact test results of recapture data collected at Redfish Lake Creek trap, Alturas Lake Creek trap, and Pettit Lake Creek trap for paired sockeye salmon presmolt releases made in 2001.

Release location	Release strategy	Number of presmolts uniquely marked	Number of out-migrants observed	% Interrogated	P value
	Redfish Lake Creek Trap				
Redfish Lake	net pen-released presmolt	41,474	1,309	3.2%	<0.001
Redfish Lake	fall direct-released presmolt	41,529	9,724	23.4%	
	Alturas Lake Creek Trap				
Alturas Lake	summer direct-released presmolt (SWT)	3,059	12	0.4%	0.382
Alturas Lake	summer direct-released presmolt (EAG)	3,064	8	0.3%	
Alturas Lake	summer direct-released presmolt (SWT)	3,059	12	0.4%	<0.001
Alturas Lake	fall direct-released	5,990	482	8.1%	
Alturas Lake	summer direct-released presmolt (EAG)	3,064	8	0.3%	<0.001
Alturas Lake	fall direct-released	5,990	482	8.1%	
	Pettit Lake Creek Trap				
Pettit Lake	summer direct-released presmolt (SWT)	2,998	200	6.7%	0.005
Pettit Lake	summer direct-released presmolt (EAG)	3,059	152	5.0%	
Pettit Lake	summer direct-released presmolt (SWT)	2,998	200	6.7%	<0.001
Pettit Lake	fall direct-released	4,993	1,451	29.1%	
Pettit Lake	summer direct-released presmolt (EAG)	3,059	152	5.0%	<0.001
Pettit Lake	fall direct-released	4,993	1,451	29.1%	

Table 11. Summary of 2002 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Rearing locations are abbreviated as follows: IDFG Sawtooth Fish Hatchery (SWT) and IDFG Eagle Fish Hatchery (EAG).

Release Strategy (Rearing Location)	Total[a]	Number Tagged	% Tagged	Estimated At Trap	Overwinter Survival At Trap	Estimated PIT Tags AT LGR[b]	% PIT Tags From Traps To LGR	Estimated At LGR	% At LGR From Release
Redfish Lake									
Wild/natural smolt	NA	630	12.7%	4,951	NA	191	30.3%	1,500	NA
Fall direct-released presmolt (SWT)	41,529	1,179	6.0%	19,758	47.6%	399	33.8%	6,678	14.1%
Net pen-released presmolt	41,474	586	9.9%	5,939	14.3%	72	12.3%	730	1.1%
Redfish Lake Creek smolt (SWT)	13,195	1,000	7.6%	13,195	NA	104	10.4%	1,372	10.4%
Alturas Lake[c]									
Wild/natural smolt	NA	158	2.6%	6,176	NA	44	27.9%	1,723	NA
Fall direct-released presmolt (SWT)	5,990	240	6.9%	3,505	58.5%	50	20.8%	729	12.2%
Summer direct-released presmolt (SWT)	3,059	7	12.0%	58	1.9%	0	0.0%	0	0.0%
Summer direct-released presmolt (EAG)	3,064	2	5.1%	39	1.3%	0	0.0%	0	0.0%
Pettit Lake[c]									
Wild/natural smolt	NA	364	34.1%	1,067	NA	114	31.3%	334	NA
Fall direct-released presmolt (SWT)	4,993	330	22.7%	1,451	29.1%	54	16.4%	238	4.8%
Summer direct-released presmolt (SWT)	2,998	33	9.4%	152	5.1%	6	18.2%	28	0.9%
Summer direct-released presmolt (EAG)	3,059	28	8.0%	200	6.5%	6	21.4%	43	1.4%

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

Table 12. Median travel times of PIT-tagged sockeye salmon smolts recorded from outlet creek traps to mainstem Snake and Columbia river dams: Lower Granite (LGR), Little Goose (LGJ), Lower Monumental (LMN), and McNary (MCN) during 2002.

Release Strategy	**Travel Time (Days)**	**LGR**	**LGJ**	**LMN**	**MCN**
Redfish Lake					
Wild/natural	Median (n)	11.4 (52)	14.5 (61)	17.8 (26)	20.7 (19)
Fall direct-released	Median (n)	9.0 (98)	11.0 (139)	12.9 (91)	16.9 (36)
Net pen-released	Median (n)	8.7 (19)	13.2 (16)	14.1 (27)	21.0 (6)
Alturas Lake					
Wild/natural	Median (n)	12.7 (12)	16.1 (12)	19.1 (13)	NA (0)
Fall direct-released	Median (n)	9.5 (16)	13.4 (14)	14.9 (11)	23.0 (1)
Summer direct-released (SWT)	Median (n)	NA (0)	14.6 (2)	NA (0)	NA (0)
Summer direct-released (EAG)	Median (n)	NA (0)	NA (0)	NA (0)	NA (0)
Pettit Lake					
Wild/natural	Median (n)	15.5 (27)	17.7 (17)	19.0 (20)	30.2 (4)
Fall direct-released	Median (n)	13.1 (14)	14.0 (22)	19.0 (12)	22.1 (5)
Summer direct-released (SWT)	Median (n)	13.5 (1)	17.0 (2)	22.1 (2)	NA (0)
Summer direct-released (EAG)	Median (n)	11.6 (1)	16.3 (1)	19.4 (1)	NA (0)
Redfish Lake Creek					
Sawtooth smolt	Median (n)	12.0 (33)	14.6 (27)	21.6 (45)	28.1 (1)

Table 13. Comparisons of distributions of PIT tag interrogations and arrival times at Lower Granite Dam by release strategy for the 2002 out-migration year based on Kolmogorov-Smirnov two-sample tests ($\alpha = 0.10$).

Release Location	Release Strategy	Test Outcome
Redfish Lake Redfish Lake	wild/natural fall direct-released presmolt	Significant
Redfish Lake Redfish Lake	wild/natural net pen-released presmolt	Significant
Redfish Lake Redfish Lake Creek	wild/natural smolt	Significant
Redfish Lake Redfish Lake Creek	fall direct-released presmolt smolt	Significant
Redfish Lake Redfish Lake Creek	net pen-released presmolt smolt	Significant
Redfish Lake Redfish Lake	net pen-released presmolt fall direct-released presmolt	Not significant
Alturas Lake Alturas Lake	wild/natural fall direct-released presmolt	Not significant
Pettit Lake Pettit Lake	wild/natural fall direct-released presmolt	Not significant
Redfish Lake Pettit Lake	fall direct-released presmolt fall direct-released presmolt	Significant
Redfish Lake Alturas Lake	fall direct-released presmolt fall direct-released presmolt	Significant
Alturas Lake Pettit Lake	fall direct-released presmolt fall direct-released presmolt	Significant
Redfish Lake Alturas Lake	wild/natural wild/natural	Not significant
Redfish Lake Pettit Lake	wild/natural wild/natural	Significant
Alturas Lake Pettit Lake	wild/natural wild/natural	Significant

Table 14. Fisher's exact test results of PIT tag interrogations of sockeye salmon smolts PIT tagged at Sawtooth Valley trap sites and detected at Snake and Columbia river dams (Lower Granite, Little Goose, Lower Monumental and McNary) in 2002 (α = 0.10). Smolts released to Redfish Lake Creek were PIT tagged prior to release.

Release Location	Release Strategy	Total PIT Tagged	Cumulative Unique Interrogations	% Detected	P value
Redfish Lake	wild/natural	630	158	25.1%	0.010
Redfish Lake	fall direct-released presmolt	1,179	364	30.9%	
Redfish Lake	wild/natural	630	158	25.1%	<0.001
Redfish Lake	net pen-released presmolt	586	68	11.6%	
Redfish Lake	wild/natural	630	158	25.1%	<0.001
Redfish Lake Creek	smolt	1,000	106	10.6%	
Redfish Lake	fall direct-released presmolt	1,179	364	30.9%	<0.001
Redfish Lake Creek	smolt	1,000	106	10.6%	
Redfish Lake	net pen-released presmolt	586	68	11.6%	<0.001
Redfish Lake Creek	smolt	1,000	106	10.6%	
Redfish Lake	net pen-released presmolt	586	68	11.6%	<0.001
Redfish Lake	fall direct-released presmolt	1,179	364	30.9%	
Alturas Lake	wild/natural	158	37	23.4%	0.159
Alturas Lake	fall direct-released presmolt	240	42	17.5%	
Pettit Lake	wild/natural	364	68	18.7%	0.369
Pettit Lake	fall direct-released presmolt	330	53	16.1%	
Redfish Lake	fall direct-released presmolt	1,179	364	30.9%	<0.001
Pettit Lake	fall direct-released presmolt	330	53	16.1%	
Redfish Lake	fall direct-released presmolt	1,179	364	30.9%	<0.001
Alturas Lake	fall direct-released presmolt	240	42	17.5%	
Alturas Lake	fall direct-released presmolt	240	42	17.5%	0.651
Pettit Lake	fall direct-released presmolt	330	53	16.1%	
Redfish Lake	wild/natural	630	158	25.1%	0.757
Alturas Lake	wild/natural	158	37	23.4%	
Redfish Lake	wild/natural	630	158	25.1%	0.023
Pettit Lake	wild/natural	364	68	18.7%	
Alturas Lake	wild/natural	158	37	23.4%	0.235
Pettit Lake	wild/natural	364	68	18.7%	

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

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

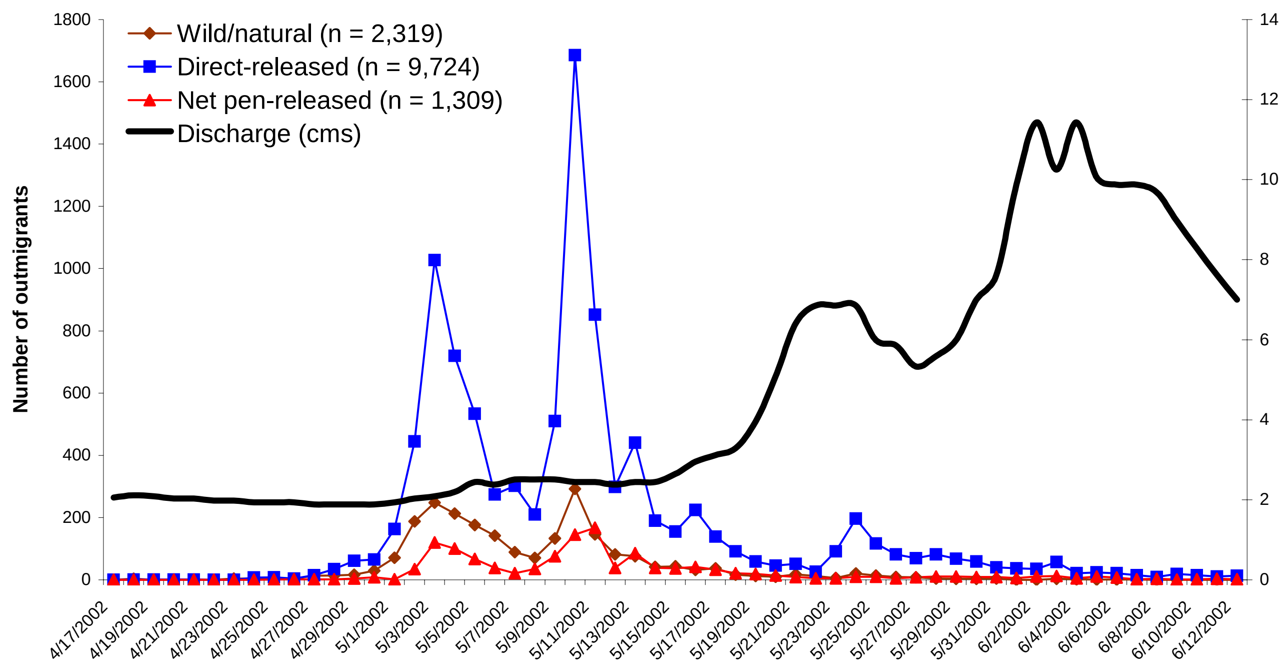

Figure 2. Daily capture of wild/natural, direct-released, and net pen-released sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2002 out-migration.

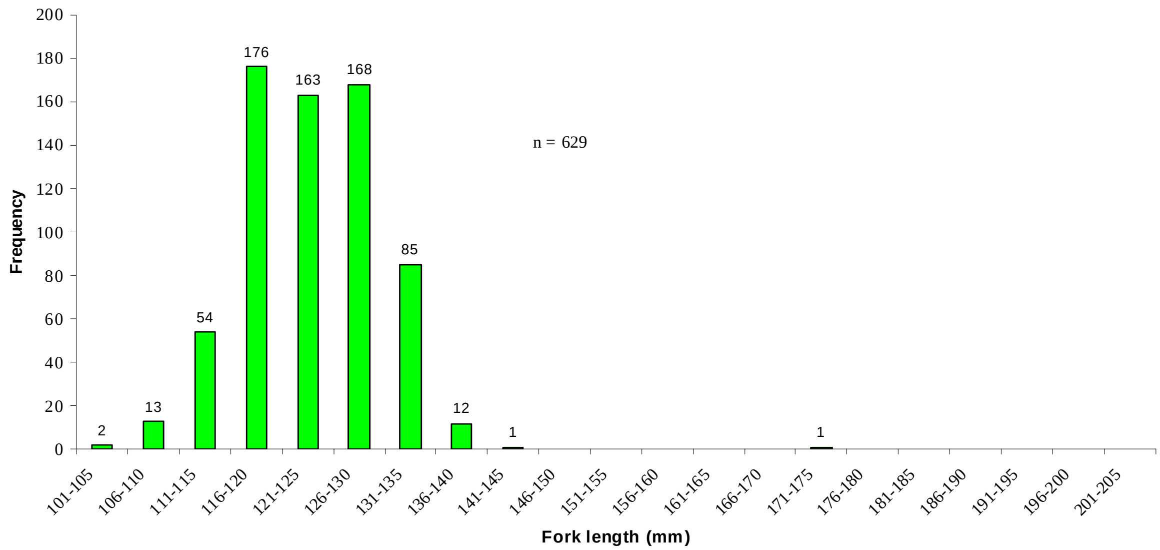

Figure 3. Length frequency of wild/natural smolts collected at Redfish Lake Creek trap in 2002. Total wild/natural out-migration estimated at 4,951 smolts.

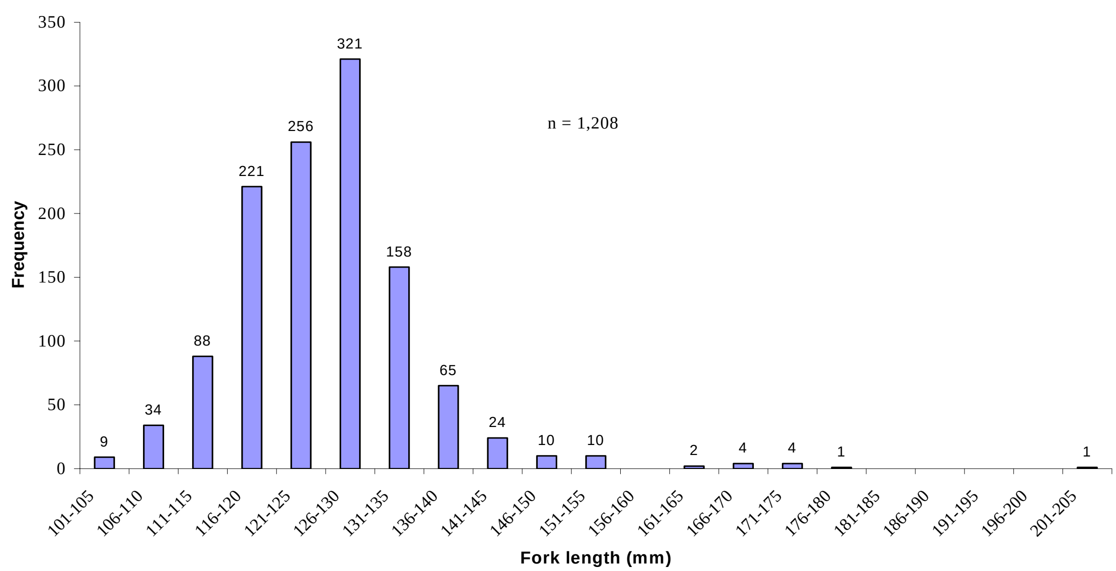

Figure 4. Length frequency of fall direct-released smolts captured at Redfish Lake Creek trap in 2002. Total fall direct-released out-migration estimated at 19,758 smolts.

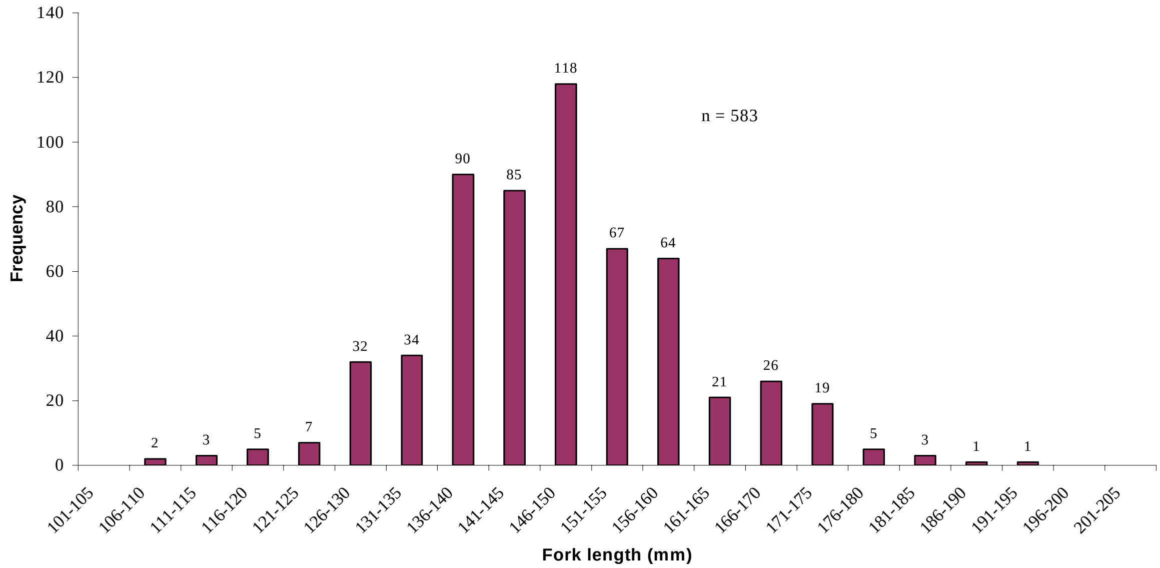

Figure 5. Length frequency of net pen-released smolts captured at Redfish Lake Creek trap in 2002. Total net pen-released out-migration estimated at 5,939 smolts.

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

INTRODUCTION

Releasing mature adult sockeye salmon into Sawtooth Valley lakes has been an important part of the "spread-the-risk" philosophy of the SBSTOC since fish from the captive broodstock program were first released back to the wild in 1993. Adult sockeye salmon raised to maturity in the hatchery and released to valley lakes to spawn provide a “natural” or unmarked smolt component that is subject to all the rigors and selection associated with the natural habitat. Beginning in 1999, returning adult hatchery-origin anadromous sockeye salmon have been released into valley lakes along with adult sockeye salmon that were raised to maturity in the hatchery. Current evaluations of adult sockeye salmon releases focus on the number of redds produced and estimations of unmarked juvenile out-migrants.

METHODS

Sockeye Salmon Spawning Investigations

On September 11 and 12, 2002, 178 hatchery-reared BY99 adult sockeye salmon and 12 anadromous adult sockeye salmon (seven females and five males) were released to Redfish Lake (Table 16). Hatchery-produced adults were from NOAA Manchester Marine Laboratory (N = 131), and IDFG Eagle Fish Hatchery (27 females and 20 males). Efforts were made to release fish of equal sex ratios. Due to a lack of sexual dimorphism, sex of the NOAA hatchery-produced component could not be positively determined at time of release for the fish.

In order to identify spawning locations, eight male hatchery-produced (EAG) sockeye salmon were implanted with radio transmitters prior to release. Telemetry investigations of adult locations began October 2, 2002 and continued weekly through October 31, 2002. Fish locations were recorded at least weekly by boat tracking.

Unmarked Juvenile Out-migrant Monitoring

Currently, success of releasing hatchery-produced adults to spawn naturally is evaluated by determining if there is an observed increase in the number of unmarked smolts out-migrating and observed egg-to-smolt survival. The weirs on Redfish Lake Creek and Pettit Lake Creek and the screw trap on Alturas Lake Creek enable us to monitor and estimate unmarked out-migrating smolts. Unmarked out-migrants can be progeny of residual sockeye salmon adults that spawn in Redfish Lake, program prespawn adults released to the lakes for natural spawning, or eyed-egg releases. Juvenile kokanee (nonanadromous) could also “fall out” of nursery lakes and contribute to trap counts. In 2002, unmarked out-migrants produced from program fish releases to Redfish Lake included age-1 out-migrants produced from 46 hatchery-produced adults and 118 hatchery-origin anadromous adults released for natural spawning in 2000 and age-2 out-migrants produced from 18 hatchery-produced adults and three anadromous adults released for volitional spawning. Unmarked out-migrants produced from program fish releases to Alturas Lake included age-1 out-migrants produced from 25 hatchery-produced adults and 52 hatchery-origin anadromous adults released for natural spawning. No program fish were released in 1999 to Alturas Lake that would have produced age-2 unmarked out-migrants. Unmarked out-migrants produced from program fish releases to Pettit Lake included age-1 out-migrants produced from 28 hatchery-origin anadromous adults released for natural spawning in 2000 and 65,200 eyed-eggs released in 2000. Additionally, age-2 out-migrants could have been produced from 20,311 eyed-eggs released in 1999. Age-1 and age-2 unmarked out-migration was determined by aging scales collected from a subsample of unmarked out-migrants. Scales were removed from a subsample of *O. nerka* and returned to the laboratory where they were pressed into acetate; three program employees aged them to determine length ranges for age classification.

RESULTS

Sockeye Salmon Spawning Investigations

The first area of excavation (possible redd) was located at the south end of Redfish Lake on October 16, 2002. Redd counts were finalized with four observers November 21, 2002. Ten to 12 excavation areas (possible redds) were located at the south end of the lake (the opposite shore from the U.S. Forest Service Transfer Camp dock), and one possible redd was located on Sockeye Beach (Table 16).

Two of the eight radio tags implanted in adult sockeye salmon were recovered during tracking efforts. None of the recovered tags were associated with their carcasses; therefore, we were not able to determine if the fish had spawned. The first tag recovery was on October 16 on the bank of Redfish Lake Creek, between the mouth of the outlet and the Redfish Lake Creek weir. The second tag was recovered on October 22 at the south end of the lake in 40 cm of water.

Unmarked Out-migrant Monitoring

In 2002, 4,951 unmarked smolts (95% CI 4,524 to 5,471) were estimated to have out-migrated from Redfish Lake, 6,176 unmarked smolts (95% CI 4,115 to 22,219) were estimated to have out-migrated from Alturas Lake, and 1,067 smolts were enumerated to have out-migrated from Pettit Lake (Figure 6). The estimated number of unmarked age-1 and age-2 smolt production is pending.

DISCUSSION

Sockeye Salmon Spawning Investigations

Sockeye salmon spawning in Redfish Lake has been identified in three locations: Sockeye Beach, the south beach area near the slide, and the area near the U.S. Forest Service transfer camp dock. 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.

Unmarked Out-migrant Monitoring

The 2002 wild/natural out-migration age class determination is pending. However, age-2 smolts are well documented in the Redfish Lake sockeye salmon population (Bjornn et al. 1968). During the 11-year study beginning in 1956, Bjornn et al. (1968) noted that for six out of the 11 years the out-migration was dominated by age-1 smolts. Age-2 smolts made up 2% to 77% of the total out-migration over the course of the early monitoring effort. Age-2 smolts are common in many other sockeye lakes, although the reasons for the additional freshwater residence time are unclear (Burgner 1991).

Currently we are working with the University of Idaho's Center for Salmonid and Freshwater Species at Risk to develop DNA microsatellite methods that will allow identification of individual parental contribution to unmarked smolt production through parental exclusion analysis. Although identifying redd construction and enumerating unmarked smolt out-migration are valuable components of our natural spawning investigations, identification of the fish (anadromous, hatchery-produced, or residual parents) contributing progeny to the smolt out-migration will allow better evaluation and refinement of our adult rearing and release strategies.

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

Lake	Rearing origin	Date released	Number released	Number of suspected redds
Redfish	Full-term hatchery	1993	20	Unknown
Redfish	Full-term hatchery	1994	65	One behavioral observation
Redfish	Full-term hatchery	1996	120	30 suspected redds
Redfish	Full-term hatchery	1997	80	30 suspected redds
Pettit	Full-term hatchery	1997	20	1 suspected redd
Alturas	Full-term hatchery	1997	20	Test digs only
Redfish	Full-term hatchery	1999	18	
Redfish	Hatchery-produced anadromous	1999	3	8 suspected redds
Redfish	Full-term hatchery	2000	36	
Redfish	Hatchery-produced anadromous	2000	120	20 to 30 suspected redds
Pettit	Hatchery-produced anadromous	2000	28	none confirmed
Alturas	Full-term hatchery	2000	25	
Alturas	Hatchery-produced anadromous	2000	52	14 to 19 suspected redds
Redfish	Hatchery-produced anadromous	2001	14	12 to 15 suspected redds
Redfish	Full-term hatchery	2001	65	
Redfish	Hatchery-produced anadromous	2002	12	10 to 12 suspected redds
Redfish	Full-term hatchery	2002	178	
		Total	**876**	

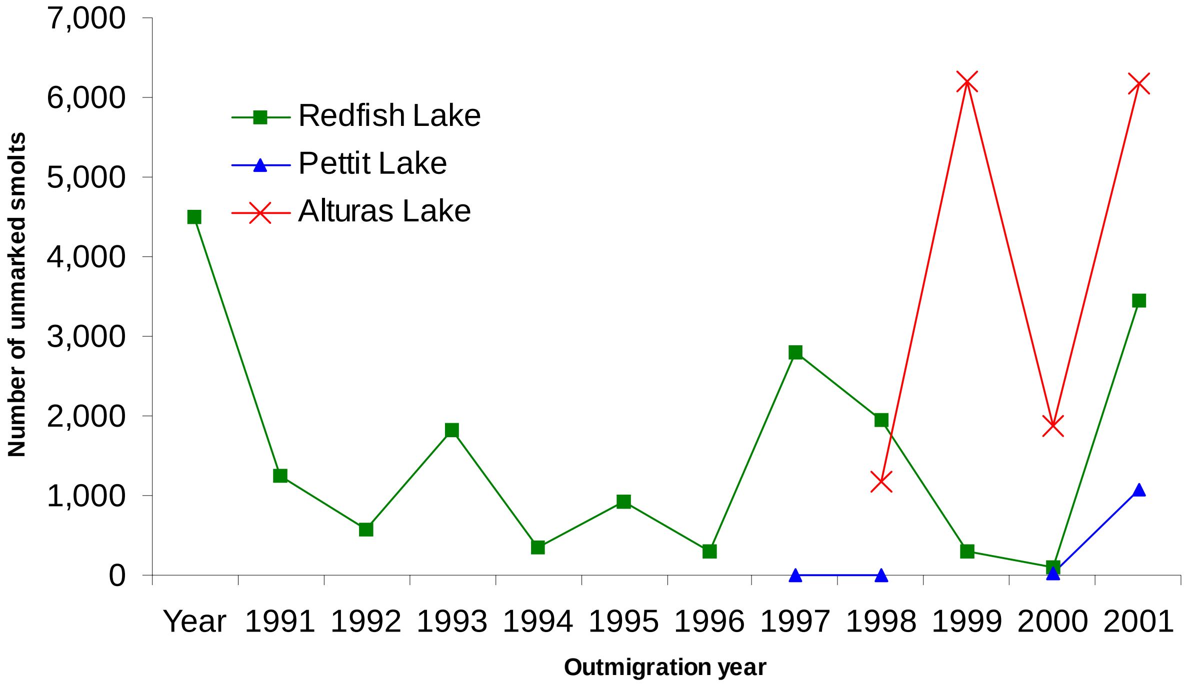

Figure 6. Wild/natural sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2002 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

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PART 6—PARENTAL LINEAGE INVESTIGATIONS

INTRODUCTION

The ability to discern the origin of unmarked returning adult sockeye salmon is vital to our ability to use anadromous adults within the captive broodstock program. Since 1999, hatchery-produced adult sockeye salmon have been returning to the Sawtooth Valley. Juvenile sockeye salmon are marked with fin clips before release; however, returning adult sockeye salmon that are unmarked could be the progeny of natural spawning sockeye salmon adults (anadromous, hatchery-produced, or residual) or eyed-egg plants.

Early in the captive broodstock program, otolith microchemistry was used to improve our knowledge of the life history of wild sockeye salmon that were captured and spawned in the captive broodstock program (Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997). Specifically, otolith microchemistry was used to determine if returning adult sockeye salmon were the progeny of anadromous sockeye salmon or residual sockeye salmon. However, because extracting an otolith is a lethal process, it has been used only on sockeye salmon that were incorporated into the captive broodstock program. This lethal sampling reduces the usefulness of the technique for large application with this endangered stock.

Currently, we are working with the University of Idaho's Center for Salmonid and Freshwater Species at Risk to develop nonlethal genetic techniques to identify the parental lineage of an individual sockeye salmon from the captive broodstock program. This nonlethal test will allow us to evaluate the contribution of the eyed-egg or hatchery-adult outplants to unmarked smolt production. In addition, the test will be used to identify returning unmarked adult sockeye salmon to allow us to maximize their use in the captive breeding program.

METHODS

In 2002, all sockeye salmon spawned in the captive broodstock program had fin tissue collected and archived in Lysis buffer solution for genetic analysis. In addition to the fin tissue, during years when anadromous adults are returned to the hatchery and spawned in the captive broodstock program (no anadromous returns were used in hatchery spawning in 2002), their otoliths are removed and archived. All adults released to Redfish Lake for natural spawning had fin tissue collected and archived.

We have 34 otoliths polished and mounted according to methods described by Kalish (1990) and Rieman et al. (1993). The otoliths are from 16 hatchery and eight wild sockeye salmon smolts collected at the RLCTRP in 1999, four smolts collected at the RLCTRP in 1998, four anadromous hatchery adults from 1999, and the remaining otolith from the lone adult that returned in 1998.

RESULTS

Otolith microchemistry analysis is pending.

Genetic analysis is pending.

DISCUSSION

The ability to identify release strategies that produce unmarked out-migrants has confounded investigators since this initiation of the 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 between lakes. Although this allows us to estimate smolt production from a given release strategy, it reduces our flexibility in relation to using the lake with the best rearing environment at the current time (high zooplankton densities, low kokanee biomass). It also does not allow us to determine residual sockeye salmon production. The DNA microsatellite parental analysis will also allow us to evaluate unmarked smolt production from hatchery-produced adult outplants, anadromous adults, and residual adults.

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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.

METHODS

Monitoring of spawning bull trout was initiated in 1995 to measure bull trout population response to no-harvest fishing regulations implemented by IDFG in 1994. In 2002, we surveyed index reaches, which were established in 1998, on principal tributary streams of Redfish and Alturas lakes to enumerate bull trout spawners and redds. Surveys were conducted on Fishhook Creek (Redfish Lake drainage) on September 4 and September 11 and on Alpine Creek (Alturas Lake drainage) on August 30 and September 12, 2002. Index sections were established with global positioning satellite (GPS) equipment. Two observers walked from the lower boundary of the index section upstream and recorded visual observations of bull trout and known or suspected bull trout redds. Coordinates of redd locations were recorded with a GPS unit. In order to avoid omission of completed redds during the final count, completed redds identified during the first count were flagged. Flagging prevented omitting redds from the final count that were obscured over time.

RESULTS

Fishhook Creek

We observed 23 adult bull trout and six completed redds on September 4. Water temperature at 1325 hours was 9.0°C. During our second survey, September 11, we observed five adult bull trout and 17 completed redds. Water temperature was 6.0°C at 1135 hours. Redd counts on the second date were cumulative with the previous count (Table 17).

Alpine Creek

We observed 20 adult bull trout and eight completed redds during the August 30 survey. Water temperature was not recorded during this survey. On September 12, we observed zero adult bull trout and 14 completed redds. Water temperature was 10.0°C at 1135 hours during the second survey. Redd counts on the second date were cumulative with the previous count (Table 18).

DISCUSSION

Bull trout spawner investigations were initiated in 1995 to track population response to no-harvest fishing regulations implemented by IDFG in 1994. Trend data of this nature have been successfully used to measure population response to fishing regulation changes implemented for adfluvial bull trout populations in Oregon and British Columbia (Ratliff 1992; Stelfox and Egan 1995).

Final index sections were established on Fishhook and Alpine creeks in 1998. Information collected in 2002 represented the fifth year data were collected in these index reaches.

From the five years of data, it appears that the no-harvest fishing regulation is affecting the bull trout population in Alpine Creek more than in Fishhook Creek. The Alpine Creek population has increased steadily since 1998; one redd was observed in 1998 and a high of 15 redds were observed in 2001 and 14 redds in 2002. 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. The effects of no-harvest regulations may take several more years to become apparent, because bull trout generally mature at five to six years of age (Leary et al. 1993), and only one cohort has been completely removed from potential harvest by anglers.

This effort represented the only attempt to monitor bull trout populations in the upper Salmon River drainage upstream of the Lemhi River (Tom Curet, IDFG, personal communication). Monitoring bull trout populations with redd counts is advantageous, because they are low cost and cause little disturbance to spawning bull trout. However, several sources of error are associated with counting redds. True redds may be missed (omissions) due to location in the stream (associations with depth or cover), or natural channel formations may be counted as redds (false identifications). In addition to the observation error, sampling index sections provide accurate counts only if the distribution of spawning does not change from year to year (Dunham et al. 2001). Despite the potential for error in redd counts, documentation of significant population declines have been identified from redd count data (Rieman and Meyers 1997).

We believe that our counts of redds in the trend sections were an accurate reflection of the numbers of redds present. The streams in our surveys were much smaller than those used by Dunham et al. (2001). For example, in the systems studied by Dunham et al. (2001) deepwater cover was defined as water greater than 1 m deep. In Fishhook and Alpine creeks, water depth rarely approached 1 m deep. Periodic (every 4-5 years) surveys of the entire drainage for spawning activity during the same time periods that index reaches are surveyed would enable us to improve the usefulness of our redd count data by determining if the proportion of spawning that is taking place in the index reaches remains constant.

Table 17. Bull trout adult fish counts and redd counts in trend survey sections of Fishhook Creek from 1998 to 2002.

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	9/4	23	6
	9/11	5	17

Table 18. Bull trout adult fish counts and redd counts in trend survey sections of Alpine Creek from 1998 to 2002.

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

[a] only one count completed

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APPENDICES

Appendix A. Fork length and weight (g) of kokanee captured during midwater trawls conducted during September 2002 on Redfish, Pettit, and Alturas lakes.

Transect	**Fork length (mm)**	**Weight**
Redfish Lake		
1	87	6.4
1	69	2.9
1	64	2.1
1	75	3.6
1	70	3.1
1	55	1.5
1	53	1.4
1	63	2.1
1	58	1.8
1	62	2.2
1	54	1.4
1	57	1.6
1	49	1.0
2	239	143.5
2	63	2.2
3	231	156.2
3	60	1.8
3	65	2.1
3	61	2.1
3	60	2.0
3	65	2.3
3	55	1.5
3	65	2.5
3	55	1.5
3	63	2.2
3	70	3.2
3	60	2.0
3	52	1.2
3	61	2.2
3	60	1.8
3	51	1.1
3	48	1.0
4	60	1.9
4	57	1.8
4	60	1.7
4	57	1.5
4	64	2.6
4	58	1.8
4	60	1.9
4	60	1.8
4	60	1.8
4	86	5.7
4	116	16.8
4	204	91.7

Appendix A. Continued.

Transect	Fork length (mm)	Weight
Alturas Lake		
1	166	51.1
1	167	53.7
1	158	43.3
1	156	40.9
1	168	53.1
1	168	53.5
1	153	40.4
1	156	43.0
1	159	42.8
1	156	32.0
1	148	34.4
1	136	26.5
1	153	38.5
1	145	29.9
1	149	36.4
1	150	37.5
1	135	25.6
1	134	27.0
1	138	28.6
1	125	20.0
1	118	17.6
1	103	10.0
1	58	1.7
1	55	1.4
2	153	41.7
2	157	41.3
2	142	36.8
2	146	42.3
2	155	38.4
3	170	50.3
3	149	37.4
3	119	18.6
3	113	15.4
3	60	2.3
4	170	57.4
4	162	46.8
4	157	44.0
4	152	37.0
4	142	31.1
4	89	6.8
4	85	4.8
5	141	32.3
5	147	33.5
5	144	31.4
5	144	30.8
5	140	28.6
5	137	28.7
5	97	8.3
5	125	22.3
5	128	24.6
5	140	33.9

Appendix A. Continued.

Transect	Fork length (mm)	Weight
Pettit Lake		
1	200	115.7
1	220	149.8
1	213	128.7
1	209	130.8
1	206	126.9
1	194	95.6
1	212	133.4
1	190	88.9
1	190	79.2
2	218	150.4
2	206	124.3
2	206	123.9
2	196	100.2
2	195	87.0
2	191	94.8
2	180	74.7
2	183	79.6
2	196	80.7
3	202	104.7
3	190	79.6
3	225	146.8
3	215	129.4
3	200	111.0
3	191	87.5
3	186	87.0
3	193	88.2
4	189	90.0
4	209	121.2
4	207	112.7
4	211	130.6
4	186	86.0
4	177	89.1
4	213	125.2
4	206	111.3
4	191	86.5

Appendix B. Arrival dates for PIT-tagged sockeye salmon smolts at Lower Granite Dam for the 2002 migration year.

	Redfish Lake				Alturas Lake		Pettit Lake			
Date	**Wild/ natural**	**Fall Direct Release (SWT)**	**Fall Net pen Release (EAG)**	**Smolt Release (SWT)**	**Wild/ natural**	**Fall Direct Release (SWT)**	**Wild/ natural**	**Fall Direct Release (SWT)**	**Summer Direct Release (SWT)**	**Summer Direct Release (EAG)**
5/08/02	1									
5/09/02										
5/10/02					1					
5/11/02		1								
5/12/02		1								
5/13/02										
5/14/02	1	1								
5/15/02										
5/16/02	2	3								
5/17/02		1	1	1	1					
5/18/02	6	2		12						
5/19/02	4			16			1			
5/20/02	3	3	1	3	2	2				
5/21/02	2	9	3	1		2	1			
5/22/02	8	11	2		5	8	3			
5/23/02	1	2						4		
5/24/02	5	3	1			2	1	1		
5/25/02	2	2	1		1	1	2			
5/26/02	3	2					3	1		
5/27/02	1	1					3	2		
5/28/02	2	3					2	2		
5/29/02		1								
5/30/02	2	2	1				1	2		
5/31/02	3	3					3			
6/1/02	2	2				1	1			
6/2/02	2	3	1		2		1	1	1	1
6/3/02	1	4	1				2			
6/4/02	1	3	2							
6/5/02		2					1	1		
6/6/02		2	1				1			
6/7/02		3								
6/8/02		7	1							
6/9/02		1								
6/10/02		2								
6/11/02		2								
6/12/02		1	2				1			
6/13/02										
6/14/02		2								
6/15/02	1	1								
6/16/02		1								
6/17/02		1	1							
6/18/02		4								
6/19/02		2								
6/20/02										
6/21/02										
6/22/02										
6/23/02		2								
6/24/02		2								
Total	**52**	**98**	**19**	**33**	**12**	**16**	**27**	**14**	**1**	**1**

Appendix C. Estimates of PIT-tagged sockeye salmon passing Lower Granite Dam for the 2002 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 smolts (RFL WN), Redfish Lake fall direct-release (RFL dir), Redfish Lake net pen-release (RFL net), Sawtooth smolt release (SMT), Alturas Lake wild/natural smolts (ALT WN), Alturas Lake fall direct-release (ALT dir), Pettit Lake wild/natural smolts, and Pettit Lake fall direct-release (PET dir).

Date	DCE	Flow	Spill	RFL WN	RFL dir	RFL net	SMT	ALT WN	ALT dir	PET WN	PET dir	Cumulative
5/08/02	0.23	68.5	24.6	4	0	0	0	0	0	0	0	4
5/09/02	0.2	63.8	24.8	0	0	0	0	0	0	0	0	4
5/10/02	0.2	60.9	24.9	0	0	0	0	5	0	0	0	10
5/11/02	0.25	56.3	17.9	0	4	0	0	0	0	0	0	14
5/12/02	0.21	56.4	22.1	0	5	0	0	0	0	0	0	18
5/13/02	0.22	55.7	22.4	0	0	0	0	0	0	0	0	18
5/14/02	0.19	64.2	17	5	5	0	0	0	0	0	0	29
5/15/02	0.2	68.6	22.7	0	0	0	0	0	0	0	0	29
5/16/02	0.23	65	24.6	9	13	0	0	0	0	0	0	51
5/17/02	0.3	66.1	15.5	0	3	3	3	3	0	0	0	64
5/18/02	0.32	70.9	19.5	19	6	0	38	0	0	0	0	128
5/19/02	0.31	78.4	22.9	13	0	0	51	0	0	3	0	195
5/20/02	0.35	98.2	27.5	9	9	3	9	6	6	0	0	235
5/21/02	0.35	109	39.9	6	25	8	3	0	6	3	0	286
5/22/02	0.33	112	42	24	33	6	0	15	24	9	0	396
5/23/02	0.35	102	34.4	3	6	0	0	0	0	0	11	416
5/24/02	0.33	98.9	24.8	15	9	3	0	0	6	3	3	455
5/25/02	0.31	92.5	22.3	7	7	3	0	3	3	7	0	485
5/26/02	0.27	84	23.4	11	7	0	0	0	0	11	4	518
5/27/02	0.27	88.8	23.4	4	4	0	0	0	0	11	7	544
5/28/02	0.26	95.7	23.3	8	12	0	0	0	0	8	8	579
5/29/02	0.26	112	37.8	0	4	0	0	0	0	0	0	583
5/30/02	0.24	126	51.7	8	8	4	0	0	0	4	8	616
5/31/02	0.18	137	60.5	17	17	0	0	0	0	17	0	666
6/1/02	0.18	137	61.1	11	11	0	0	0	6	6	0	700
6/2/02	0.18	132	57.1	6	17	6	0	11	0	6	6	750
6/3/02	0.19	134	61.1	5	22	5	0	0	0	11	0	793
6/4/02	0.22	120	60.3	5	14	9	0	0	0	0	0	820
6/5/02	0.14	115	68.9	0	14	0	0	0	0	7	7	848
6/6/02	0.15	110	59.9	0	14	7	0	0	0	7	0	876
6/7/02	0.09	108	53.1	0	33	0	0	0	0	0	0	908
6/8/02	0.21	105	40.6	0	33	5	0	0	0	0	0	946
6/9/02	0.22	89.6	29.2	0	4	0	0	0	0	0	0	950
6/10/02	0.25	79	55.7	0	8	0	0	0	0	0	0	958
6/11/02	0.3	82.1	28	0	7	0	0	0	0	0	0	965
6/12/02	0.33	75	23.1	0	3	6	0	0	0	3	0	977
6/13/02	0.29	75.7	22.6	0	0	0	0	0	0	0	0	977
6/14/02	0.28	76.2	18	0	7	0	0	0	0	0	0	984
6/15/02	0.28	77.6	22.9	4	4	0	0	0	0	0	0	992
6/16/02	0.3	82.3	19.8	0	3	0	0	0	0	0	0	995
6/17/02	0.28	94.3	27.3	0	4	0	0	0	0	0	0	999
6/18/02	0.36	96.9	39.5	0	11	3	0	0	0	0	0	1012
6/19/02	0.34	99.4	40.5	0	6	0	0	0	0	0	0	1018
6/20/02	0.28	89.9	29.1	0	0	0	0	0	0	0	0	1018
6/21/02	0.4	85.9	20.4	0	0	0	0	0	0	0	0	1018
6/22/02	0.47	79.7	4.9	0	0	0	0	0	0	0	0	1018
6/23/02	0.48	87.1	11.3	0	4	0	0	0	0	0	0	1022
6/24/02	0.4	89.5	25.4	0	5	0	0	0	0	0	0	1027
			Totals	191	399	72	104	44	50	114	54	

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