

# **Stock Assessment of Salmon Lake Sockeye and Coho Salmon 2002**

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Alaska Department of Fish and Game

Division of Sport Fish





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## ABSTRACT

A stock assessment of sockeye (*Oncorhynchus nerka*) and coho (*Oncorhynchus kisutch*) salmon at Salmon Lake was continued in 2002. A floating weir and field camp were established at the outlet of the lake to enumerate and sample returning sockeye and coho between June 1 and October 31, 2002. In addition to the floating weir, mark-recapture experiments were done to estimate total escapements into the lake. We estimate that 1,051 sockeye (SE = 20) entered Salmon Lake and 1139 coho (SE = 39) entered Salmon Lake in 2002. Underwater snorkel counts represented approximately 5.4% of the coho escapement.

A total lake population of 14,169 sockeye salmon fry and 984 sticklebacks were estimated from hydroacoustic analysis and the estimated density of sockeye salmon fry in Salmon Lake is  $0.0511 \text{ fry} \cdot \text{m}^{-2}$ . This population of sockeye salmon fry is expected to produce approximately 10,600 smolt in spring 2003, based on 70% overwinter survival.

In October 2002, 5,045 coho presmolt  $\geq 85$  mm were tagged with coded-wire tags and released in Salmon Lake. The mean weight of tagged coho salmon presmolt was 14.7 g (SE = 0.47). Mean length was 108.3 mm (SE = 1.03).

## INTRODUCTION

Information from a past study (Schmidt 1996) describes a declining trend in coho escapement in Salmon Lake and an increasing trend in exploitation for this stock and suggests that the sustainability of Salmon Lake coho salmon may be at risk from overharvest. In March 2000, the Southeast Alaska Regional Advisory Council (SERAC) identified Sitka Sound coho (*Oncorhynchus kisutch*) and sockeye (*Oncorhynchus nerka*) salmon assessment as a subsistence fisheries monitoring priority. Fishing pressure on coho salmon has grown throughout Southeast Alaska and particularly in the vicinity of Sitka Sound. Of the coho salmon stocks produced in Sitka Sound, Salmon Lake coho are of particular concern due to the stock's proximity to concentrated commercial effort on hatchery stocks, increased sport fishing effort, and a newly established federal coho subsistence fishery. In October 2000, the SERAC recommended that subsistence-fishing opportunity be provided for coho salmon in Southeast Alaska. Expanded subsistence opportunity for coho salmon had heightened the existing concern for Salmon Lake coho and increased the need to assess the status of this stock.

Sockeye returning to Redoubt and Salmon Lakes support the only two sockeye salmon subsistence fisheries in Sitka Sound. Both lakes are important to local subsistence fishers because they support populations of sockeye salmon and are easily accessed from Sitka. Since 1982, Redoubt Lake sockeye escapement has been counted using a weir operated at the outlet of the lake. In 2000 through 2001, Redoubt Lake sockeye subsistence and sport fisheries were closed early by federal and state agencies in response to low escapements. Similar closures by the state occurred in 1992, 1995, and 1996. Such closures raise the concern of a shift in fishing effort to the smaller stock at Salmon Lake, where no program existed for estimating and managing for escapements needed to sustain subsistence harvests. Local reports of declining abundance of sockeye salmon and potential shifts in subsistence and sport fishing effort to Salmon Lake present a need to assess the status of this sockeye stock.

From 1983 to 1990, the Alaska Department of Fish and Game (ADF&G) conducted a coded-wire tag mark-recapture project at Salmon Lake to estimate annual smolt abundance, harvest, and escapement of coho salmon. Schmidt (1996) reported exploitation rates for Salmon Lake coho increased from 35% in 1985 to 72% in 1989 and spawning escapements decreased from 1,514 in 1984 to 204 in 1990. In 1994, ADF&G repeated the CWT portion of this project to assess fishery impacts to Salmon Lake coho salmon. In 1995, Salmon Lake contributed 1,740 coho salmon to commercial troll (73%), marine sport (14%), Deep Inlet terminal area commercial seine and gillnet (9%), and commercial seine (4%) fisheries.

Since 1998, ADF&G and the Northern Southeast Regional Aquaculture Association (NSRAA) have conducted foot and snorkel surveys of Salmon Lake inlet streams to provide a low-cost indication of abundance for sockeye and coho salmon in that system. Since salmon runs are dynamic as fish continually move into and out of streams, spawn, and die, observer

counts are inherently biased low for the actual total escapement across a season and usually underestimate the actual escapement on any given day (Jones and McPherson 1997; Dangel and Jones 1988; Sharr et al. 1993). Furthermore, the visibility of spawning salmon depends on many factors such as water clarity, stream morphology, and the ecology, behavior, size, and color of salmon (Bevan 1961; Neilson and Geen 1981; Jones and McPherson 1997). Without comparable estimates of escapement, it is not known whether foot or snorkel surveys of Salmon Lake inlet streams can be used as an index of trends in spawning abundance.

Two thousand one (2001) was the first year and 2002 the second year of a multi-year study designed to assess the status of both sockeye and coho salmon. The long-term objectives of this study strived for in 2002 include:

1. Estimate the escapements of sockeye and coho salmon into Salmon Lake in 2002 such that the estimates fall within 10 percentage points of the true value 90% of the time.
2. Estimate the age, length, and sex composition of adult sockeye and coho salmon in Salmon Lake in 2002 such that each multinomial proportion is within 5 percentage points of the true value 95% of the time.
3. Count the number of sockeye and coho salmon in Salmon Lake inlet streams in 2002 using underwater (snorkel) stream surveys.
4. Estimate the abundance of coho salmon presmolt in October 2002, leaving Salmon Lake the following spring such that the estimate is within 20 percentage points of the true value 95% of the time.
5. Estimate the age, length, and weight composition of coho salmon presmolt in Salmon Lake in 2002 such that each multinomial proportion is within 5 percentage points of the true value 95% of the time.
6. Estimate the commercial gillnet harvest of coho salmon in the Deep Inlet terminal harvest area in 2003 such that the estimate is within 15 percentage points of the true value 95% of the time.
7. Estimate the marine harvest of coho salmon from Salmon Lake in 2003 such that the estimate is within 25 percentage points of the true value 90% of the time.
8. Estimate the age, length, and weight composition of sockeye fry in Salmon Lake in 2002 such that each multinomial proportion is within 5 percentage points of the true value 95% of the time.
9. Estimate the in-lake productivity of Salmon Lake in 2002 using established ADF&G limnological sampling procedures.
10. Provide an index of sockeye fry biomass in 2002 through hydroacoustic and trapping methods.

During 2002, a weir and field camp were established at the outlet of Salmon Lake to achieve these objectives. Objectives 1-3, 5, 8-10 were realized during 2002 while objectives 4, 6, and 7 will be accomplished through the sampling of the marine harvests and adult returns to Salmon Lake and through coded-wire tag recoveries of Salmon Lake coho salmon in 2003.

## STUDY AREA

Salmon Lake is located 15.2 km southeast of Sitka at the terminus of Silver Bay in eastern Sitka Sound (Figure 1). The lake lies at 17 m elevation and is fed primarily by two main inlet streams and several smaller tributaries opposite the 1.4 km outlet stream. The lake is accessible by floatplane or by boat and foot. The U.S. Forest Service maintains a recreational use cabin on the lake and a foot trail that provides access to Salmon and Redoubt Lakes from Silver Bay. The lake supports populations of sockeye, pink (*Oncorhynchus gorbuscha*); chum (*Oncorhynchus keta*); and coho salmon;

Dolly Varden (*Salvelinus malma*); cutthroat trout (*Oncorhynchus clarki*); stickleback (*Gasterosteus aculeatus*); sculpin; and steelhead (*Oncorhynchus mykiss*).

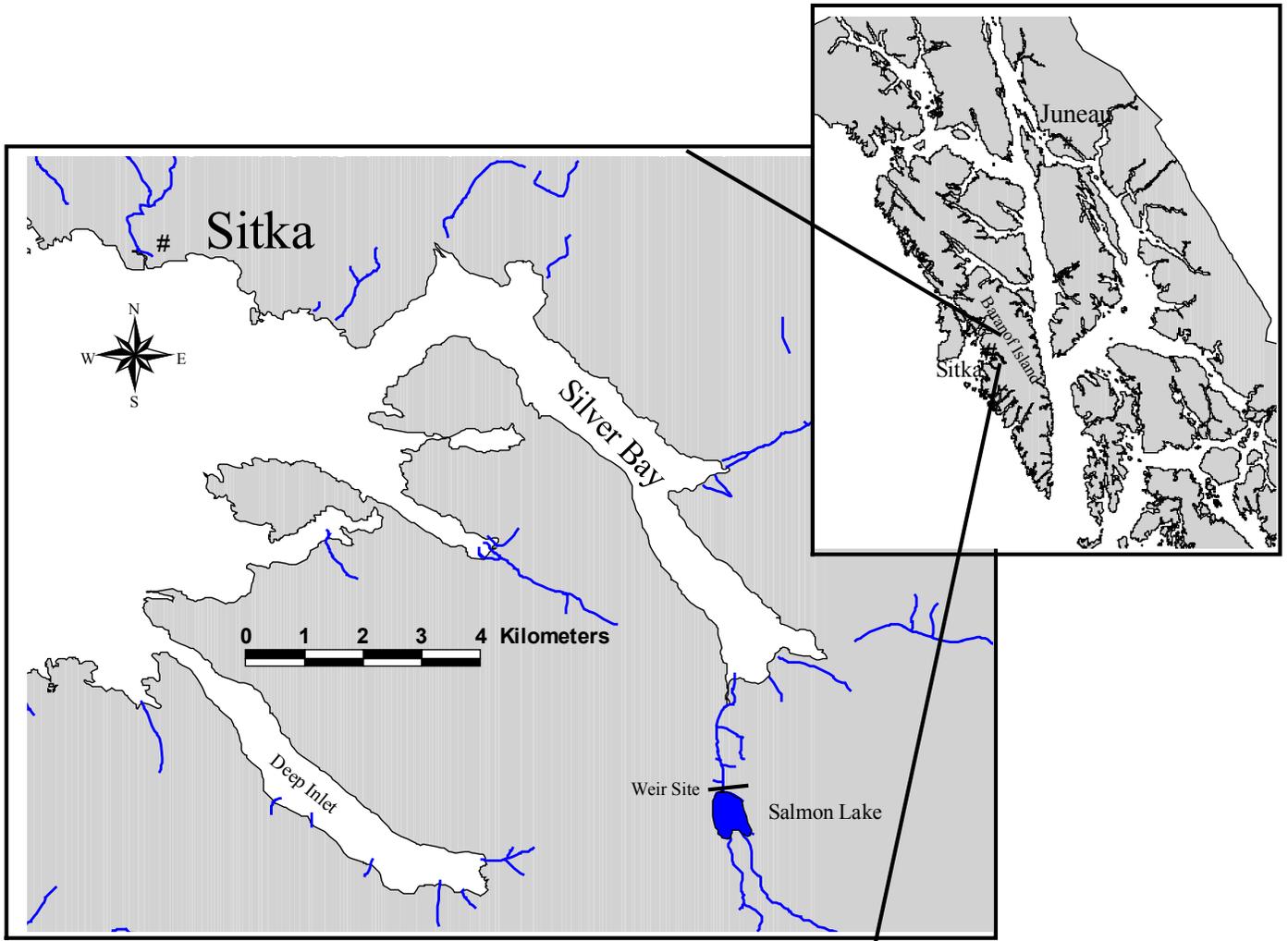


Figure 1. Study area showing Salmon Lake, weir site and major tributaries.

### STUDY DESIGN

This project has been proposed as a long-term, comprehensive assessment of Salmon Lake sockeye and coho salmon stocks. The primary components of this study consist of:

1. An adult weir and mark-recapture experiment to estimate escapement of sockeye and coho salmon in Salmon Lake;

2. Biweekly observer counts of sockeye and coho salmon in Salmon Lake inlet streams for comparison with escapement estimates;
3. A coded-wire tag mark-recapture experiment to estimate presmolt abundance, adult harvest, and harvest distribution for Salmon Lake coho salmon;
4. A fall hydroacoustic assessment of sockeye fry rearing biomass;
5. An independent on-site survey to estimate commercial coho salmon harvest and CWT fraction in the Deep Inlet terminal harvest area gillnet fishery;
6. In-lake limnological sampling.

## METHODS

### **Estimate of escapement of sockeye and coho salmon**

A floating weir was used to capture, tag, and enumerate coho and sockeye salmon migrating upstream. The weir, located 10 m downstream of the outlet of Salmon Lake, was fashioned after a weir described in Tobin (1994). It consisted of hollow PVC panels attached to an anchored cable laid across the stream channel, with a fixed live box attached on the upstream side. One-inch diameter schedule 40 PVC was used as the weir pickets. They were spaced at 19 pickets per 4 ft panel that were 20 ft long. A rigid weir was established on either side of the 40 ft of floating weir. The rigid weir was supported by bipods and consisted of 3-inch aluminum channel with a hole spacing of 49 per 8 ft. The pickets used for the rigid weir were 3/4-inch galvanized conduit.

All fish captured in the live box were enumerated and passed upstream using dip nets except for adult sockeye and coho which were anesthetized with a mixture of clove oil and Everclear™ alcohol (12 ml clove oil to 108 ml alcohol) in 15 gal of water prior to being tagged with a uniquely numbered t-bar anchor Floy™ Tag. Each fish was tagged immediately below the middle of the dorsal fin on its left side. Sockeye were tagged with blue sequentially numbered tags and coho were tagged with gray sequentially numbered tags. In addition to the tag, each fish was given a combination of operculum punches based on the week the fish was captured. The tagging guns, nets, gloves, scale tweezers, and hole punches were rinsed with a solution of 1-part Betadine™ to 10 parts water between sampling each fish. Upon sampling, each fish was allowed to safely recover in a holding box before release on the upstream side of the weir.

### **Age, length, and sex composition of adult sockeye and coho salmon**

All sockeye and coho salmon taken from the weir trap were sampled for scales, length, and sex. Each fish was measured from mid eye to tail fork to the nearest 5 mm. Four to five scales were removed from the preferred area (one row up from the lateral line on an imaginary line between the posterior base of the dorsal fin and the anterior portion of the ventral fin (Scarnecchia 1979)) on the left side of the fish. Scales were mounted on gum cards and numbered consecutively. Scale impressions were transferred to acetate and read to determine ages post-season. Sex was determined from secondary maturation characteristics.

### **Recapture events**

The first recapture event was done immediately after weir installation to ensure that no fish had immigrated into the lake prior to weir installation. No fish were found immediately after weir installation, but subsequent recapture events showed that some fish passed through the weir undetected (likely during high water events). Because of this, recapture events were scheduled on a biweekly basis to estimate total escapement. Coho and sockeye were captured from the lake and two inlet streams using a 5 by 40 m beach seine modified for use in the inlet streams. In addition to the beach seine, hook and line gear was used in the inlet streams. During the recapture events, the lake perimeter was surveyed by boat to locate areas where sockeye or coho were present. Each fish captured was examined for tags, operculum punch, and other marks and recorded by date, tag number, gear type used for capture, and location. Any untagged fish were sexed, measured, and its adipose fin removed to identify it as a previously observed fish.

## **Snorkel counts of sockeye and coho salmon in Salmon Lake inlet streams using underwater stream surveys**

Snorkel counts of sockeye and coho salmon were conducted biweekly when possible in the two inlet streams using mask, snorkel, and a dry suit. Counts began at fixed points of each of the two inlet streams approximately 2 km upstream of the inlet of the lake and ended at the inlet of the lake. Adult fish were counted and recorded by species for each inlet stream.

Habitat variables recorded at the beginning of each survey included: surface water temperature in degrees Celsius, and weather conditions (cloud cover, wind, precipitation). Additionally, the visibility was given a subjective rating of very poor, poor, good, or excellent.

A permanent benchmark for water levels was established prior to the first survey. On each survey, the water level was recorded. Rain, wind, high water, and turbidity occasionally obscured subsurface visibility and prevented the surveys.

## **Abundance of coho salmon presmolt and age, length, and weight composition of coho salmon presmolt**

A mark-recapture experiment was begun in 2001 and continued in 2002 to estimate presmolt abundance by marking and tagging presmolts with CWT's. We will inspect adult coho for these marks as they return at adults. We anticipate that most of the fish tagged in 2001 will return in 2003 and those tagged in 2002 should return in 2004.

Three technicians implanted microwire tags in coho salmon presmolt during fall 2002. Baited minnow traps were deployed in Salmon Lake and lake inlet streams during October to capture coho salmon presmolt. Between 20 and 50 traps were baited daily with salmon eggs, fished continuously, and checked every 12 hrs or more often as needed. All captured coho salmon  $\geq 85$  mm FL without adipose clips were tranquilized with the alcohol/clove oil mixture described above, given a CWT following procedures in Koerner (1977), their adipose fins removed, and released. Any coho salmon captured with a missing adipose fin was passed through a magnetic tag detector to test for post 24-hr tag retention. Mark IV (primary) tagging machines produced by Northwest Marine Technology, Inc. were used to apply the CWTs. All tagged fish were held overnight in a net pen to test for mortality and tag retention. To minimize recaptures and the potential for predation, tagged presmolt were released just prior to the onset of darkness each evening in locations of cover near their capture site.

A systematically drawn sample of 191 coho salmon juveniles  $\geq 85$  mm FL were taken to estimate age, length, and weight composition of presmolt. Scales were scraped off a small area on the side of each pre-smolt and placed on slides for age analysis. Lengths were taken to the nearest mm and weights to the nearest tenth gram.

## **Sockeye fry rearing density within Salmon Lake**

Hydroacoustic and midwater trawl sampling estimated the distribution and abundance of rearing sockeye salmon fry. Salmon Lake was divided into seven sampling areas based on surface area. Sample design consisted of a series of seven stratified, randomly chosen transects across the lake, one from each sampling area. Transect sampling was conducted during post-sunset darkness in one night. A constant boat speed of about 2.0 m sec<sup>-1</sup> was attempted for all transects. A Biosonics DT-4000™ scientific echosounder (420 kHz, 6° single beam transducer) with Biosonics Visual Acquisition © version 4.0.2 software was used to collect data. Ping rate was set at 5 pings sec<sup>-1</sup> and pulse width at 0.4 ms. Data were analyzed using Biosonics Visual Analyzer © version 4.0.2 software after returning to the office.

A 2 m by 2 m elongated trawl net was used for pelagic fish sampling. Trawl depths and duration were determined by fish densities and distributions throughout the lake based on observations during the hydroacoustic survey. Fish were euthanized with MS-222, preserved in 10% alcohol, and transported to the ADF&G laboratory in Ketchikan. Mean fork length was measured to the nearest mm, and weight was measured to the nearest gram. All sockeye salmon fry under 50 mm fork length were assumed to be age 0. Scales were collected from fish over 50 mm fork length for aging. Sockeye fry scale aging was conducted through the microscopic examination and interpretation of scale growth patterns per

Mosher (1968). Two trained technicians using a Carton microscope with a video monitor independently aged fry. The results of each independent scale ageing were compared. In instances of discrepancy between the two age determinations, a third independent examination was conducted.

**Age, length and weight composition of sockeye fry in Salmon Lake**

All sockeye captured in the midwater tow net were sampled for scales, length, and weight, as described for coho salmon pre-smolt.

**In-lake productivity of Salmon Lake using established ADF&G limnological sampling procedures.**

Limnology sampling was conducted by the weir crew opportunistically from July through October using established ADF&G limnological sampling procedures. Physical, chemical, and biological production data was collected at two fixed sampling sites within Salmon Lake for the duration of the project.

Light penetration, temperature, dissolved oxygen, and conductivity vertical profiles were measured and recorded monthly at varying depth intervals at two sampling sites within the lake. Bulk (~5 L) water samples were collected from the 1 m and mid-hypolimnion depths at two sites within the lake to characterize general and nutrient water chemistry of the epilimnion and hypolimnion. Primary production (algal standing crop) samples were collected from the two sampling sites on the same sampling interval as the vertical profiles. Vertical zooplankton tows were collected from a standard depth of 1 m less than the sampling site depth. These tows were collected using a 0.5 m diameter, 153 u-mesh, 1:3 conical zooplankton net. The net was retrieved at a constant rate of 1 m/sec. rinsed with lake water to remove all of the organisms collected and preserved in a solution of 10% neutralized formalin. Samples were analyzed for genus abundance, density, body length, and biomass.

**DATA ANALYSIS**

**Escapement of sockeye and coho salmon into Salmon Lake**

All captured adult sockeye and coho salmon were marked and counted as they entered Salmon Lake through the weir and live box. Surveys above the weir indicated some salmon passed the weir without being marked or counted, so a mark-recapture experiment was used to estimate the abundance of adult salmon above the weir. Chapman’s modification to the Petersen estimator or a time-stratified Darroch (1961) estimator was used to estimate escapement.

**Relationship between observer counts and estimated escapement**

The snorkel counts were compared to the actual weekly escapement estimates of coho and sockeye. The counts were compared to the weekly escapement estimate as a proportion or percentage of the total estimated escapement. The peak snorkel count was also compared to the total escapement estimate.

**Age, length, and sex composition of adult sockeye and coho salmon**

All composition estimates and the associated variances were calculated as:

$$\hat{p}_i = \frac{n_i}{n} \quad \text{and} \quad \hat{V}[\hat{p}_i] = \left(1 - \frac{n}{N}\right) \frac{\hat{p}_i(1 - \hat{p}_i)}{n - 1} \tag{1 and (2)}$$

where:

- $\hat{p}_i =$  the proportion of the population in group  $i$ ;
- $n_i =$  the number in the sample in group  $i$ ,
- $n =$  the total number sampled.
- $N =$  population size

### Length and weight at age estimates for juvenile and adult coho and sockeye salmon

Estimates of mean length and weight at age and their variance were calculated with standard normal procedures (Cochran 1977).

### Age composition of juvenile sockeye and coho salmon:

Proportions by age of sockeye fry and coho presmolt were estimated by:

$$\hat{p}_j = \frac{n_j}{n} \quad \text{and} \quad \text{var}[\hat{p}_j] = \frac{\hat{p}_j(1 - \hat{p}_j)}{n-1} \quad (3) \text{ and } (4)$$

where  $p_j$  is the proportion in the population in group  $j$ ,  $n$  is sample size, and  $n_j$  is the subset of  $n$  that belong to group  $j$ . The systematic selection of samples and uniformity of procedures provides for sampling proportional to abundance between sampling sites resulting in little potential for bias from any in-season changes in age composition.

## RESULTS

### Estimate of escapement of sockeye and coho salmon

The floating weir was operational on June 1. The first sockeye was captured in the upstream trap on June 6 (Appendix A1). The sockeye migration into Salmon Lake continued through September 13 (Appendix A1, Figure 2) by which time 947 (743 adult and 204 jack) sockeye had been counted through the weir. Observations of sockeye above the weir and in the lake revealed that not all sockeye had been marked at the weir. It is likely that sockeye and coho had passed through the weir undetected during periodic high water events that breached the weir. Several recapture events were conducted in the lake and inlet streams to estimate the total escapement. Of the sockeye marked at the weir, 203 individual sockeye were recaptured at least once during subsequent recapture events. Another 23 previously unmarked sockeye were also captured. The escapement of jack sockeye was estimated as a proportion of jacks recovered in the recapture event, which was considered unbiased.

We estimate that 815 adult sockeye and 236 jack sockeye for a total of 1,051 (SE = 20) sockeye (both adults and jacks) entered Salmon Lake in 2002.

The first coho was captured on August 2. A total of 1,020 coho were captured and marked at the weir. During the recapture events ninety two (92) previously marked coho were recaptured and 10 unmarked coho were captured.

We estimate that 1,104 adult coho and 35 jack coho for a total of 1,139 (SE = 39) coho (both adults and jacks) entered Salmon Lake in 2002.

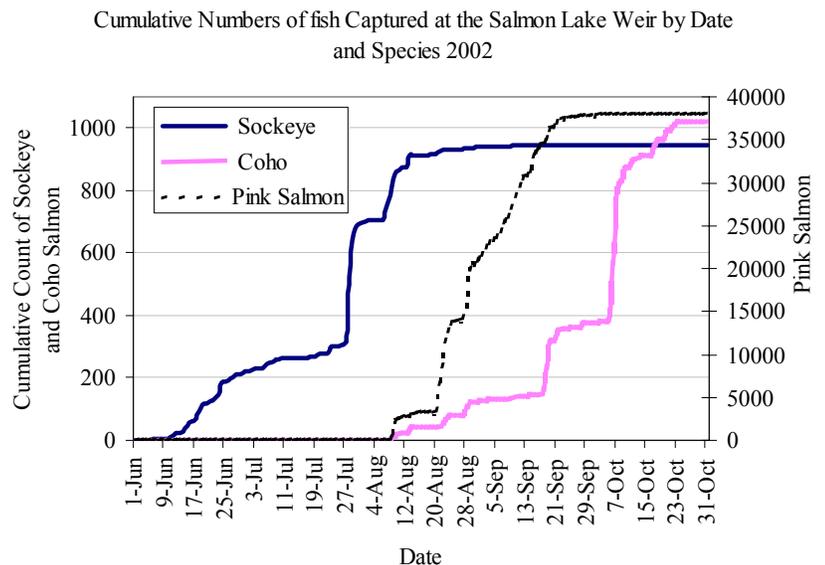


Figure 2. Cumulative numbers of fish counted past the Salmon Lake weir in 2002.

### Age, length, and sex composition of adult sockeye and coho salmon

Sockeye captured at the weir were predominately one of six age classes (Figure 3). A strong bimodal length distribution was also evident (Figure 5). This appears to be due to the predominate presence of two strong saltwater year classes; 1 year and 3 years (Figure 4). The cut-off length for jack sockeye (the fish that returned after only one year at saltwater) was established at 446 mm (Table 1).

Coho were predominately age 1.1 fish. The average lengths of coho examined at the weir were 617 mm (adults) and 355 mm (jacks) (Table 5). The cut-off length for Jack coho (those fish that returned after only one summer at saltwater) was established at 399 mm (Table 2, Figure 6).

### Snorkel counts of sockeye and coho salmon in Salmon Lake inlet streams using underwater stream surveys.

Underwater snorkel counts were done on 5 occasions beginning on August 22 (Table 3). Peak snorkel counts represented approximately 5.3% of the coho run. Three (3) sockeye were observed in the inlet streams on August 25. This was the highest sockeye count in the inlet streams during the 2002 field season. Counts were not possible every week primarily due to high water conditions.

Numbers and Ages of Sockeye Sampled at Salmon Lake Weir 2002

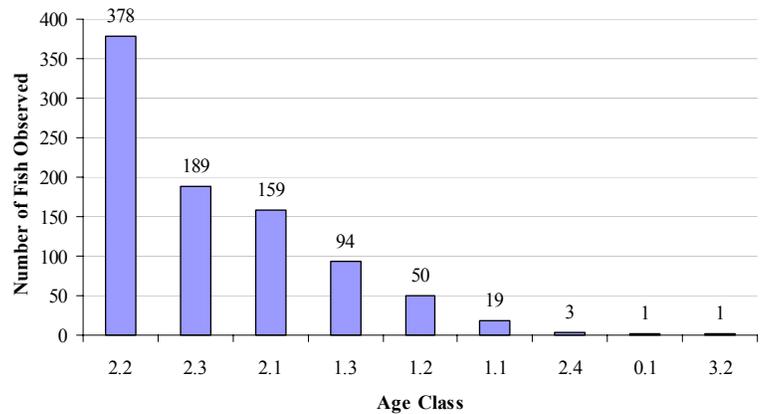


Figure 3. Number of sockeye by age class observed at Salmon Lake weir in 2002.

### Abundance of coho salmon presmolt and age, length, and weight composition of coho salmon presmolt

In October 2002 5,045 coho presmolt  $\geq 85$ mm were captured and tagged with coded-wire tags, then released in Salmon Lake. Tag retention was 99.6% leaving a valid tag release of 5,026. The mean weight of tagged coho salmon presmolt was 14.7 g (SE = 0.47). Mean length was 108.3 mm (SE = 1.03) (Table 4). Abundance of coho salmon presmolt will be determined through examination of returning adult coho in 2004 for presence or absence of adipose fins, indicating that the coho had been tagged with a coded wire tag.

Age analysis of coho presmolt scales is underway and should be completed during the summer of 2003.

Length Distributions of Sockeye by Years in Saltwater Collected at Salmon Lake 2002

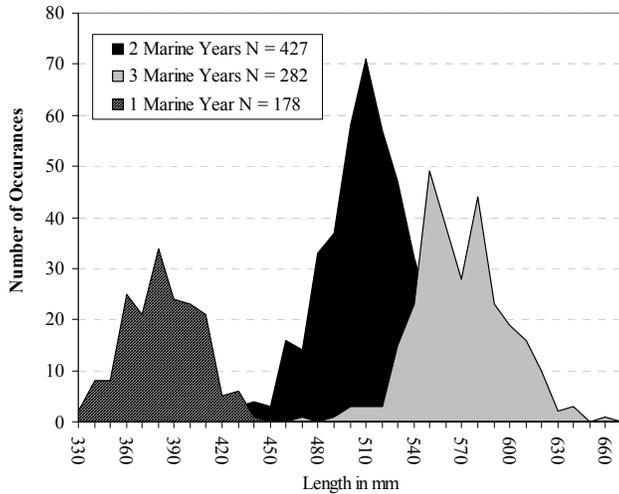


Figure 4. Length distributions of sockeye captured at the Salmon Lake weir in 2002 based on number of years spent in salt water.

Relative and Cumulative Length Frequencies of Sockeye Captured at the Salmon Lake Weir in 2002 N = 994

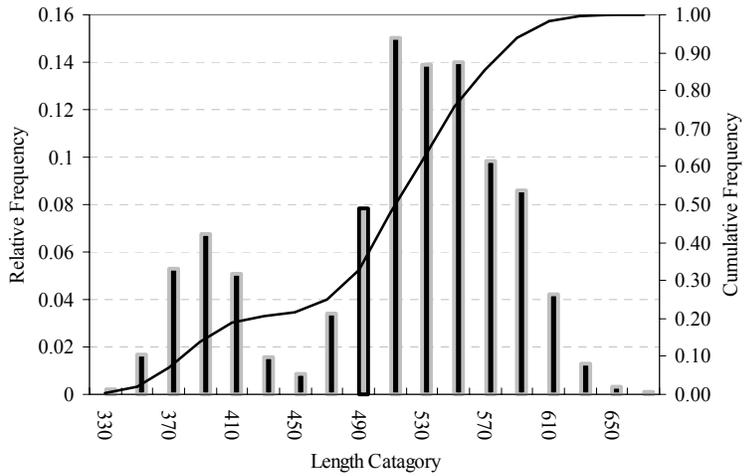


Figure 5. Length distribution of all measured sockeye at the Salmon Lake weir in 2002.

Table 3. Count of sockeye and coho in the inlet streams of Salmon Lake in 2002. Counts were done with the use of a snorkel and dry suit.

Date	Sockeye Observed	Coho Observed
8/14/2002	2	
8/25/2002	3	
10/3/2002		7
10/19/2002		61
10/25/2002		54

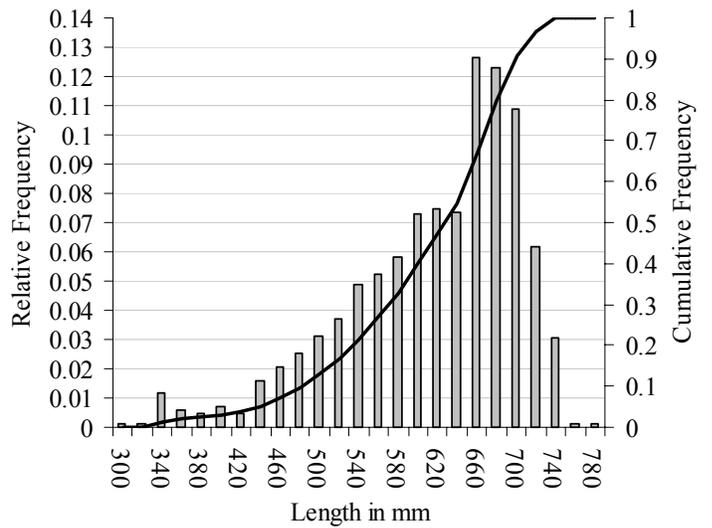


Figure 6. Relative length frequency distribution of Salmon Lake coho salmon captured and measured at the Salmon Lake weir in 2002.

Table 1. Cut off size for jack sockeye salmon in Salmon Lake 2002.

Age one sockeye <446 mm	Age one sockeye >446 mm	Sockeye older than age one <446 mm	Sockeye older than age one >446 mm	% age one sockeye <446 mm	% older than age one sockeye >446 mm
178	0	9	700	100	99

Table 2. Cut off size for jack coho salmon in Salmon Lake 2002.

Age one coho <399mm	Age one coho >399mm	Age 0 coho <399 mm	Age 0 coho >399mm	% age zero coho <399 mm	% age one coho >399mm
8	954	20	2	90.9%	99.2%

Table 5. Mean lengths (mm) of coho salmon adults and jacks examined at the Salmon Lake weir in 2002.

	Jacks	Adults
Mean	355	617
Standard Error	4.3	2.4
Standard Deviation	24.1	76.6
Count	31	987

Table 4. Mean weight and length of tagged coho salmon presmolt in Salmon Lake 2002.

	Weight (g)	Length (mm)
Mean	14.7	108.5
Standard Error	0.47	1.03
Sample Variance	42.61	202.43
Count	189	191

### Sockeye fry rearing density within Salmon Lake

A total lake population of 14,169 sockeye salmon fry and 984 sticklebacks were estimated from the hydroacoustic survey conducted on 22 August 2002. The estimated density of sockeye salmon fry in Salmon Lake was  $0.0511 \text{ fry} \cdot \text{m}^{-2}$ . Seventy two (72) fish (Table 6) were captured between four midwater trawl tows; 32 sockeye salmon fry and 4 stickleback from tow 1 which lasted for 15 minutes at a depth of 7 m; 17 sockeye salmon fry from tow 2 which lasted for 15 minutes at a depth of 7 m; 14 sockeye salmon fry from tow 3 which lasted for 15 minutes at a depth of 9 m; and 9 sockeye salmon fry and one stickleback from tow 4 which lasted for 15 minutes at a depth of 9 m. Sixty six (66) sockeye salmon fry (92%) were smaller than 50 mm fork length and were assumed to be age 0. Six salmon fry were greater than 50 mm, all of which also were age 0. The sockeye salmon fry had a mean fork length of 40.1 mm and a mean weight of 0.57 g. Five sticklebacks (6.4% of total catch) were caught with a mean fork length of 46.8 mm and a mean weight of 1.1 g. The length frequency (Figure 7.) shows a strong age 0 class. This population of sockeye salmon fry is expected to produce approximately 10,600 smolt in spring 2003, based on 70% over-winter survival.

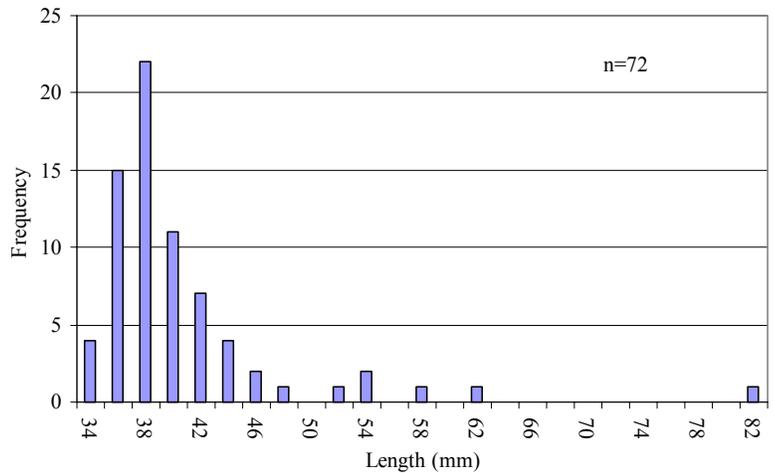


Figure 7. Length frequency distribution of sockeye captured in trawl surveys in Salmon Lake on August 22, 2002.

Table 6. Species and age distribution from midwater trawl net on August 22, 2002.

Species	Sample size	Percent Species	Age	Percent of Age	Population	Mean length (mm)	Mean weight (g)
Sockeye	72	94%	0	100%	14,167	40.1	0.6
Stickleback	5	6%	No Age	100%	984	46.8	1.1

### In-lake productivity of Salmon Lake using established ADF&G limnological sampling procedures.

Limnology samples were taken four times during the summer field season. Analysis of limnological samples should be completed by summer of 2003.

## DISCUSSION

This was the second year a weir was placed at the outlet of Salmon Lake to enumerate sockeye. The weir was not “fish tight” throughout the course of the summer. Because of this, some fish were able to pass through the weir undetected. The mark-recapture experiment to estimate the total escapement of coho and sockeye showed that the weir captured approximately 90% of both coho and sockeye migrating upstream.

Several assumptions were required to estimate the sockeye and coho abundances using the mark-recapture experiment. Included in these were:

1. Every fish had an equal probability of being marked at the weir, or that every fish had an equal probability of being captured in the mark-recapture sample, or that marked fish mixed completely with unmarked fish;
2. Recruitment and mortality did not occur between samples;
3. Marking did not affect the catchability of fish;
4. Fish did not lose their marks in the time between the initial marking and subsequent recapture
5. All marks were seen on recovery in the recapture events; and
6. Double sampling did not occur.

Chi-square tests were used to determine if assumption (1) was met. The null hypothesis tested was that the fraction of marked fish was constant across the recapture events and that the probability of recovering a fish was independent of its initial strata (time) in the marking event. Two Kolmogorov-Smirnov (K-S) 2-sample tests were used to test the hypothesis that fish of different sizes were captured with equal probability ( $\alpha = 0.05$ ) (Appendix A2). Failure to confirm one of these hypotheses (fish had an equal probability of being marked at the weir) required a stratified (by size) estimate of escapement for sockeye (Arnason et al. 1996).

The hydroacoustic data was collected only once during the summer. Because relatively few (4) transects were used for trawl tows and only 72 sockeye fry were captured during these tows, we believe that the results from hydroacoustic analysis should be used only as an index of total sockeye fry abundance.

We found that only 13 (4.3%) of the 301 marked fish recaptured with a secondary mark had actually lost their primary (Floy™ tag) mark. Marking did not appear to affect the behavior or movement of fish, as marked fish were observed spawning with or near unmarked fish throughout the entire project. Because of the low occurrence of tag loss, either an operculum punch or Floy™ tag alone may be sufficient in future tagging efforts. Additionally we believe that handling effects were minor. Pre-spawn live fish recaptured in the lake appeared to be in good condition. Many tagged fish were recaptured in good condition more than a month after initial tagging.

The population was assumed to be closed to recruitment because sampling covered the entire duration of the immigration of the fish to the river. Marking was assumed to have little effect on behavior of released fish or the catchability of fish in the recapture events since different gear types were used to catch fish (weir vs. seine). The use of multiple marks, (Floy™ tag and operculum punch) inspection of all fish captured in the recapture events, and additional marking of all fish inspected in the recapture events helped to insure that the assumptions in 4, 5, and 6 were met.

Lake surveys of Salmon Lake indicate that many sockeye spawn in the littoral areas of the lake (peak sockeye counts in the inlet streams represented less than 1% of the total estimated escapement). While we suspect that coho use primarily the inlet streams for spawning, only 5.3% of the estimated escapement was observed during the peak count. Because of this, snorkel surveys may not be useful to provide an index of escapement.



## **ACKNOWLEDGEMENTS**

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## APPENDICIES

Appendix A1. Daily and cumulative weir counts at the Salmon Lake Weir 2002.

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Date	Adult Sockeye	Cumulative Adults	Jack Sockeye	Cumulative Jacks	Total Cumulative Sockeye	Adult Coho	Cumulative Adult Coho	Jack Coho	Cumulative Jack Coho	Cumulative Total Coho	Pink Salmon	Cumulative Pink
6/1/02	-	0	-	0	0	-	0	-	0	0	-	0
6/2/02	-	0	-	0	0	-	0	-	0	0	-	0
6/3/02	-	0	-	0	0	-	0	-	0	0	-	0
6/4/02	-	0	-	0	0	-	0	-	0	0	-	0
6/5/02	-	0	-	0	0	-	0	-	0	0	-	0
6/6/02	3	3	-	0	3	-	0	-	0	0	-	0
6/7/02	-	3	-	0	3	-	0	-	0	0	-	0
6/8/02	-	3	-	0	3	-	0	-	0	0	-	0
6/9/02	3	6	-	0	6	-	0	-	0	0	-	0
6/10/02	1	7	-	0	7	-	0	-	0	0	-	0
6/11/02	7	14	-	0	14	-	0	-	0	0	-	0
6/12/02	9	23	-	0	23	-	0	-	0	0	-	0
6/13/02	-	23	-	0	23	-	0	-	0	0	-	0
6/14/02	15	38	-	0	38	-	0	-	0	0	-	0
6/15/02	10	48	-	0	48	-	0	-	0	0	-	0
6/16/02	13	61	-	0	61	-	0	-	0	0	-	0
6/17/02	4	65	-	0	65	-	0	-	0	0	-	0
6/18/02	29	94	-	0	94	-	0	-	0	0	-	0
6/19/02	18	112	1	1	113	-	0	-	0	0	-	0
6/20/02	6	118	-	1	119	-	0	-	0	0	-	0
6/21/02	6	124	-	1	125	-	0	-	0	0	-	0
6/22/02	7	131	-	1	132	-	0	-	0	0	-	0
6/23/02	15	146	-	1	147	-	0	-	0	0	-	0
6/24/02	34	180	-	1	181	-	0	-	0	0	-	0
6/25/02	8	188	-	1	189	-	0	-	0	0	-	0
6/26/02	5	193	-	1	194	-	0	-	0	0	-	0
6/27/02	9	202	-	1	203	-	0	-	0	0	-	0
6/28/02	7	209	-	1	210	-	0	-	0	0	-	0
6/29/02	2	211	-	1	212	-	0	-	0	0	-	0
6/30/02	6	217	1	2	219	-	0	-	0	0	-	0
7/1/02	2	219	-	2	221	-	0	-	0	0	-	0
7/2/02	3	222	-	2	224	-	0	-	0	0	-	0
7/3/02	3	225	2	4	229	-	0	-	0	0	-	0
7/4/02	-	225	-	4	229	-	0	-	0	0	-	0
7/5/02	1	226	-	4	230	-	0	-	0	0	-	0
7/6/02	12	238	2	6	244	-	0	-	0	0	-	0
7/7/02	6	244	1	7	251	-	0	-	0	0	-	0
7/8/02	2	246	2	9	255	-	0	-	0	0	-	0
7/9/02	2	248	1	10	258	-	0	-	0	0	-	0
7/10/02	2	250	1	11	261	-	0	-	0	0	-	0
7/11/02	-	250	-	11	261	-	0	-	0	0	-	0

Appendix A1. Continued. Daily and cumulative weir counts at the Salmon Lake Weir 2002.

Page 2 of 4

Date	Adult Sockeye	Cumulative Adults	Jack Sockeye	Cumulative Jacks	Total Cumulative Sockeye	Adult Coho	Cumulative Adult Coho	Jack Coho	Cumulative Jack Coho	Cumulative Total Coho	Pink Salmon	Cumulative Pink
7/12/02	-	250	-	11	261	-	0	-	0	0	-	0
7/13/02	-	250	-	11	261	-	0	-	0	0	-	0
7/14/02	-	250	1	12	262	-	0	-	0	0	-	0
7/15/02	-	250	-	12	262	-	0	-	0	0	-	0
7/16/02	1	251	-	12	263	-	0	-	0	0	-	0
7/17/02	-	251	2	14	265	-	0	-	0	0	-	0
7/18/02	1	252	-	14	266	-	0	-	0	0	-	0
7/19/02	1	253	3	17	270	-	0	-	0	0	-	0
7/20/02	5	258	1	18	276	-	0	-	0	0	-	0
7/21/02	-	258	2	20	278	-	0	-	0	0	1	1
7/22/02	-	258	-	20	278	-	0	-	0	0	1	2
7/23/02	13	271	10	30	301	-	0	-	0	0	-	2
7/24/02	1	272	-	30	302	-	0	-	0	0	-	2
7/25/02	-	272	-	30	302	-	0	-	0	0	-	2
7/26/02	1	273	1	31	304	-	0	-	0	0	1	3
7/27/02	11	284	-	31	315	-	0	-	0	0	-	3
7/28/02	141	425	67	98	523	-	0	-	0	0	3	6
7/29/02	112	537	29	127	664	-	0	-	0	0	1	7
7/30/02	14	551	6	133	684	-	0	-	0	0	-	7
7/31/02	8	559	4	137	696	-	0	-	0	0	-	7
8/1/02	3	562	3	140	702	-	0	-	0	0	-	7
8/2/02	1	563	1	141	704	-	0	1	1	1	-	7
8/3/02	-	563	-	141	704	-	0	-	1	1	-	7
8/4/02	-	563	-	141	704	-	0	-	1	1	-	7
8/5/02	-	563	-	141	704	-	0	-	1	1	-	7
8/6/02	-	563	1	142	705	-	0	-	1	1	-	7
8/7/02	32	595	18	160	755	-	0	-	1	1	66	72
8/8/02	47	642	10	170	812	8	8	-	1	9	468	540
8/9/02	28	670	9	179	849	5	13	1	2	15	1587	2127
8/10/02	11	681	7	186	867	8	21	-	2	23	491	2618
8/11/02	6	687	-	186	873	-	21	1	3	24	140	2758
8/12/02	1	688	2	188	876	-	21	-	3	24	34	2792
8/13/02	29	717	5	193	910	13	34	2	5	39	183	2975
8/14/02	3	720	1	194	914	1	35	-	5	40	172	3147
8/15/02	-	720	-	194	914	-	35	-	5	40	85	3232
8/16/02	-	720	-	194	914	-	35	-	5	40	-	3232
8/17/02	-	720	-	194	914	-	35	-	5	40	51	3283
8/18/02	-	720	-	194	914	-	35	-	5	40	16	3299
8/19/02	1	721	-	194	915	-	35	-	5	40	9	3308

Appendix A1. Continued. Daily and cumulative weir counts at the Salmon Lake Weir 2002.

Date	Adult Sockeye	Cumulative Adults	Jack Sockeye	Cumulative Jacks	Total Cumulative Sockeye	Adult Coho	Cumulative Adult Coho	Jack Coho	Cumulative Jack Coho	Cumulative Total Coho	Pink Salmon	Cumulative Pink
8/20/02	1	722	-	194	916	-	35	-	5	40	41	3349
8/21/02	7	729	3	197	926	7	42	-	5	47	3566	6915
8/22/02	3	732	-	197	929	9	51	-	5	56	2800	9715
8/23/02	2	734	-	197	931	20	71	-	5	76	2940	12655
8/24/02	-	734	-	197	931	4	75	-	5	80	985	13640
8/25/02	-	734	-	197	931	-	75	-	5	80	243	13883
8/26/02	-	734	1	198	932	1	76	-	5	81	138	14021
8/27/02	-	734	-	198	932	1	77	-	5	82	117	14138
8/28/02	1	735	1	199	934	27	104	1	6	110	1462	15599
8/29/02	1	736	2	201	937	14	118	-	6	124	4327	19926
8/30/02	-	736	-	201	937	-	118	-	6	124	540	20466
8/31/02	2	738	1	202	940	-	118	-	6	124	360	20826
9/1/02	-	738	-	202	940	1	119	-	6	125	919	21745
9/2/02	-	738	1	203	941	3	122	-	6	128	782	22527
9/3/02	-	738	-	203	941	-	122	2	8	130	492	23019
9/4/02	-	738	-	203	941	-	122	-	8	130	408	23427
9/5/02	-	738	-	203	941	-	122	1	9	131	371	23798
9/6/02	-	738	-	203	941	-	122	-	9	131	534	24332
9/7/02	1	739	-	203	942	-	122	1	10	132	905	25237
9/8/02	-	739	-	203	942	-	122	-	10	132	779	26016
9/9/02	-	739	-	203	942	3	125	1	11	136	921	26937
9/10/02	2	741	-	203	944	4	129	-	11	140	1490	28427
9/11/02	1	742	-	203	945	2	131	-	11	142	1068	29495
9/12/02	-	742	-	203	945	1	132	-	11	143	879	30374
9/13/02	1	743	-	203	946	-	132	-	11	143	560	30934
9/14/02	-	743	-	203	946	1	133	-	11	144	327	31261
9/15/02	-	743	-	203	946	1	134	-	11	145	2049	33310
9/16/02	-	743	-	203	946	1	135	1	12	147	565	33875
9/17/02	-	743	-	203	946	3	138	-	12	150	612	34487
9/18/02	-	743	-	203	946	85	223	1	13	236	612	35099
9/19/02	-	743	-	203	946	80	303	-	13	316	1055	36154
9/20/02	-	743	-	203	946	5	308	1	14	322	440	36594
9/21/02	-	743	1	204	947	22	330	-	14	344	572	37166
9/22/02	-	743	-	204	947	11	341	1	15	356	241	37407
9/23/02	-	743	-	204	947	-	341	-	15	356	82	37489
9/24/02	-	743	-	204	947	1	342	-	15	357	61	37550
9/25/02	-	743	-	204	947	2	344	2	17	361	63	37613
9/26/02	-	743	-	204	947	-	344	-	17	361	39	37652
9/27/02	-	743	-	204	947	-	344	-	17	361	65	37717

Appendix A1. Continued. Daily and cumulative weir counts at the Salmon Lake Weir 2002.

Date	Adult Sockeye	Cumulative Adults	Jack Sockeye	Cumulative Jacks	Total Cumulative Sockeye	Adult Coho	Cumulative Adult Coho	Jack Coho	Cumulative Jack Coho	Cumulative Total Coho	Pink Salmon	Cumulative Pink
9/28/02	-	743	-	204	947	15	359	-	17	376	76	37793
9/29/02	-	743	-	204	947	-	359	-	17	376	31	37824
9/30/02	-	743	-	204	947	1	360	-	17	377	17	37841
10/1/02	-	743	-	204	947	-	360	-	17	377	6	37847
10/2/02	-	743	-	204	947	-	360	-	17	377	34	37881
10/3/02	-	743	-	204	947	-	360	2	19	379	13	37894
10/4/02	-	743	-	204	947	1	361	2	21	382	4	37898
10/5/02	-	743	-	204	947	18	379	1	22	401	4	37902
10/6/02	-	743	-	204	947	227	606	3	25	631	1	37903
10/7/02	-	743	-	204	947	177	783	2	27	810	1	37904
10/8/02	-	743	-	204	947	23	806	-	27	833	3	37907
10/9/02	-	743	-	204	947	34	840	1	28	868	2	37909
10/10/02	-	743	-	204	947	8	848	-	28	876	1	37910
10/11/02	-	743	-	204	947	16	864	-	28	892	2	37912
10/12/02	-	743	-	204	947	10	874	-	28	902	1	37913
10/13/02	-	743	-	204	947	7	881	1	29	910	-	37913
10/14/02	-	743	-	204	947	1	882	-	29	911	-	37913
10/15/02	-	743	-	204	947	1	883	-	29	912	1	37914
10/16/02	-	743	-	204	947	-	883	-	29	912	-	37914
10/17/02	-	743	-	204	947	36	919	2	31	950	-	37914
10/18/02	-	743	-	204	947	14	933	-	31	964	-	37914
10/19/02	-	743	-	204	947	1	934	-	31	965	-	37914
10/20/02	-	743	-	204	947	27	961	-	31	992	-	37914
10/21/02	-	743	-	204	947	-	961	-	31	992	-	37914
10/22/02	-	743	-	204	947	21	982	-	31	1013	-	37914
10/23/02	-	743	-	204	947	5	987	-	31	1018	-	37914
10/24/02	-	743	-	204	947	-	987	-	31	1018	-	37914
10/25/02	-	743	-	204	947	1	988	-	31	1019	-	37914
10/26/02	-	743	-	204	947	-	988	-	31	1019	-	37914
10/27/02	-	743	-	204	947	-	988	-	31	1019	-	37914
10/28/02	-	743	-	204	947	-	988	-	31	1019	1	37915
10/29/02	-	743	-	204	947	-	988	-	31	1019	-	37915
10/30/02	-	743	-	204	947	1	989	-	31	1020	-	37915
10/31/02	-	743	-	204	947	-	989	-	31	1020	-	37915
Totals	743	743	204	204	947	989	989	31	31	1020	37915	37915

Appendix A2.—Detection of size-selectivity in sampling and its effects on estimation of abundance and age and size composition.

Results of hypothesis tests, K-S on lengths of fish

*Case I:*

Accept  $H_0$

Accept  $H_0$

There is no size-selectivity during marking or recapture, gear types, or locations.

*Case II:*

Accept  $H_0$

Reject  $H_0$

There is no size-selectivity during recapture but there is during marking.

*Case III:*

Reject  $H_0$

Accept  $H_0$

There is size-selectivity during both marking and recapture, between all gear types, or all locations.

*Case IV:*

Reject  $H_0$

Reject  $H_0$

There is size-selectivity during recapture; the status of size-selectivity during marking is unknown.

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Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both marking and recapture events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from recapture to estimate proportions in compositions.

Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition and apply formulae to correct for size bias to the pooled data (p. 17).

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only recapture to estimate proportions in compositions, and apply formulae to correct for size bias to the data from recapture.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during Event 2 (Cases I or II).