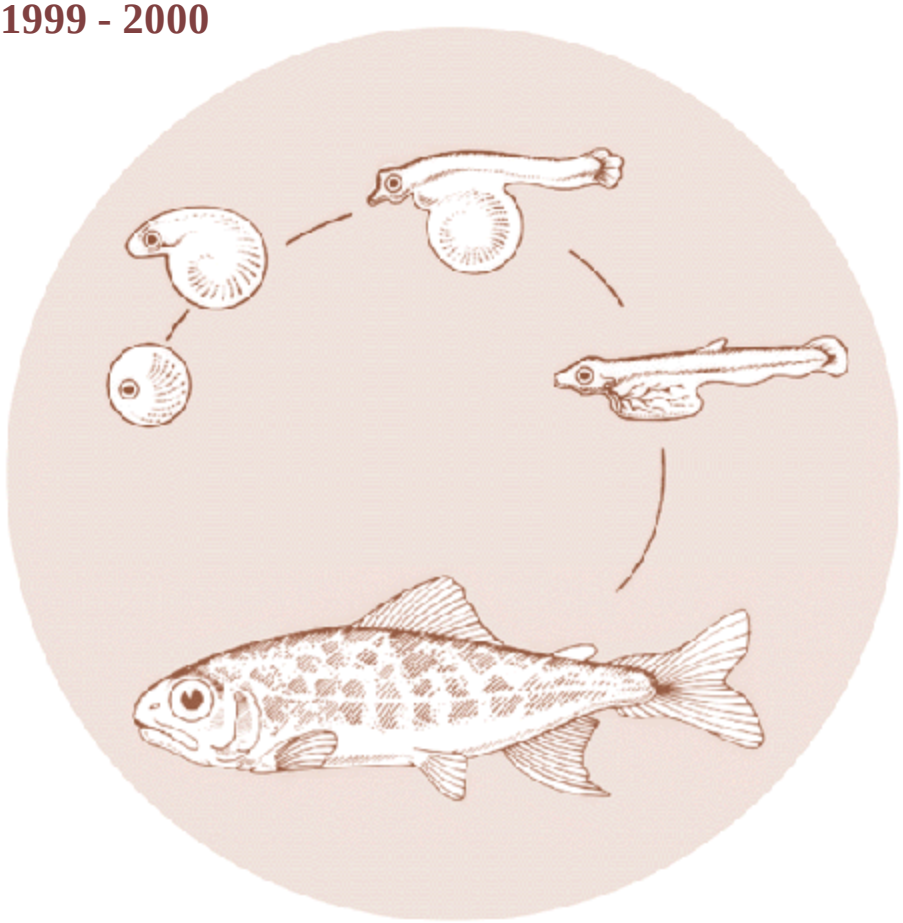
Snake River Sockeye Salmon Captive Broodstock Program

Research Element

Annual Report
1999 - 2000



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FISHERY RESEARCH

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

ANNUAL PROGRESS REPORT
January 1, 1999–December 31, 1999

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IDFG Report Number 00-47
October 2000

SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT

Project Progress Report

1999 Annual Report

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ABSTRACT

On November 20, 1991, the National Marine Fisheries Service 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.

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 Idaho Fish and Game's Sawtooth Fish Hatchery. In 1999, a combination of four release strategies were used in Sawtooth Valley waters. Age-1 smolts were released to the upper Salmon River below Idaho Department of Fish and Game's Sawtooth Fish Hatchery and into Redfish Lake Creek upstream of Little Redfish Lake. Eyed eggs were placed in Pettit Lake and presmolts were released to all three lakes in October. Hatchery-reared sexually maturing adult sockeye were released to the lake for volitional spawning in September along with three anadromous "jacks."

Total *O. nerka* abundance in Redfish Lake was estimated at 42,916, which was slightly lower than the long-term average. The biomass estimate of 0.9 kg/ha is the lowest value recorded to date. Abundance of *O. nerka* in Alturas Lake was estimated at 56,675, which was slightly higher than the long-term average. The biomass estimate of 0.4 kg/ha is close to the lowest value recorded. Abundance of *O. nerka* in Pettit Lake was estimated at 31,422, which was slightly higher than the long-term average. The biomass estimate of 6.4 kg/ha was the highest estimated for the three lakes sampled but not overly high compared to long-term trends in Pettit Lake.

The kokanee fishery on Redfish Lake was reopened in 1995 by the National Marine Fisheries Service on the recommendation of the Stanley Basin Sockeye Technical Oversight Committee as a way to help reduce kokanee competition with sockeye through angler harvest. Anglers fished an estimated 3,951 hours and harvested approximately 1,100 kokanee during the 1999 season. Angler effort and harvest were also monitored on Pettit Lake during 1999. Effort on Pettit Lake was lower than on Redfish Lake at only 1,148 hours and harvest of kokanee was minimal (estimated at 11 fish).

The out-migrant trap on Redfish Lake Creek is used to estimate numbers of smolts migrating from Redfish Lake. The trap was operated from April 25 to June 4, 1999. A total of 543 wild/natural and 6,204 hatchery-produced sockeye smolts were captured, and total out-migration was estimated at 1,944 wild/natural and 22,425 hatchery-produced smolts. Hatchery-produced sockeye released directly to the lake overwintered and out-migrated significantly better than hatchery-produced sockeye reared in net pens prior to release in the lake.

Estimates of smolt out-migration were made by release strategy and were based on PIT-tag interrogations recorded at Lower Granite Dam (LGR). An estimated 764 wild/natural smolts passed LGR from Redfish Lake. An estimated 33,320 smolts released as presmolts into Sawtooth basin lakes passed LGR. An estimated 3,166 age-1 smolts released into Sawtooth valley waters passed LGR.

Telemetry studies of adults released for volitional spawning began on September 21 and were conducted weekly through October 27. Eighteen hatchery-reared adults were released to Redfish Lake along with three anadromous "jacks." Six of the hatchery-reared males were implanted with ultrasonic transmitters prior to release. Eight areas of excavation (potential redds) were located during telemetry tracking.

Index reaches on principal tributary streams of Redfish and Alturas lakes were surveyed in August 1999 to track bull trout population response to no-harvest fishing regulations implemented by IDFG in 1994. Survey reaches were established on Fishhook and Alpine creeks. Forty adult bull trout and 15 completed redds were observed on the Fishhook Creek index section, while a total of 13 adult bull trout and three completed redds were located on Alpine Creek. The authors felt that the survey conducted on Alpine Creek was conducted prior to the peak of spawning activity.

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INTRODUCTION

Snake River sockeye salmon *Oncorhynchus nerka* were listed as endangered under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) on November 20, 1991. Residual sockeye salmon in Redfish Lake were listed as endangered by the NMFS in 1992.

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

The Idaho Department of Fish and Game (IDFG) is charged with the responsibility of reestablishing sockeye salmon runs to the Sawtooth basin, with emphasis placed on efforts to utilize Sawtooth basin sockeye salmon and kokanee *O. nerka* (IDFG 1992). The Snake River Salmon Sawtooth Valley Project was started in 1991 as a cooperative effort between the Shoshone-Bannock Tribes (SBT), NMFS, and IDFG with the goal of conserving and rebuilding sockeye salmon populations in Idaho. Bonneville Power Administration (BPA) funds the project. Coordination and guidance for the recovery effort is 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 (NMFS Permit Nos. 1120, 1124, and 1150).

Idaho Department of Fish and Game participation in the Snake River Salmon Sawtooth Valley Project covers two areas of effort: 1) the sockeye salmon captive broodstock program; and 2) Sawtooth basin fisheries research. While 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. This report details fisheries research information collected between January 1, 1999 and December 31, 1999, including Sawtooth basin lakes *O. nerka* population monitoring, sport fishery evaluation on Redfish and Pettit lakes, smolt out-migration monitoring and evaluation, telemetry studies of mature adult *O. nerka* released to Sawtooth basin lakes, and predator investigations on tributaries to Redfish and Alturas lakes.

PROJECT GOAL

The ultimate goal of 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 and kokanee resources. The immediate project goal is to maintain this unique sockeye salmon population through captive broodstock technology and avoid species extinction.

PROJECT OBJECTIVES

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

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

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

Objective 4. Refine our ability to discern the origin of wild and broodstock *O. nerka* to provide maximum effectiveness in their utilization within the broodstock program.

Objective 5. Technology transfer.

STUDY AREA

Recovery efforts for Idaho sockeye salmon focus on Redfish, Alturas, and Pettit lakes in the Sawtooth basin (Figure 1) located within the Sawtooth National Recreation Area. Basin 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 basin are considered oligotrophic. The lakes are part of the upper Salmon River watershed. The Salmon River flows into the Snake River, then the Columbia River, which drains into the Pacific Ocean. The Stanley basin is approximately 1,450 river km from the mouth of the Columbia River at the Pacific Ocean.

In addition to *O. nerka*, numerous native and nonnative fish reside in the study lakes and outlets within the Stanley basin. Native fish present in Sawtooth basin 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 basin waters include lake trout *S. namaycush* and brook trout *S. fontinalis*. Rainbow trout are released from the Sawtooth Hatchery into Pettit, Alturas, and Stanley lakes throughout the summer months to increase sport fishing opportunity. Sport fishing on Pettit, Alturas, and Stanley lakes is covered by Idaho's statewide general fishing regulations, which allows fishing year round and harvest of six trout/landlocked salmon per day excluding bull trout, which must be released if caught (IDFG 1998). Sport-fishing regulations on Redfish Lake restricted kokanee fishing/harvest to January 1 through August 7, and no trout have been stocked since 1992.

Captive Broodstock Program Egg and Juvenile Supplementation

The IDFG captive broodstock program annual report appears under a separate cover, but due to the nature of this project, a discussion of the supplementation of hatchery-produced sockeye salmon that occurred in 1998 and 1999 to Sawtooth basin waters is provided.

All hatchery-produced sockeye salmon were adipose fin-clipped, and a portion were Passive Integrated Transponder (PIT) tagged before release. One hundred fish from each release group were measured for fork length (1 mm) and weight (0.1 g) during PIT tagging. Mean release weights were collected at the hatchery before release using grab sample counts. Fish condition

(presence/absence of cultural and congenital anomalies) was assessed during PIT tagging and documented in PIT tag data files.

In 1998, 223,486 *O. nerka* were released into Sawtooth basin waters from the captive broodstock program (Table 2). Redfish Lake received 55,830 age-0 presmolts released from net pens and 39,418 age-0 presmolts released directly to the lake in October. Pettit Lake received 7,246 age-0 presmolts released directly to the lake in July, and Alturas Lake received 39,377 age-0 presmolts released directly to the lake in October. Presmolts released directly to Redfish and Alturas lakes in 1998 were from brood year 1997 and were reared at Sawtooth Fish Hatchery (IDFG). Redfish Lake net pen presmolts and Pettit Lake direct release presmolts were from brood year 1997 and were reared at Eagle Fish Hatchery (IDFG). Redfish Lake Creek received 37,583 age-1 smolts, and the upper Salmon River received 44,032 age-1 smolts. All smolts were from brood year 1996 and were reared at either Bonneville Fish Hatchery, Oregon Department of Fish and Wildlife (ODFW), or Sawtooth Fish Hatchery (IDFG).

In 1999, 70,321 *O. nerka* were released into Sawtooth basin waters from the captive broodstock program (Table 3). Redfish Lake received 23,886 age-0 presmolts released directly to the lake in October. Twenty-one sexually maturing, brood year 1996, hatchery-produced adults were released for volitional spawning directly to the lake in September (10 hatchery-reared females, eight hatchery-reared males and three anadromous males). Alturas Lake received 12,955 presmolts released directly to the lake in October. Pettit Lake received 3,430 age-0 presmolts released directly to the lake in October and 20,311 eyed eggs planted in egg boxes in November. Redfish Lake Creek and the upper Salmon River received 4,859 age-1 smolts (brood year 1997) each. All presmolts released in 1999 were from brood year 1997 and were reared at the Sawtooth Fish Hatchery (IDFG).

METHODS

O. nerka Abundance, Density, and Biomass Estimation

To estimate *O. nerka* abundance, density, and biomass in Sawtooth basin lakes, midwater trawling was conducted at night during the dark (new) phase of the moon in September. The month of September was chosen so that spawning-age fish in Redfish and Alturas lakes would be in the tributaries, not sampled by the gear. In addition, juvenile *O. nerka* that remain in basin lakes are tightly stratified during this period. Redfish, Pettit, and Alturas lakes were sampled on September 8, 9, and 10. 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. All sampling on an individual lake was completed in one night. Total *O. nerka* abundance, density, and biomass was estimated using the TRAWL.WK1 spreadsheet for Lotus 1-2-3 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 sockeye salmon stratum. Biomass estimates generated by the program are extrapolations of catch data to the total 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* (Appendix A). Sagittal otoliths and scales were removed from a subsample of *O. nerka* and returned to the laboratory where they were aged by three readers. Scales were pressed into acetate

before aging. Tissue samples were collected and sent to the University of Idaho's Hagerman Fish Culture Experiment Station for genetic analysis. Stomachs were removed and preserved for diet analysis by SBT biologists.

Kokanee Fishery Investigations

Redfish Lake

Permit 1150 (NMFS) requires IDFG to monitor angler harvest of listed sockeye salmon in Redfish Lake; therefore, a roving creel survey was conducted from May 24 through August 7, 1999 (kokanee harvest closes on August 7 to protect residual sockeye salmon). The census was stratified by 14 day intervals, broken into weekday and weekend day types, and morning (0600 to 1600) and evening (1600 to 2000) day periods. Angler counts were conducted two weekdays and one weekend day during each week of the 14 day interval. On each angler count day, the number of boats and bank anglers were enumerated 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 fished, and the type of gear they used. Fin clips were taken from all creeled *O. nerka* that were checked, and stored in lysis buffer solution for DNA analysis by University of Idaho personnel. 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 creel survey of Pettit Lake was conducted from May 24 through September 1, 1999 following the same procedures described above for Redfish Lake, except fin clips were not collected for genetic analysis, and there was no kokanee harvest closure on Pettit Lake.

Out-migrant Monitoring and Evaluations

Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) is used to estimate numbers of wild/natural sockeye smolts migrating from Redfish Lake and to monitor and estimate smolt out-migration from different hatchery release strategies. The trap is located 1.4 km downstream from the lake outlet at a permanent weir site and was operated from April 25 to June 4, 1999. The trap functions as a juvenile trap and with only minor modifications an adult trap (Bjornn et al. 1968, Craddock 1958). The weir contains nine bays, five of which contain juvenile traps. Personnel from IDFG checked the trap twice daily.

All *O. nerka* captured at RLCTRP were anesthetized in buffered MS222 (Methane Tricaine Sulfonate), measured for fork length (1 mm) and weight (0.1g), and scanned for PIT tags. Hatchery-produced fish, determined by lack of an adipose fin, were scanned for PIT tags and released downstream of the weir one half hour after sunset. Hatchery-produced *O. nerka* captured at the trap originated from 1998 releases of 95,248 age-0 presmolts [55,830 direct midwater (pelagic) release

and 39,418 net pen release]. Overwinter survival and out-migration between the two hatchery-produced groups was compared using chi-square analysis of PIT tag detections (α=0.10).

To estimate trapping efficiency, the majority of wild/natural out-migrants, determined by presence of an adipose fin, were PIT tagged 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 two intervals based on stream discharge and on the number of PIT-tagged wild/natural fish recaptured following release. Out-migrant run size and 95% confidence intervals were estimated using maximum likelihood and profile likelihood estimators based on a program developed by Wu and Steinhorst (2000). Estimates were generated separately for wild/natural and hatchery-produced fish.

Out-migrant trapping on Pettit Lake Creek and Alturas Lake Creek is the responsibility of the SBT, and results will be presented under a separate cover. The out-migrant trap on the Salmon River at the Sawtooth Fish Hatchery, located downstream from Pettit and Alturas lakes, was operated in 1999, but no attempt was made to develop an estimate of *O. nerka* out-migration at this location.

Mainstem Snake and Columbia River Dams

Out-migration of sockeye smolts was evaluated using PIT tag interrogation data collected at the 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. PIT tag interrogation data for mainstem Snake and Columbia river dams was retrieved from the Columbia River Basin PIT Tag Information System (PTAGIS) (Appendix C). Tagged to untagged ratios of smolts observed at Sawtooth basin 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. Wild/natural and hatchery-produced smolt total 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) (Sanford and Smith, NMFS Coastal Zone) estimated for chinook smolts was used to expand estimates of PIT tag interrogations for sockeye smolts migrating past LGR (Appendix D). 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. Distribution of arrival times for PIT-tagged fish at LGR were compared for wild/natural and hatchery-produced progeny (by release strategy) using two-sample Kolmogorov-Smirnov tests (α=0.10) (Sokal and Rohlf 1981). Chi-square tests (α=0.10) paired by release strategy were used to compare cumulative unique PIT tag interrogations at LGR, LGJ, LMN, and MCN for similar release strategies between lakes and for different release strategies within a lake (Zar 1974).

A priori power analysis for chi-square tests was performed to determine PIT tag sample sizes needed for comparisons (Cohen 1988). Using a range of values for overwinter survival, out-migration, and cumulative unique interrogations at mainstem Snake and Columbia River dams and a desired power of 0.80 at α=0.10, it was estimated that a minimum of 850 fish in each release strategy needed to be PIT tagged.

Volitional Spawning Investigations

On September 15, 1999, 21 maturing adult sockeye salmon were released to Redfish Lake from the public boat ramp. The 21 fish consisted of 10 brood year 1996 hatchery-reared females, eight brood year 1996 hatchery-reared males, and three brood year 1996 hatchery-produced anadromous "jacks" (Appendix B). The hatchery-reared fish were selected based on signs of sexual maturation (coloration, sexual dimorphism, and interpretation from physical handling). Six of the hatchery-reared males were implanted with ultrasonic transmitters (Sonotronics, Tucson, Arizona). Tag frequencies were coded with unique, self-identifying codes allowing several tags to be assigned the same tracking frequency. The tags were 65 mm long, 18 mm wide, and weighed 22 g. Transmitters were lubricated with vegetable oil and inserted orally (posterior to the pharyngeal sphincter in the gut) with the assistance of a plunger.

Adult sockeye were tracked weekly from date of release by boat using a Sonotronics model USR-5W receiver and model DH-2-10 directional hydrophone. Fish location was determined by triangulation from at least two locations. Locations were marked on a map of Redfish Lake so that the position of transmitters could be monitored from week to week. Aerial surveys were conducted when most transmitters could no longer be located or had remained stationary for an extended period of time. Visual counts of suspected redds were made by boat and from the air.

Parental Lineage Investigations

Differences between Sr/Ca ratios in otolith primordia are great enough to identify individual life history, with respect to habitat location of the female parent during vitellogenesis. Otolith preparation followed procedures developed by Kalish (1990) and Rieman et al. (1993). Sample preparations are analyzed at Oregon State University (College of Oceanography, Corvallis, OR 97331-5503) following procedures outlined by Toole and Nielsen (1992).

Predator Investigations

In 1999, we surveyed index reaches on principal tributary streams of Redfish and Alturas lakes to enumerate bull trout spawners and redds. Monitoring was initiated in 1995 to measure bull trout population response to no-harvest fishing regulations implemented by IDFG in 1994. Surveys were conducted on Fishhook Creek (Redfish Lake drainage) and Alpine Creek (Alturas Lake drainage) on August 26 and August 27, respectively. Upper and lower bounds for index sections were relocated in 1999 using coordinates established with global positioning satellite (GPS) equipment. Visual observations of bull trout and known or suspected bull trout redds were recorded.

RESULTS

O. nerka Abundance, Density, and Biomass Estimation

Redfish Lake

September trawl catch (six transects) included 53 wild/natural *O. nerka,* zero hatchery-produced *O. nerka,* and four redside shiners. Abundance of *O. nerka* was estimated at 42,916 fish

(95% CI ±13,177). Density and biomass were estimated at 69.7 fish/ha and 0.9 kg/ha (Table 4). Ages 0, 1, 2, and 3 fish were all captured in the trawl on Redfish Lake. Abundance was inversely related to age (age-0 most numerous), but age-2 fish contributed most (67%) to the biomass estimate (Table 5).

Alturas Lake

Four transects were trawled in Alturas Lake capturing 91 wild/natural *O. nerka* and zero hatchery-produced *O. nerka.* Abundance was estimated at 56,675 fish (95% CI ±43,477). Density and biomass were estimated at 167.7 fish/ha and 0.4 kg/ha (Table 4). Only age-0 and age-1 fish were captured, (age-0 fish were the most numerous), but both contributed equally to the biomass estimate (Table 5).

Pettit Lake

Four transects were trawled in Pettit Lake capturing 57 wild/natural *O. nerka*, zero hatchery-produced *O. nerka*, one redside shiner and one bull trout. Abundance was estimated at 31,422 fish (95% CI ±21,280). Density and biomass were estimated at 196.4 fish/ha and 6.3 kg/ha (Table 4). Only age-2 and -3 fish were captured in the trawl, and age-2 fish were the most numerous and contributed most of the biomass 95% (Table 5).

Stanley Lake

Stanley Lake was not sampled in 1999.

Kokanee Fishery Investigation

Redfish Lake

Angler interviews conducted at Redfish Lake during 1999 contacted 115 angler parties representing 227 anglers. Residents made up 59% of those interviewed. Most angling was done with bait (59%), followed by lures (39%) and only a small amount with flies (2%). Total angler effort was estimated at 3,951 hours (95% CI ±1,060) from May 24 through August 7. Boat anglers accounted for more effort than bank anglers (Table 6). The average fishing trip lasted 1.4 hours.

Catch rates for all fish caught (harvested and released) was almost one fish/hour for the season. Seasonal catch rates (all fish) were much higher for weekdays (0.99 fish/hour) than for weekend days (0.19 fish/hour) (Table 7). Kokanee catch rates (caught and released) averaged almost 0.5 fish/hour for all day periods. Bull trout catch rates were consistently 0.3 fish/hour (IDFG regulations require no harvest). Other fish (brook trout, redside shiners, mountain whitefish, and northern pikeminnow) accounted for catch rates of less than 0.2 fish/hour for the season.

Total number of fish caught (harvested and released) at Redfish Lake was estimated at 3,662 (95% CI ±1,622) (Table 8). The majority of fish (67%) caught were released. Kokanee harvest accounted for over 99% of all the fish harvested and was estimated at 1,187 fish (95% CI ±843) for the season. Bull trout and kokanee comprised the majority of the fish released by anglers.

Pettit Lake

Angler interviews at Pettit Lake during 1999 contacted 34 angler parties representing 64 anglers. Residents made up 80% of those interviewed. Most angling was done with bait (51%) followed by lures (44%) and only a small amount of fishing with flies (5%). Total angler effort was estimated at 1,148 hours (95% CI ±455) from May 24 through September 1 (Table 6). Angling effort was almost equally divided between boat anglers 659 (95% CI ±367) and bank anglers 491 (95% CI ±269). The average fishing trip lasted 1.7 hours.

Catch rates for all fish caught (harvested and released combined) was 0.3 fish/hour for the season (Table 7). Seasonal catch rates (all fish) were much higher for weekdays (0.29 fish/hour) than for weekend days (0.06 fish/hour). Kokanee catch rates (caught and released) averaged 0.08 fish/hour for the season. Bull trout catch rates averaged 0.0 fish/hour (IDFG regulations require no harvest). Catch rates for rainbow trout were higher on weekend days (0.26 fish/hour) than for weekdays (0.01 fish/hour). Other fish (brook trout, redside shiners, mountain whitefish, and northern pikeminnow) accounted for catch rates of less than 0.2 fish/hour for the season.

Total number of fish caught (harvested and released) at Pettit Lake was estimated at 479 fish (95% CI ±456) (Table 8). Rainbow trout accounted for 26% of harvested fish while kokanee accounted for less than 4% of fish harvested. Other fish harvested included brook trout, redside shiners, and northern pikeminnow.

Out-migrant Monitoring and Evaluation

Redfish Lake Creek Trap

A total of 6,567 *O. nerka* smolts (543 wild/natural, 6,024 hatchery) were trapped during the 1999 out-migration season (Figure 2). Discharge measured at the weir varied from 1 m^3/s to 8 m^3/s. The majority of wild/natural fish captured were PIT tagged and released above the trap to estimate trap efficiency. Two periods of similar discharge were used to estimate trap efficiency. Efficiency Period 1 was between April 25 and May 20. Trap efficiency during this period was based on 288 releases above the weir and was calculated at 0.33 (95% CI 0.27 to 0.39) (Table 9). Efficiency Period 2 was between May 21 and June 4; based on 122 releases, efficiency was estimated at 0.23 (95% CI 0.15 to 0.30).

Fork-length of wild/natural *O. nerka* captured at RLCTRP averaged 101 mm and ranged from 76 mm to 162 mm (Figure 3). Based on length at age data from *O. nerka* collected during the September 1999 trawl on Redfish Lake, 92% of the wild/natural smolts were assumed to be age-1, and 8% were assumed to be age-2. Out-migration for wild/natural smolts for Efficiency Period 1 was estimated at 949 (95% CI 794 to 1,153) and 980 (95% CI 712 to 1,423) for Efficiency Period 2. Total out-migration of wild/natural smolts at RLCTRP was estimated at 1,929 (95% CI 1,607 to 2,401) (Table 9).

Mean fork-length of hatchery-produced *O. nerka* captured at RLCTRP averaged 111 mm and ranged from 82 mm to 160 mm (Figure 4). No PIT tags were recovered from any releases performed in 1997; therefore, all hatchery smolts were assumed to be age-1. The bimodal distribution of fish lengths observed reflected different presmolt release strategies used in 1998. Net-pen reared fish were released to the lake larger (mean length 110 mm, mean weight 14.4 g)

than the direct lake release fish (mean length 101 mm, mean weight 9.6 g). It is assumed that the fish would retain this size difference over the winter and, therefore, the larger smolts were presumably from the net-pen release and the smaller fish from the direct fall release. Out-migration for hatchery-produced smolts was estimated at 8,562 (95% CI 7,315 to 10,199) for Efficiency Period 1 and 13,733 (95% CI 10,178 to 19,601) for Efficiency Period 2. Total out-migration of hatchery-produced smolts at RLCTRP was estimated at 22,295 (95% CI 18,438 to 28,303) (Table 9).

A total of 85 hatchery-produced fish were interrogated at RLCTRP with PIT tags (19 net pen, 66 direct fall). A significantly higher proportion ($P<0.001$) of presmolts overwintered and out-migrated from the fall compared to net pen release strategies. Presmolts from the Redfish Lake direct fall release overwintered and out-migrated significantly better ($P<0.001$) than net pen fish. Based on PIT tag interrogations at RLCTRP, we estimated total out-migration for the net pen release strategy at 4,923 smolts and 17,372 smolts for the direct fall release strategy.

Mainstem Snake and Columbia River Dams

Estimates of smolt out-migration were made by release strategy and were based on PIT tag interrogations recorded at LGR. Estimates reflect numbers of smolts passing LGR. Redfish Lake had three groups of smolts for which estimates of out-migration were made: wild/natural, direct fall presmolt release and net pen presmolt release. Numbers of wild/natural, direct fall release and net pen smolts passing LGR were estimated at 764, 11,317 and 2,882, respectively. Alturas and Pettit lakes each had one group of presmolts for which estimates of out-migration to LGR were made (direct fall release). An estimated 16,289 smolts from Alturas Lake and 2,732 smolts from Pettit Lake were estimated to have passed LGR. Two smolt releases, which took place in 1999 in Redfish Lake Creek and the upper Salmon River, produced an estimated 1,521 and 1,645 smolts, respectively (Table 10).

Median travel times for smolts were recorded from Sawtooth basin trap sites to LGR, LGJ, LMN, and MCN (Table 11). Travel times to LGR for wild/natural and hatchery-produced presmolt release groups ranged from six to nine days. Hatchery-produced smolt release group travel time ranged from 15-16 days. Significant differences (Kolmogorov-Smirnov test, $p<0.10$) in distribution of arrival times at LGR were detected for all groups except wild/natural vs. Redfish Lake net pen and Redfish Lake net pen vs. Alturas fall direct (Table 12).

Comparisons of overwinter success and out-migration to mainstem Snake and Columbia River dams were performed for presmolt release groups within a lake and between similar release strategies. Between Redfish Lake release strategies, a significantly higher proportion ($P <0.001$) of direct fall presmolts overwintered and out-migrated than net pen released presmolts (Table 13). Comparisons among direct lake release presmolts indicated that Alturas and Pettit lake fish overwintered and out-migrated significantly better than Redfish Lake direct release fish (Table 13). We detected no significant difference ($P=0.542$) in out-migration survival to LGR between Pettit Lake and Alturas Lake direct release presmolt groups.

Comparisons of out-migration survival (based on PIT tag interrogations) to the mainstem Snake and Columbia River dams were conducted on Redfish Lake Creek released smolts, upper Salmon River released smolts and wild/natural smolts PIT tagged at RLCTRP. Wild/natural and upper Salmon River released smolts displayed significantly higher (P-0.004, $P=0.046$, respectively) detection rates at the mainstem Snake and Columbia river dams than the Redfish Lake Creek smolt release group (Table 14).

Volitional Spawning Investigations

Telemetry studies of adults began on September 21 and continued weekly until October 27. Tagged fish remained in the north end of Redfish Lake from September 28 to October 5. Movement from the north end of the lake was noticed for the first time on October 12. The first suspected redds were located on October 20 at the south end of the lake on the east shore opposite the U.S. Forest Service transfer camp dock. One ultrasonic-tagged fish and two nontagged fish were observed on one redd. There were approximately eight areas of excavation (potential redds) in the same vicinity. The final boat tracking activity conducted on October 27 located only one transmitter signal. The signal had not moved from the week prior, and it was assumed that the transmitter had been shed or was in a carcass. Aerial surveys conducted on November 12 over Redfish and Little Redfish lakes yielded no additional areas of excavation.

The first documented mortality of an adult sockeye released in 1999 was a female collected at the mouth of Fishhook Creek on October 10. She was unspawned when the carcass was recovered. The carcass of a male sockeye was reported in Redfish Lake Creek below the first bridge but was not recovered. A second female, also unspawned, was found on Sockeye Beach on October 29.

Parental Lineage Investigations

Otoliths from 1998 and 1999 anadromous adult sockeye and 1999 smolts (hatchery and wild/natural from RLCTRP mortalities) were prepared for analysis and will be sent to Oregon State University.

Predator Investigations

We observed 40 adult bull trout and 15 completed redds in the Fishhook Creek index section. Spawning fish and completed redds were observed primarily in pool tail-outs created by large woody debris. Water temperature measured at 1040 hours was 9.0°C on August 26. Based on fish appearance and on the number of completed redds still associated with attending females, bull trout spawning activity was estimated to be nearly complete.

In contrast, bull trout spawning activity in Alpine Creek was just beginning. A total of 13 adult bull trout and three completed redds were observed in the Alpine Creek index section. Several fish were observed as pairs but had not initiated redd construction. Completed or active redds were located primarily in tail-outs created by in-channel boulders. Water temperature measured at 1245 hours was 11.0°C on August 27.

DISCUSSION

Abundance, Density and Biomass Estimation

Redfish Lake

Redfish Lake *O. nerka* abundance exhibits the least amount of fluctuation of the three lakes studied yearly since 1990. In 1999 the estimate of abundance was slightly lower than the average (45,899) for the nine years of study, well below the high of 61,646 (1995) and above the low of 24,431 (1990). Although Redfish Lake has the largest surface area of the three lakes studied, kokanee abundance is limited by availability of spawning habitat. (Redfish Lake kokanee are stream spawners.) A limited reach of Fishhook Creek is the only accessible spawning area for kokanee in the lake. Density estimates for *O. nerka* mimic the pattern of abundance, but the biomass estimate for 1999 is the lowest value recorded since 1990. The low biomass estimate reflects the dominant presence (over 50%) of age-0 fish in the trawl.

Alturas Lake

Abundance of *O. nerka* in Alturas Lake is highly variable. The population has exhibited variation from a high of over 120,000 fish (1990) to a low of less than 6,000 fish (1994). The 1999 estimate is only slightly higher than the ten-year average (52,202) and is down slightly from the 1998 estimate. Abundance of *O. nerka* in Alturas Lake is not limited by spawning habitat, which could explain the drastic population variability seen over the last ten years. Density again mimics the pattern of abundance, but the biomass estimate is as low as the lowest value recorded in the last ten years. Again, this was due to the dominance of age-0 fish (88%) in the trawl. If Alturas Lake is entering a boom or crash cycle, the abundance is so close to the ten-year average that it is unlikely to approach the historical high or a low extreme in the next year.

Pettit Lake

Historically, *O. nerka* abundance in Pettit Lake has been subject to the widest relative fluctuations of all three lakes studied yearly. Peak abundance of 71,654 fish (1996) is over 23 times the low value recorded in 1992 (3,009) fish. The 1999 abundance was only slightly higher than the eight-year average of 29,966 fish. Pettit Lake *O. nerka* exhibit the highest densities and biomass observed in the three lakes. If past trends continue, *O. nerka* abundance will continue to increase as it has since 1997 (at least through 2000 and possibly beyond). Estimated *O. nerka* biomass for 1999 was slightly lower than in 1998. However, the 1999 estimate of biomass was well above the lowest values recorded during the past eight years of investigation.

Kokanee Fishery Investigation

Redfish Lake

The kokanee fishery on Redfish Lake, which was closed in 1993 due to the presence of ESA listed residual sockeye salmon, was reopened in 1995 (NMFS permit 1150). The fishery was reopened based on the recommendation of the SBSTOC to help reduce kokanee competition with

sockeye through angler harvest. Up to 15 unmarked residual sockeye salmon may be harvested incidental to the kokanee fishery on Redfish Lake. Eleven fin clips collected from angler-harvested kokanee (1999 season) were analyzed by the University of Idaho's Hagerman Fish Culture Experiment Station. Of the 11 fin clips analyzed, none exhibited a mitochondrial haplotype known to be unique to residual sockeye salmon in Redfish Lake. Genetic analysis of fin clips collected from angler-caught kokanee began in 1996. To date, 115 fin clips from angler-harvested kokanee have been analyzed, and only one (collected in 1996) was found to exhibit a haplotype unique to residual sockeye salmon. Anglers harvested an estimated 1,100 kokanee in 1999. Most kokanee recruit to the fishery (become susceptible to fishing gear) as they increase in age and length. The Redfish Lake fishery primarily removes adults of spawning age from the population. This removal of spawning-age fish helps to reduce kokanee recruitment and competition in future years. In addition to the benefits of reducing competition, Redfish Lake also provides an important recreational fishery. In 1999, anglers fished an estimated 4,000 hours between May 24 and August 7. A considerable portion of anglers interviewed (41%) were nonresidents. Every effort should be made to keep Redfish Lake open to kokanee fishing to reduce intraspecific competition between kokanee and sockeye and to provide angler opportunities.

Pettit Lake

Public access at Pettit Lake is extremely limited compared to Redfish Lake. Despite a longer creel census period, effort on Pettit Lake was only one third of that recorded on Redfish Lake. Lower effort combined with almost 50% of the effort from bank anglers resulted in a lower catch rate for kokanee (estimated harvest of only 11 fish). Improved boat ramp facilities could increase the effort from boat anglers and increase the harvest of kokanee from the lake. Until then, it is likely that kokanee exploitation from this lake will remain low.

Pettit Lake receives 3,000 catchable rainbow trout planted during the summer to increase sport fishing opportunity. In 1999, we estimated that anglers harvested 60 rainbow trout. Estimated angler exploitation of catchable rainbow trout is 2%. The estimate had very wide confidence intervals, but overall this data suggests a very low catch and keep rate for catchable rainbow trout planted in Pettit Lake.

Out-migration Monitoring and Evaluation

Redfish Lake Creek Trap

Trap efficiencies for the 1999 out-migration year (0.23-0.33) were less variable than previous years (1996, 0.05 to 0.45; 1997, 0.15 to 0.45; 1998, 0.07 to 0.50). The estimated number of sockeye smolts passing RLCTRP in 1999 (28,319 wild/natural and hatchery-produced) was similar to historical estimates for wild out-migrants collected from 1955 to 1964 [median 23,000 smolts, mean 28,757 smolts (Chapman et. al 1990, Bjornn et al. 1968)]. Mean smolt length observed in 1999 was also similar to mean smolt length observed between 1955 and 1964. Wild/natural and hatchery-produced smolts collected in 1999 averaged 101 mm and 111 mm in fork length, respectively, while wild smolts collected between 1955 and 1964 averaged 103 mm in fork length (Chapman et. al 1990, Bjornn et al. 1968).

The estimated 1,944 wild/natural *O. nerka* smolts that emigrated from Redfish Lake in 1999 could be the progeny of wild residual sockeye salmon, sexually mature hatchery-reared adults released to the lake, the result of eyed eggs placed in in-lake incubation boxes, or any combination

of the three. The majority of the wild/natural smolts captured at the trap were age-1, brood year 1997 fish (92%). Snorkeling surveys conducted in 1997 at Sockeye Beach and the south end of the lake documented the presence of residual adult sockeye salmon. In that same year, 80 mature adult sockeye salmon were released to Redfish Lake to spawn. This adult release produced 30 suspected redds near the U.S. Forest Service transfer camp dock. In 1997, 85,378 eyed eggs were placed in in-lake incubation boxes in Redfish Lake. Considering recent wild out-migrant run strength (Figure 5), it is likely that wild residual sockeye did not contribute more than about 800 smolts (5-year average wild smolt estimate) to the 1999 out-migration. The majority of wild/natural out-migrants (1,100+) are likely the result of some combination of volitional spawning by hatchery-produced adults and eyed egg plants.

Hatchery presmolts released directly to Redfish Lake in the fall overwintered and out-migrated significantly better than the presmolts reared in net pens. The net pen fish were reared in 40 foot deep enclosures during the summer months and released to Redfish Lake about the same time as the direct fall group. It was hypothesized that subjecting the fish to variable lake conditions (e.g., temperature, photoperiod, etc.) while protecting them from predators and supplementing natural diet with a commercial diet would give this group of fish an advantage over the direct fall release group when it came to overwinter survival and out-migration. However, PIT tag interrogation data from RLCTRP clearly showed that the direct fall release fish overwintered and out-migrated significantly better than the net pen fish. It is possible that the net pen fish residualized and remained in the lake, but no hatchery produced *O. nerka* were collected during the midwater trawling conducted in September to confirm this. It is also possible that the difference in out-migration success reflects differences in early rearing locations of the two release groups. The net pen fish were reared at Eagle Fish Hatchery (IDFG) until they were placed in the net pens, while the direct fall release fish were reared at Sawtooth Fish Hatchery until release into the lake. At this time, the most likely explanation is that overwinter mortality was very high in the net pen release strategy and that the fish simply died.

Mainstem Snake and Columbia River Dams

Although the mechanisms responsible for the differences are not clear, a higher proportion of presmolts planted in Pettit and Alturas lakes in the fall overwintered and out-migrated to LGR than presmolts planted in Redfish Lake. These estimates of overwinter survival and out-migration at LGR are based on expansions of sockeye salmon PIT tag interrogations using daily collection efficiencies (DCE) of the juvenile bypass and collection system estimated for chinook smolts. Currently, there are no sockeye-specific estimates of daily collection efficiency, although sockeye are known to have lower fish guidance efficiencies than chinook salmon (Chapman 1990); DCE (estimated for chinook smolts) is the best adjustment for guidance and spill currently available (Russ Kiefer, IDFG, personal communication). During the period when sockeye smolts were being detected, DCE varied from 0.182 to 0.783. The Kolmogorov-Smirnov tests indicated that distributions of arrival times at LGR were significantly different for most groups, which indicates that handling and detection were not equal for all groups. The method for calculating DCE is constant, and although comparisons made from these estimates should be valid because they are based on DCE calculated for another species, they should be used with caution. Future investigations should focus on identifying the factors responsible for the differences observed in overwinter survival between the three lakes.

Volitional Spawning

Telemetry investigations documented males and females near areas of excavation at the southeast end of Redfish Lake, and it is assumed that some successful redds were produced. The area of excavation selected in 1999 is a new location, but it is similar in substrate size and depth

to locations previously selected by hatchery adults. In 1999, two of the 10 females were recovered unspawned. Past information suggests that in some years only half of the captive-reared adult females placed into Sawtooth basin lakes successfully spawned. If only four of the eight females which survived to spawning had spawned successfully, we can assume that 8,000 green eggs were deposited in Redfish Lake and expect approximately 400 smolts from this spawning to out-migrate in 2001.

Predator Investigations

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 has 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). Predatory fish population status and stability are not well understood in Sawtooth basin lakes. Tracking changes in bull trout spawner abundance will hopefully facilitate a more thorough interpretation of potentially limiting nursery habitat variables and provide insight for prioritizing future research needs.

Final index sections were established on Fishhook and Alpine creeks in 1998. Information collected in 1999 represents the second year data were collected in the same index reaches. Currently Fishhook Creek supports more bull trout spawning activity than Alpine Creek, with three times the number of bull trout observed and five times the number of redds. Both tributaries showed a slight increase in the total number of redds observed from 1998 to 1999, but the maximum number of bull trout observed during a survey more than doubled in Alpine Creek while the number observed in Fishhook Creek remained the same. Our future observations will help to clarify the trends that are beginning to emerge.

Table 1. Physical and morphometric characteristics of five study lakes located in the Sawtooth basin (Sawtooth Valley National Recreation Area), Idaho.

Surface Area (ha)	Elevation (m)	Volume (m^3x10^6)	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	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. Hatchery-produced sockeye salmon released to Sawtooth basin waters in 1998. Adults and eyed-eggs were reared at the Eagle Fish Hatchery (IDFG). Sawtooth Fish Hatchery (IDFG) reared smolts and presmolts, and Bonneville Fish Hatchery (ODFW) reared smolts.

Strategy	Brood year	Release Date	Number Released	Number PIT tagged	Date Tagged	Weight at Tagging (g)	Weight at Release (g)
Upper Salmon River							
Smolt (IDFG)	1996	Apr 27	999	995	—	—	26.5
Smolt (ODFW)	1996	Apr 28, May 5	43,033	1,054	—	—	63.5
Redfish Lake Creek							
Smolt (IDFG)	1996	Apr 28, May 5	13,218	1,047	—	—	26.5
Smolt (ODFW)	1996	Apr 28, May 5	24,365	999	—	—	63.5
Redfish Lake							
Net pen presmolt	1997	Oct 1	55,830	2,973	Jun 25	7.4	14.4
Fall presmolt direct	1997	Oct 14	39,418	1,206	Oct 8	9.6	9.6
Pettit Lake							
Summer presmolt direct	1997	Jul 30	7,246	1,501	Jul 14-15	8.7	9.8
Eyed-egg	1999	Nov 18	20,311	—	—	—	—
Alturas Lake							
Fall presmolt direct	1997	Oct 14	39,377	1,246	Oct 8	9.5	10.3

Table 3. Hatchery-produced sockeye salmon released to Sawtooth basin waters in 1999. Adults and eyed-eggs were reared at the Eagle Fish Hatchery (IDFG). Smolts and presmolts were reared at the Sawtooth Fish Hatchery (IDFG).

Strategy	Brood Year	Release Date	Number Released	Number PIT tagged	Date Tagged	Weight at Tagging (g)	Weight at Release (g)
Upper Salmon River							
Smolt	1997	May 4	4,859	399	Apr 1	22.4	25.4
Redfish Lake Creek							
Smolt	1997	May 5	4,859	400	Apr 1	22.4	25.4
Redfish Lake							
Adult	1996	Sep 15	18	18	1997	NA	2,600.0
Adult (anadromous)	1996	Sep 15	3	0	NA	NA	NA
Fall presmolt direct	1998	Oct 13	23,886	1,560	Oct 5-6	9.7	9.7
Pettit Lake							
Fall presmolt direct	1998	Oct 13	3,430	2,009	Oct 5-6	10.4	10.4
Eyed-egg	1999	Nov 18	20,311	NA	NA	NA	NA
Alturas Lake							
Fall presmolt direct	1998	Oct 13	12,955	1,559	Oct 5-6	10.8	10.8

Table 4. Estimated *O. nerka* abundance, density (fish/ha), and biomass (kg/ha) in Sawtooth basin lakes, 1990-1999.

Date Sampled	Abundance (95% C.I.)		Density	Biomass
	Redfish Lake (615 surface hectares)			
9/8/99	42,916	(13,177)	69.7	0.9
9/21/98	31,486	(11,349)	51.2	1.8
9/2/97	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
9/6/94	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)			
9/9/99	56,675	(43,477)	167.7	0.4
9/23/98	65,468	(34,284)	193.7	1.4
9/4/97	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
9/7/94	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
9/8/91	125,045	(30,708)	370	3.9
8/19/90	126,644	(31,611)	374.7	3.3
	Pettit Lake (160 surface hectares)			
9/10/99	31,422	(21,280)	196.4	6.3
9/22/98	27,654	(8,764)	172.8	9.7
9/3/97	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
9/8/94	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)			
9/24/98	14,936	(7,391)	184.4	5.0
9/27/95	1,021	(702)	12.6	0.2
9/7/94	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] single transect estimate

Table 5. Estimated 1999 *O. nerka* abundance, density (fish/ha), and biomass (kg/ha) by age-class in Sawtooth basin lakes.

	Age-0	Age-1	Age-2	Age-3	Total
Redfish Lake (615 surface hectares)					
# captured	31	11	9	2	53
Length range (mm)	0-70	71-120	121-180	181-200	—
Mean length (mm)	52.6	88	171	191	—
Mean weight (g)	1.4	6.5	50.2	71	—
Abundance	28,341	5,668	7,288	1,619	42,916
95% CI High	39,395	10,305	12,755	3,667	56,093
95% CI Low	17,285	1,030	1,819	-429	29,739
Density (fish/ha)	46	9	12	3	70
Biomass (kg/ha)	0.1	0.1	0.6	0.2	0.9
Alturas Lake (338 surface hectares)					
# captured	81	10	0	0	91
Length range (mm)	0-70	71-120	—	—	—
Mean length (mm)	55	103	—	—	—
Mean weight (g)	1.4	10.8	—	—	—
Abundance	50,447	6,228	—	—	56,675
95% CI High	93,708	10,542	—	—	100,152
95% CI Low	7,184	1,913	—	—	13,198
Density (fish/ha)	149	18	—	—	167.7
Biomass (kg/ha)	0.2	0.2	—	—	0.4
Pettit Lake (160 surface hectares)					
# captured	0	0	55	3	58
Length range (mm)	—	—	140-179	180-200	—
Mean length (mm)	—	—	155	184	—
Mean weight (g)	—	—	31.6	47.4	—
Abundance	—	—	30,338	1,083	31,422
95% CI High	—	—	49,644	3,199	50,944
95% CI Low	—	—	10,784	-1,066	11,900
Density (fish/ha)	—	—	262	9	196.4
Biomass (kg/ha)	—	—	6.1	0.3	6.4

Table 6. Estimated angler effort for the 1999 fishing season on Redfish and Pettit lakes.

	Boat	Bank	Total
Redfish Lake			
Hours fished	2,538	1,414	3,951
±95% CI	899	561	1,060
Pettit Lake			
Hours fished	659	491	1,148
±95% CI	367	269	455

Table 7. Catch rates (fish/hour) for the 1999 fishing season 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	0.36	0.16	0.52	0.29	0.00	0.01	0.00	0.18	0.36	0.63	0.99
Weekend Day	0.44	0.14	0.58	0.26	0.00	0.00	0.01	0.08	0.45	0.48	0.19
Season Average	0.38	0.15	0.53	0.28	0.00	0.01	0.00	0.15	0.39	0.59	0.97
Pettit Lake											
Weekday	0.00	0.06	0.06	0.00	0.02	0.01	0.15	0.05	0.17	0.12	0.29
Weekend Day	0.01	0.11	0.12	0.00	0.03	0.26	0.00	0.03	0.04	0.40	0.06
Season Average	0.00	0.08	0.08	0.00	0.02	0.08	0.11	0.04	0.13	0.20	0.33

Table 8. Estimated number of fish kept and released on Redfish and Pettit lakes during the 1999 fishing season.

	Harvested			All Fish		
	Kokanee	Rainbow Trout	Other	Released	Harvested	Combined
Redfish Lake						
Number of fish	1,187	0	7	2,468	1,194	3,662
±95% CI	843	0	19	682	843	1,622
Pettit Lake						
Number of fish	11	60	159	250	230	479
±95% CI	18	68	351	179	362	456

Table 9. Out-migration data (by trap efficiency period) for *O. nerka* captured at the Redfish Lake Creek Trap from April 25 to June 4, 1999.

	Efficiency Period 1	Efficiency Period 2	Total
Dates	4-25 to 5-20	5-21 to 6-4	—
Trap efficiency	0.33	0.23	—
# efficiency releases	288	122	—
# efficiency recaptures	96	28	—
Wild/Natural Out-migrants			
Actual #	317	226	543
Estimated #	949	980	1,929
Upper bound	1,153	1,423	2,401
Lower bound	794	712	1,607
Hatchery-produced Out-migrants			
Actual #	2,859	3,165	6,024
Estimated #	8,562	13,733	22,295
Upper bound	10,199	19,601	28,303
Lower bound	7,315	10,178	18,438

Table 10. Summary of 1999 *O. nerka* smolt out-migration information (by release strategy) at trap locations and Lower Granite Dam (LGR).

Initial No. Released	Initial No. PIT tagged	Estimated No. of Total Out-migrants	No. of PIT tag Interrogations at LGR	Estimated No. of PIT-tagged Smolts at LGR	Estimated No. of Total Smolts at LGR	Percent Survival from Trap to LGR	Percent Survival from Release to LGR
Redfish Lake Wild/Natural Out-migrants							
1,936	410	1,936	41	162	764	39.5%	39.5%
Redfish Lake Net Pen Out-migrants							
55,830	2,973	4,870	11	40	2,839	58.3%	5.1%
Redfish Lake Direct Lake Out-migrants							
39,418	1,206	17,555	47	157	11,149	63.5%	28.3%
Alturas Lake Direct lake Out-migrants							
39,377	1,246	—	140	515	16,289	—	41.4%
Pettit Lake Direct Lake Out-migrants							
7,256	1,501	—	187	533	2,754	—	38.0%
Redfish Lake Creek Smolt Release							
4,859	400	4,859	26	125	1,521	31.3%	31.3%
Upper Salmon River Smolt Release							
4,859	400	4,859	27	135	1,645	33.8%	33.8%

Table 11. Travel times recorded from outlet creek traps to mainstem Snake and Columbia river dams, Lower Granite (LGR), Little Goose (LGJ), Lower Monumental (LMN), and McNary (MCN).

Release Strategy	Travel Time (Days)	LGR	LGJ	LMN	MCN
Redfish Lake					
wild/natural	median	9	13	13	17
	n	*41*	*59*	*27*	*6*
fall direct presmolt	median	6	11	10	0
	n	*15*	*10*	*9*	*0*
net pen presmolt	median	6	9	8	0
	n	*1*	*3*	*2*	*0*
Alturas Lake					
fall direct presmolt	median	6	9	10	16
	n	*12*	*19*	*9*	*1*
Pettit Lake					
summer direct presmolt	median	6	20	14	0
	n	*27*	*8*	*9*	*0*
Redfish Lake Creek					
smolt	median	16	19	20	26
	n	*26*	*27*	*26*	*4*
Upper Salmon River					
Smolt	median	15	18	20	22
	n	*27*	*45*	*32*	*10*

Table 12. Comparisons of distributions of PIT tag interrogations at Lower Granite Dam by release strategy for the 1999 out-migration year. Multiple two-sample Kolmogorov-Smirnov tests were used to determine significance (alpha = 0.10).

	Redfish Lake Wild	**Redfish Lake Net Pen**	**Redfish Lake Fall Direct**	**Alturas Lake Fall Direct**	**Redfish Lake Creek Smolt**	**Upper Salmon River Smolt**
Pettit Lake summer	significant					
Redfish Lake net pen	not significant	significant				
Redfish Lake fall direct	significant	significant	significant			
Alturas Lake fall direct	significant	not significant	significant	significant		
Redfish Lake Creek smolt	significant	significant	significant	significant	significant	
Upper Salmon River smolt	significant	significant	significant	significant	significant	significant

Table 13. Comparisons of overwinter survival and smolt out-migration to the mainstem Snake and Columbia River dams with juvenile detection systems (Lower Granite, Little Goose, Lower Monumental, and McNary).

Location	Release Strategy	PIT Tags at Release	Cumulative Unique Detections	% PIT Tags to Dams	Chi square P value
Redfish Lake	net pen	2,973	31	1.0%	P<0.001
Redfish Lake	direct fall	1,206	138	11.4%	
Redfish Lake	direct fall	1,206	138	11.4%	P<0.001
Alturas Lake	direct fall	1,246	380	30.5%	
Redfish Lake	direct fall	1,206	138	11.4%	P<0.001
Pettit Lake	direct summer	1,501	436	29.0%	
Alturas Lake	direct fall	1,246	380	30.5%	P=0.542
Pettit Lake	direct summer	1,501	436	29.0%	

Table 14. Comparisons of smolt out-migration to the mainstem Snake and Columbia River dams with juvenile detection systems (Lower Granite, Little Goose, Lower Monumental, and McNary).

Location	Release Strategy	PIT Tags at Release	Cumulative Unique Detections	% PIT Tags to Dams	Chi square P value
Redfish Lake	wild/natural	410	133	32.4%	P=0.004
Redfish Lake Creek	smolt	400	83	20.8%	
Redfish Lake	wild/natural	410	133	32.4%	P=0.384
Upper Salmon River	smolt	399	114	28.8%	
Redfish Lake Creek	smolt	400	83	20.8%	P=0.046
Upper Salmon River	smolt	399	114	28.8%	

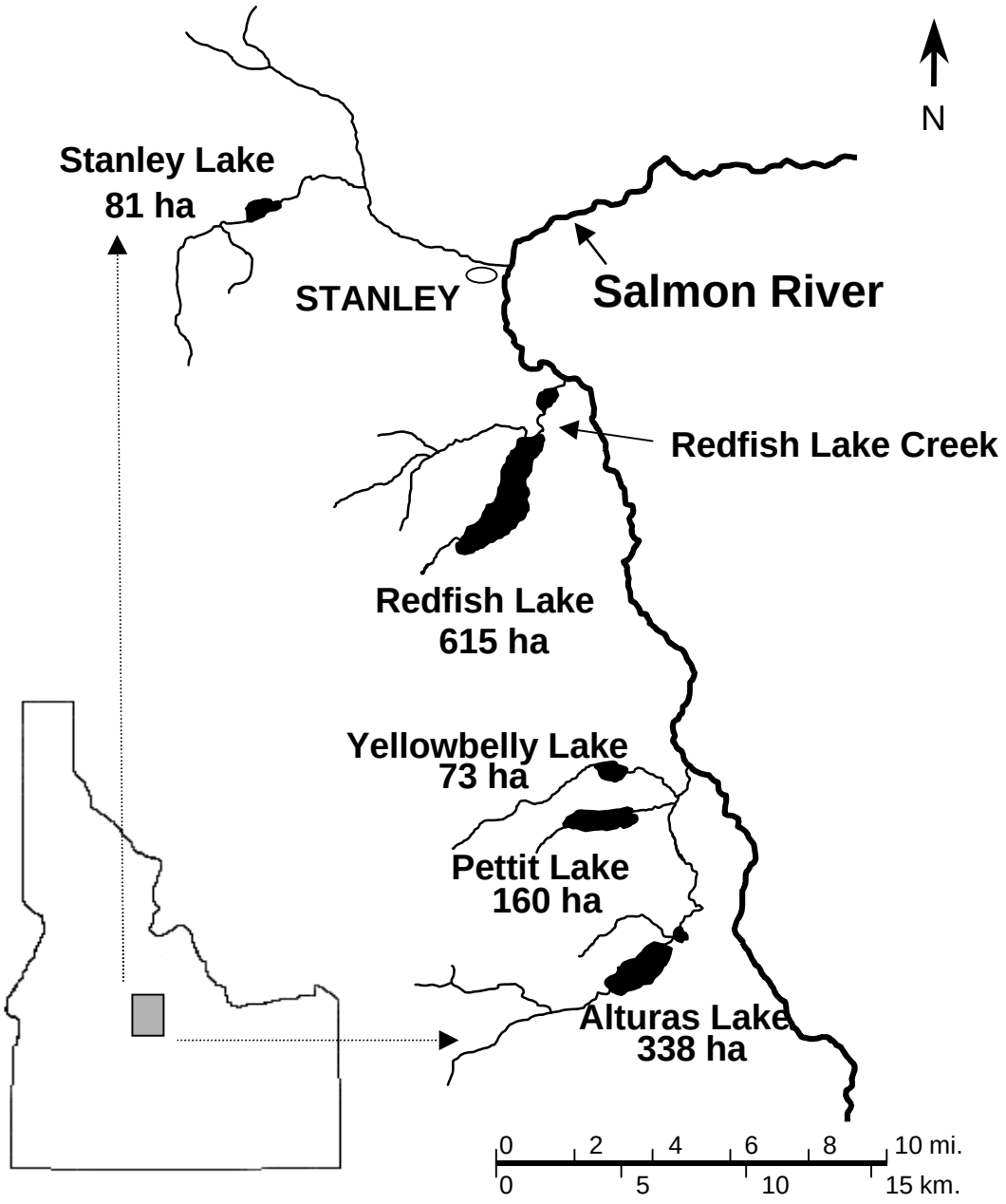

Figure 1. Location of Sawtooth basin in Idaho.

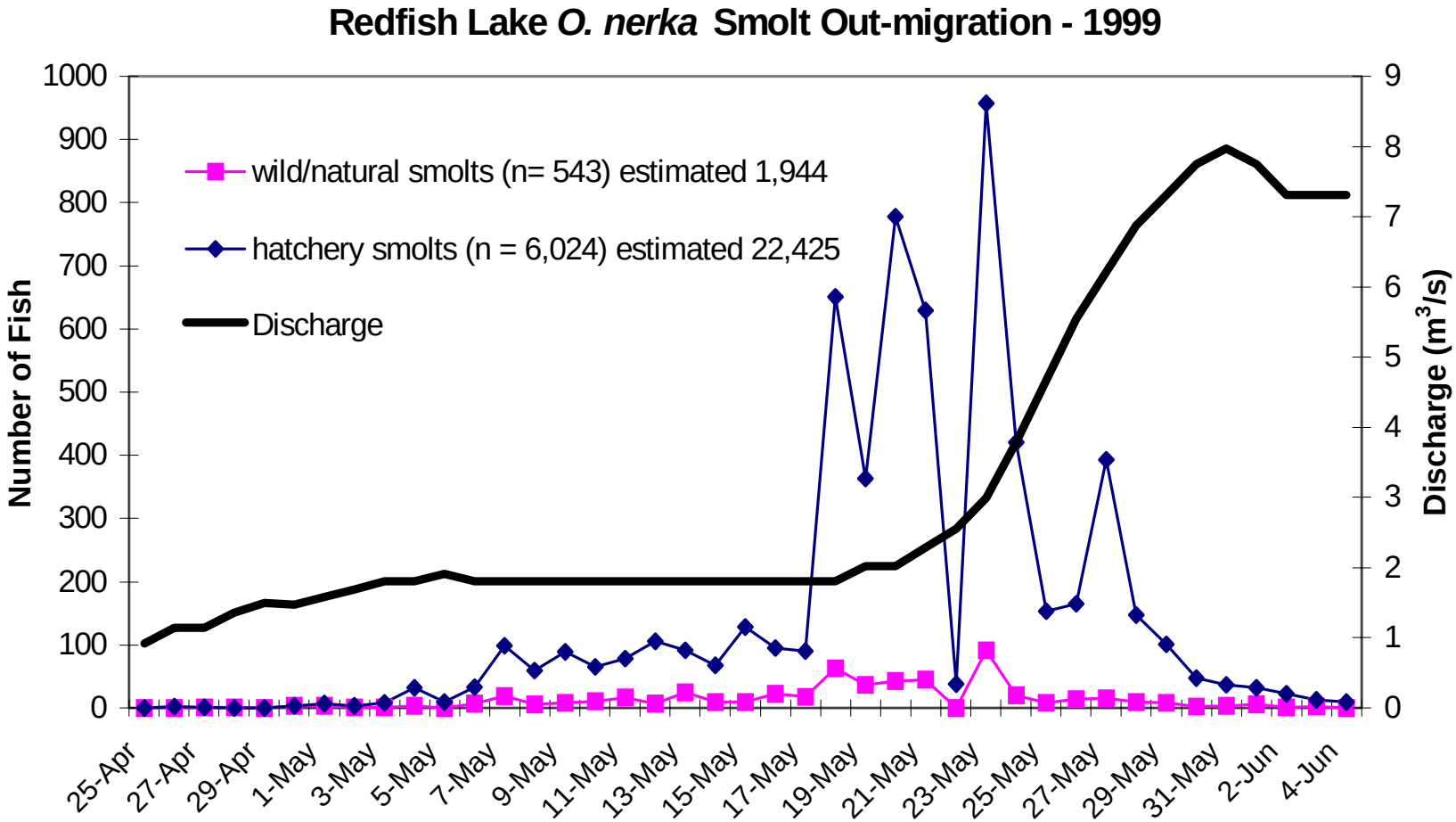

Figure 2. Daily capture of wild/natural and hatchery sockeye salmon smolts *O. nerka* and discharge at the Redfish Lake Creek Trap during the 1999 out-migration year.

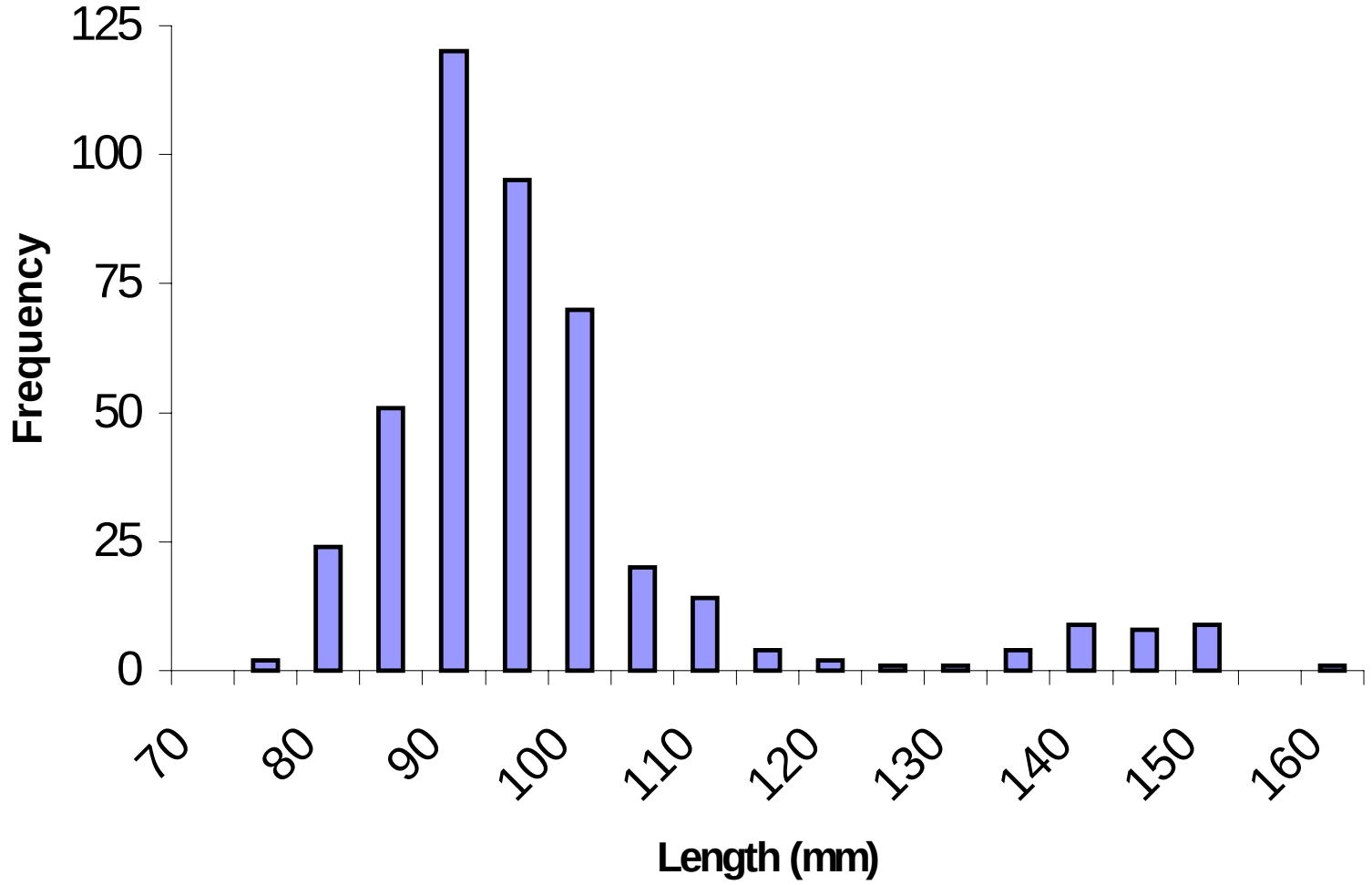

Figure 3. Length frequency of wild/natural sockeye smolts captured at the Redfish Lake Creek Trap in 1999. Four hundred age-1 (70 mm-119 mm) 92%; 35 age-2 (120 mm-180 mm) 8%; Total = 435.

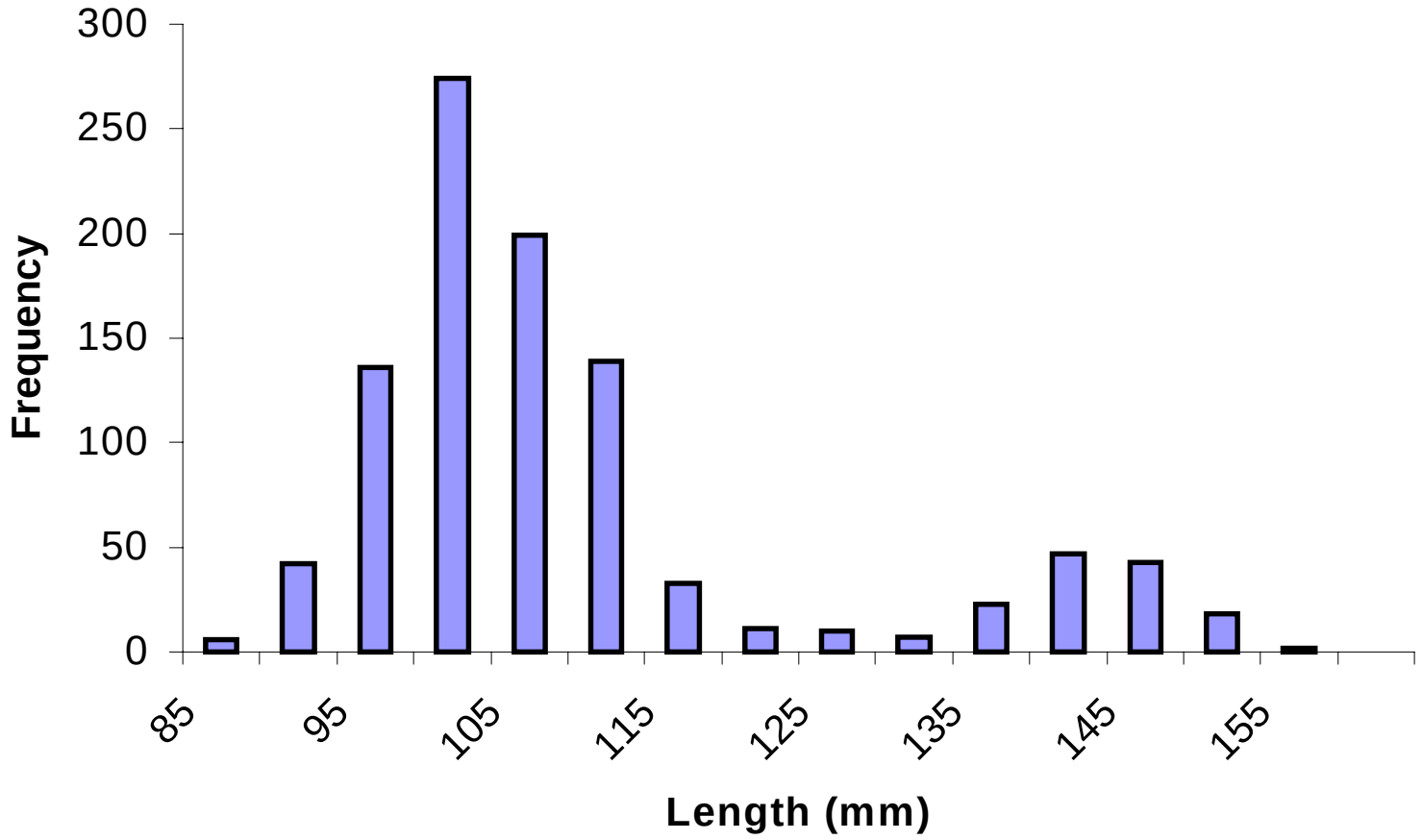

Figure 4. Length frequency of a subset of measured hatchery smolts captured at the Redfish Lake Creek Trap in 1999. Total = 990.

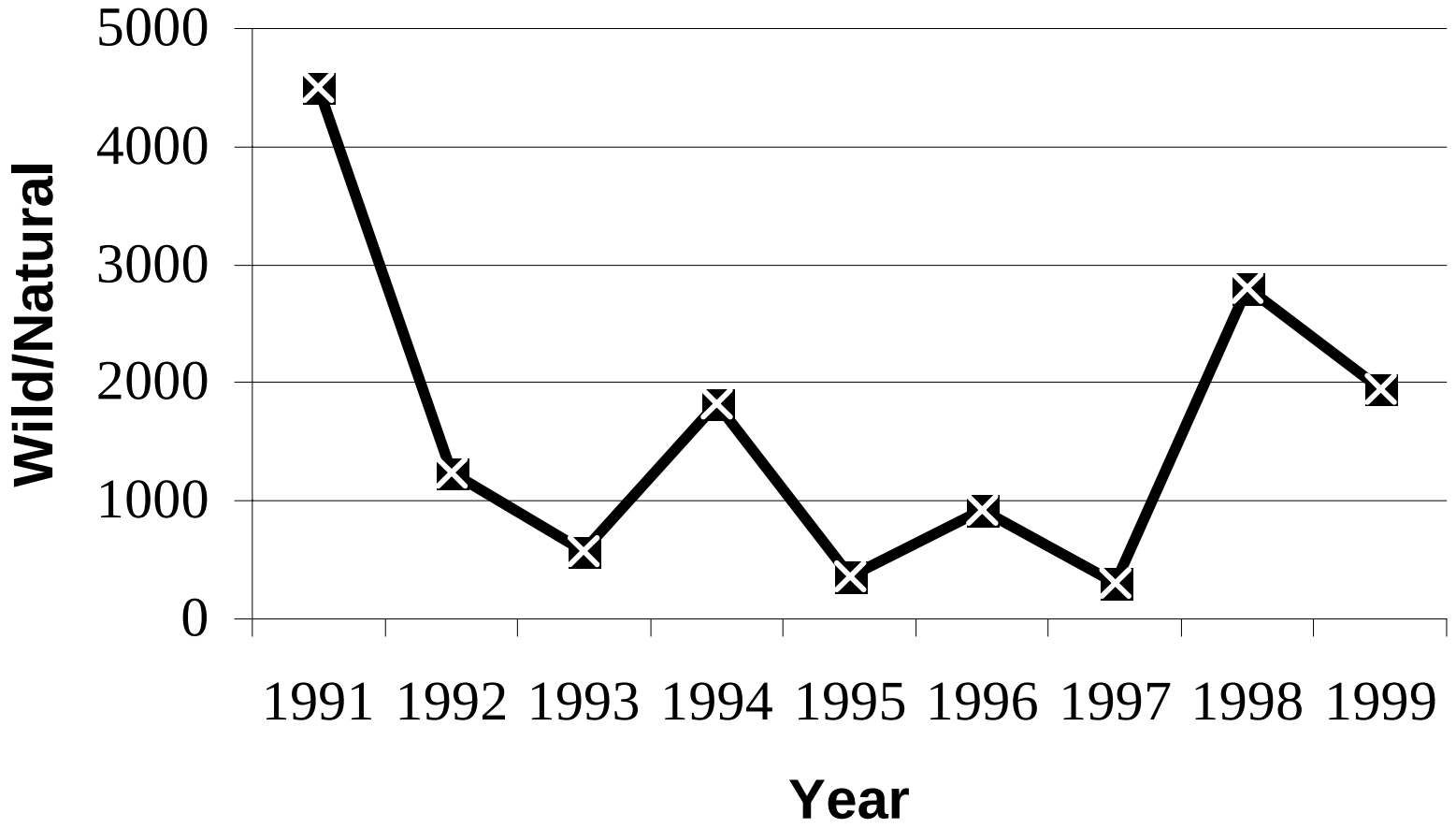

Figure 5. Wild/natural smolt out-migration estimated at Redfish Lake Creek Trap from 1991 to 1999.

LITERATURE CITED

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

Chapman, D. W., W. S. Platts, D. Park, and M. Hill. 1990. Status of Snake River sockeye salmon. Don Chapman Consultants, Inc. Boise, Idaho.

Cohen, J. 1988. Statistical power analysis for the behavioral sciences, 2nd ed. Lawrence Erlbaum Associates. Hillsdale, New Jersey.

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

IDFG (Idaho Department of Fish and Game). 1992. Anadromous fish management plan 1992-1996. Boise, Idaho.

IDFG (Idaho Department of Fish and Game) 1998. General fishing seasons and rules including steelhead. Boise, Idaho.

Kalish, J. M. 1990. Use of otolith microchemistry to distinguish the progeny of sympatric anadromous and non-anadromous salmonids. Fishery Bulletin 88:657-666.

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

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

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

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

Rieman, B. E., D. L. Myers, and R. L. Nielsen. 1993. The use of otolith microchemistry to discriminate *Oncorhynchus nerka* of resident and anadromous origin. Idaho Department of Fish and Game. Boise, Idaho.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry, 2nd ed. W. H. Freeman and Company. New York, New York.

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

Toole, C. L., and R. L. Nielsen. 1992. Effects of microprobe precision on hypotheses related to otolith Sr:Ca ratios. Fishery Bulletin, 41:239-255.

Wu, Y., and K. Steinhorst. 2000. Confidence intervals for escapement estimates derived from stratified samples. Masters Thesis. University of Idaho, Moscow, Idaho.

Zar, J. H. 1984. Biostatistical Analysis, 2nd ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey

APPENDICES

Appendix A. Length (mm) and weight (mm) of *O. nerka* captured during midwater trawls conducted in September 1999 on Redfish, Alturas, and Pettit lakes.

Transect	Fork Length (mm)	Weight (gm)	Age
Redfish Lake			
2	43	0.6	0
1	44	0.9	0
2	44	0.7	0
2	44	0.8	0
5	46	0.8	0
2	47	0.9	0
5	47	0.9	0
3	48	1.0	0
3	48	0.9	0
5	48	0.8	0
2	49	0.9	0
4	49	1.0	0
5	50	1.0	0
3	51	1.1	0
2	52	1.2	0
6	52	1.2	0
2	53	1.2	0
2	53	1.2	0
3	54	4.5	0
3	54	1.2	0
5	54	1.2	0
6	54	1.3	0
4	56	1.4	0
6	56	1.3	0
4	57	1.5	0
3	58	1.4	0
3	58	1.7	0
3	62	2.2	0
1	66	2.5	0
2	67	2.7	0
1	68	3.5	0
4	72	3.5	1
2	73	3.3	1
4	73	3.3	1
5	74	3.1	1
3	80	4.2	1
3	82	4.5	1
1	96	10.1	1
6	96	8.0	1
6	104	8.9	1
3	109	10.0	1
5	110	12.2	1
1	159	46.5	2
4	165	42.2	2
1	168	49.1	2
5	169	47.5	2

3	170	46.6	2

Appendix A. (Continued.)

Transect	Fork Length (mm)	Weight (gm)	Age
Redfish Lake			
1	173	53.6	2
3	175	58.6	2
1	177	48.8	2
2	179	59.2	2
5	190	65.6	3
1	191	76.4	3
Alturas Lake			
1	37	0.5	0
1	44	0.8	0
3	44	0.6	0
3	44	0.6	0
4	46	0.8	0
3	47	0.9	0
3	47	0.8	0
4	47	1.0	0
4	47	0.8	0
3	49	0.9	0
4	49	0.9	0
4	49	1.0	0
1	50	1.5	0
3	50	0.8	0
3	50	1.0	0
4	50	1.0	0
1	51	1.4	0
1	51	1.2	0
3	51	1.1	0
4	51	1.1	0
1	52	1.4	0
1	52	1.4	0
4	52	1.1	0
4	52	1.2	0
4	52	1.3	0
1	53	1.3	0
4	53	1.2	0
4	53	1.3	0
4	53	1.3	0
4	53	1.3	0
4	53	1.2	0
4	53	1.2	0
1	54	1.4	0
4	54	1.2	0
4	54	1.3	0
4	54	1.3	0
1	55	1.5	0
1	55	1.4	0
4	55	1.4	0
4	55	1.3	0

4	55	1.3	0
4	55	1.1	0

Appendix A. (Continued.)

Transect	Fork Length (mm)	Weight (gm)	Age
Alturas Lake			
4	55	1.4	0
4	55	1.2	0
1	56	1.5	0
1	56	1.8	0
3	56	1.6	0
4	56	2.0	0
4	56	1.3	0
4	56	1.3	0
4	56	1.4	0
3	57	1.6	0
3	57	1.4	0
4	57	1.6	0
4	57	1.6	0
4	57	1.7	0
4	57	1.4	0
4	57	1.3	0
2	58	1.8	0
2	58	1.7	0
3	58	1.4	0
4	58	1.8	0
4	58	1.2	0
4	58	1.4	0
2	59	1.8	0
4	59	1.7	0
4	59	1.8	0
3	60	1.7	0
4	60	1.9	0
4	60	1.9	0
2	61	1.9	0
4	61	1.7	0
1	62	2.1	0
2	62	2.1	0
2	62	1.9	0
4	62	2.1	0
4	62	2.0	0
2	63	2.1	0
4	64	2.2	0
4	65	2.0	0
2	68	2.9	0
1	80	4.6	1
1	83	5.0	1
2	99	9.6	1
3	100	9.2	1
2	101	10.2	1
2	109	10.7	1
2	111	13.8	1

4	111	14.8	1
3	118	14.7	1
2	119	15.8	1

Appendix A. (Continued.)

Transect	Fork Length (mm)	Weight (gm)	Age
Pettit Lake			
3	143	27.2	2
3	145	27.7	2
1	146	24.3	2
3	148	25.1	2
4	148	27.5	2
2	149	28.5	2
3	149	27.6	2
2	150	32.2	2
3	150	29.3	2
3	150	28.4	2
3	151	29.1	2
3	151	30.0	2
4	151	27.7	2
1	152	31.8	2
1	152	32.0	2
1	152	30.8	2
2	152	31.6	2
1	153	29.4	2
1	153	29.1	2
1	153	30.9	2
3	154	31.1	2
3	154	30.5	2
3	154	31.1	2
1	155	28.1	2
1	155	31.0	2
2	155	29.9	2
3	155	27.0	2
3	155	28.5	2
3	155	28.6	2
3	155	29.2	2
3	156	33.0	2
3	156	33.5	2
1	157	30.1	2
1	157	35.5	2
1	157	35.1	2
1	157	36.6	2
2	157	34.4	2
1	158	33.2	2
1	158	32.8	2
1	158	33.2	2
3	158	32.2	2
3	158	34.6	2
3	158	30.9	2
3	158	32.6	2
3	158	33.8	2

4	159	30.0	2
4	160	35.6	2
1	161	36.6	2
2	162	31.8	2

Appendix A. (Continued.)

Transect	Fork Length (mm)	Weight (gm)	Age
Pettit Lake			
3	162	35.0	2
4	162	33.3	2
3	163	35.0	2
1	164	42.3	2
3	168	40.9	2
4	173	39.8	2
3	184	46.3	3
3	188	46.3	3

Appendix B. Information on adult sockeye released for volitional spawning in Redfish Lake.

Hatchery (BY 1996) Sockeye Releases to Redfish Lake (9/15/99)								
Brood Year	**Lineage**	**Sex**	**Fork Length (cm)**	**Weight (g)**	**Marks**	**Tags**	**Tag Number**	**PIT Number**
1996	B5	F	58	3164	AD	NONE	-	22171C2B3C
1996	B5	F	56	2644	AD	NONE	-	22171C3227
1996	OM	F	56	2272	AD	NONE	-	416D64727A
1996	LL	F	58	2804	AD	NONE	-	416C363423
1996	B5	F	58	2818	AD	NONE	-	2217291364
1996	B5	F	58	2828	AD	NONE	-	416B787052
1996	B5	F	60	2980	AD	NONE	-	2217022958
1996	B4	F	59	3034	AD	NONE	-	2216760575
1996	OM	F	54	2540	AD	NONE	-	416E49115C
1996	B5	F	58	2746	AD	NONE	-	416D632618
1996	B4	M	51	1702	AD	NONE	-	2217197072
1996	B4	M	59	2842	AD	NONE	-	22171A336F
1996	B4	M	58	2724	AD	SONIC	233	2217114B09
1996	UNK*	M	52	1662	AD	SONIC	253	221746102D
1996	A3	M	57	2488	AD	SONIC	346	22170A5F25
1996	OM	M	59	3096	AD	SONIC	445	221702587F
1996	LL	M	59	2940	AD	SONIC	264	2216763B60
1996	LL	M	59	2844	AD	SONIC	555	2217225C72
n = 18 (10 females + 8 males)			**57**	**2674**				

1999 Anadromous Sockeye Returns—Redfish Lake Releases (9/15/99)										
Trap Date	**Trap Location**	**Sex**	**Fork Length (cm)**	**Marks (AD, LV, RV)**	**Tags (PIT, CWT)**	**Note Injury**	**Zip-Tie Color**	**PIT Number**	**Comments**	
8/20/99	SFH	M	43	AD, LV	None	Minor	Green	7F7D3F032C	No Haplotype	PIT—H9
8/21/99	SFH	M	45	AD, LV	CWT	None	Green	416C361614	No Haplotype	PIT—H9
8/25/99	SFH	M	43	AD, LV	CWT	Minor	Green	505979294B	No	PIT—H9

Haplotype

Appendix C. Sockeye smolt PIT tag detections at Lower Granite Dam by date for 1999.

	WILD	PETTIT	RFL-NP	RFL FALL	ALT FALL	RLC	USR	Total	Cumulative
14-May-98							1	1	1
15-May-98	1						2	3	4
16-May-98							3	3	7
17-May-98	1					2	5	8	15
18-May-98							1	1	16
19-May-98	2					6		8	24
20-May-98					1	2	5	8	32
21-May-98	1				1	6	3	11	43
22-May-98	2				1	2	4	9	52
23-May-98	2				1	4	1	8	60
24-May-98	1				8	1	1	11	71
25-May-98	6			3	4	1		14	85
26-May-98	4		1	2	6	2		15	100
27-May-98	6	2	5	2	16			31	131
28-May-98	4	6	2	6	22			40	171
29-May-98	1	1		6	39			47	218
30-May-98		20		12	20			52	270
31-May-98	2	13		3	12		1	31	301
1-Jun-98	2	23	1	3	5			34	335
2-Jun-98	1	10	1					12	347
3-Jun-98		7		1				8	355
4-Jun-98	2	15		2	1			20	375
5-Jun-98		22						22	397
6-Jun-98		18	1	1	1			21	418
7-Jun-98		1		1				2	420
8-Jun-98		3						3	423
9-Jun-98								0	423
10-Jun-98		1			2			3	426
11-Jun-98	2			1				3	429
12-Jun-98	1	1						2	431
13-Jun-98		3						3	434
14-Jun-98		2						2	436
15-Jun-98								0	436
16-Jun-98		1						1	437
17-Jun-98								0	437
18-Jun-98		6		1				7	444
19-Jun-98		3						3	447
20-Jun-98		2		1				3	450
21-Jun-98		2						2	452
22-Jun-98		7						7	459
23-Jun-98		1						1	460
24-Jun-98		3						3	463
25-Jun-98		2						2	465
26-Jun-98		1						1	466
27-Jun-98								0	466
28-Jun-98		1						1	467
29-Jun-98		2						2	469
30-Jun-98								0	469
1-Jul-98		1						1	470
2-Jul-98								0	470
3-Jul-98		1						1	471
4-Jul-98		1						1	472

Appendix C. (Continued.)

	WILD	PETTIT	RFL-NP	RFL FALL	ALT FALL	RLC	USR	Total	Cumulative
5-Jul-98								0	472
6-Jul-98		1						1	473
7-Jul-98								0	473
8-Jul-98		1						1	474
9-Jul-98								0	474
10-Jul-98		1						1	475
11-Jul-98								0	475
12-Jul-98				1				1	476
13-Jul-98				1				1	477
14-Jul-98		2						2	479
15-Jul-98								0	479
16-Jul-98								0	479
17-Jul-98								0	479
18-Jul-98								0	479
19-Jul-98								0	479
TOTALS	**41**	**187**	**11**	**47**	**140**	**26**	**27**		
LOWER GRANITE GRAND TOTAL					**479**				

Appendix D. Number of PIT tag detections for sockeye smolts detected at Lower Granite Dam estimated from daily collection efficiency (DCE).

	Flow	Spill	% Spill	DCE	Wild	Pettit	Rflnp	Rflfall	Altfall	RLC	USR
14-May-98	86.6	35.4	0.41	0.185	0	0	0	0	0	0	5
15-May-98	83.1	35.2	0.42	0.182	5	0	0	0	0	0	11
16-May-98	81.8	36.1	0.44	0.185	0	0	0	0	0	0	16
17-May-98	82.7	35.3	0.43	0.189	5	0	0	0	0	11	26
18-May-98	82.3	35.0	0.43	0.194	0	0	0	0	0	0	5
19-May-98	88.7	35.2	0.40	0.193	10	0	0	0	0	31	0
20-May-98	88.9	35.3	0.40	0.195	0	0	0	0	5	10	26
21-May-98	94.4	34.8	0.37	0.203	5	0	0	0	5	30	15
22-May-98	113.6	44.3	0.39	0.212	9	0	0	0	5	9	19
23-May-98	115.7	35.0	0.30	0.224	9	0	0	0	4	18	4
24-May-98	131.4	42.3	0.32	0.231	4	0	0	0	35	4	4
25-May-98	154.8	56.2	0.36	0.240	25	0	0	12	17	4	0
26-May-98	181.2	78.8	0.43	0.251	16	0	4	8	24	8	0
27-May-98	187.5	84.6	0.45	0.258	23	8	19	8	62	0	0
28-May-98	161.4	58.8	0.36	0.266	15	23	8	23	83	0	0
29-May-98	157.8	57.9	0.37	0.280	4	4	0	21	139	0	0
30-May-98	172.1	71.6	0.42	0.292	0	68	0	41	68	0	0
31-May-98	172.7	68.7	0.40	0.299	7	43	0	10	40	0	3
1-Jun-98	169.2	65.5	0.39	0.303	7	76	3	10	16	0	0
2-Jun-98	174.3	70.4	0.40	0.318	3	31	3	0	0	0	0
3-Jun-98	161.7	60.3	0.37	0.339	0	21	0	3	0	0	0
4-Jun-98	152.5	59.0	0.39	0.354	6	42	0	6	3	0	0
5-Jun-98	151.7	56.4	0.37	0.357	0	62	0	0	0	0	0
6-Jun-98	146.5	51.0	0.35	0.371	0	49	3	3	3	0	0
7-Jun-98	138.3	44.5	0.32	0.374	0	3	0	3	0	0	0
8-Jun-98	137.7	59.5	0.43	0.381	0	8	0	0	0	0	0
9-Jun-98	129.8	42.8	0.33	0.368	0	0	0	0	0	0	0
10-Jun-98	118.3	36.7	0.31	0.356	0	3	0	0	6	0	0
11-Jun-98	108.8	32.0	0.29	0.363	6	0	0	3	0	0	0
12-Jun-98	107.6	35.5	0.33	0.365	3	3	0	0	0	0	0
13-Jun-98	108.2	33.1	0.31	0.354	0	8	0	0	0	0	0
14-Jun-98	118.8	36.1	0.30	0.362	0	6	0	0	0	0	0
15-Jun-98	131.4	41.2	0.31	0.395	0	0	0	0	0	0	0
16-Jun-98	147.7	51.9	0.35	0.415	0	2	0	0	0	0	0
17-Jun-98	156.0	56.0	0.36	0.426	0	0	0	0	0	0	0
18-Jun-98	157.4	59.3	0.38	0.430	0	14	0	2	0	0	0
19-Jun-98	165.8	63.7	0.38	0.436	0	7	0	0	0	0	0
20-Jun-98	162.6	61.0	0.38	0.449	0	4	0	2	0	0	0
21-Jun-98	150.6	48.9	0.32	0.469	0	4	0	0	0	0	0
22-Jun-98	145.0	49.9	0.34	0.482	0	15	0	0	0	0	0
23-Jun-98	133.6	46.0	0.34	0.492	0	2	0	0	0	0	0
24-Jun-98	121.5	43.6	0.36	0.504	0	6	0	0	0	0	0
25-Jun-98	119.6	39.1	0.33	0.539	0	4	0	0	0	0	0
26-Jun-98	120.0	44.3	0.37	0.573	0	2	0	0	0	0	0
27-Jun-98	104.6	27.5	0.26	0.594	0	0	0	0	0	0	0
28-Jun-98	98.6	21.9	0.22	0.599	0	2	0	0	0	0	0
29-Jun-98	87.0	9.9	0.11	0.609	0	3	0	0	0	0	0
30-Jun-98	86.1	9.3	0.11	0.631	0	0	0	0	0	0	0
1-Jul-98	82.5	7.0	0.08	0.661	0	2	0	0	0	0	0
2-Jul-98	78.1	1.9	0.02	0.645	0	0	0	0	0	0	0
3-Jul-98	68.2	0.0	0.00	0.642	0	2	0	0	0	0	0

Appendix D. (Continued.)

	Flow	Spill	% Spill	DCE	Wild	Pettit	Rflnp	Rflfall	Altfall	RLC	USR
4-Jul-98	64.7	0.0	0.00	0.646	0	2	0	0	0	0	0
5-Jul-98	60.0	0.0	0.00	0.666	0	0	0	0	0	0	0
6-Jul-98	59.5	0.0	0.00	0.720	0	1	0	0	0	0	0
7-Jul-98	55.2	0.0	0.00	0.783	0	0	0	0	0	0	0
8-Jul-98	54.6	0.0	0.00	0.744	0	1	0	0	0	0	0
9-Jul-98	58.2	0.0	0.00	0.775	0	0	0	0	0	0	0
10-Jul-98	55.2	0.0	0.00	0.772	0	1	0	0	0	0	0
11-Jul-98	53.3	0.0	0.00	0.739	0	0	0	0	0	0	0
12-Jul-98	54.1	0.0	0.00	0.716	0	0	0	1	0	0	0
13-Jul-98	51.1	0.0	0.00	0.700	0	0	0	1	0	0	0
14-Jul-98	54.0	0.0	0.00	0.678	0	3	0	0	0	0	0
15-Jul-98											
16-Jul-98											
17-Jul-98											
18-Jul-98											
19-Jul-98											
TOTALS					**162**	**533**	**40**	**157**	**515**	**125**	**135**

LOWER GRANITE GRAND TOTAL ADJUSTED FOR DAILY COLLECTION EFFICIENCY = **1,667**

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