Fishery Data Series No. 06-35

Stock Assessment of Salmon Lake Sockeye and Coho Salmon, 2001-2003

by

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

A stock assessment of sockeye salmon *Oncorhynchus nerka* and coho salmon *O. kisutch* at Salmon Lake was conducted between 2001 and 2003. A floating weir and field camp were established at the outlet of the lake to count and sample returning sockeye and coho salmon between early June and late October each year. In addition to the floating weir, inlake mark-recapture experiments were conducted to estimate total escapements into the lake. The estimated adult sockeye salmon escapements in 2001, 2002 and 2003 were 1,313, 840, and 1,431, respectively; estimated adult coho escapements in those years were 1,338, 1,114, and 832.

In October 2001, 4,895 coho salmon presmolt ≥85 mm FL were injected with coded wire tags and released in Salmon Lake. Harvest of Salmon Lake coho salmon in 2003 was estimated at 2,973 in the combined sport and commercial fisheries. Exploitation of this stock was 78.1%. Presmolt abundance in 2001 was estimated at 108,370 (SE = 17,347). Presmolt to adult survival was 3.5%.

Hydroacoustic methods were used to estimate lake populations of 44,000 and 14,169 sockeye salmon fry in 2001 and 2002. The estimated density of sockeye salmon fry was $0.140 m^{-2}$ in 2001 and $0.0511 m^{-2}$ in 2002. This population of sockeye salmon fry was expected to produce approximately 31,000 smolt in 2002 and 9,900 smolt in 2003 based on 70% over-winter survival.

Key words: Salmon Lake, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *Oncorhynchus kisutch*, floating weir, coded wire tag, mark-recapture, hydroacoustic analysis, limnology.

INTRODUCTION

Information from a past study (Schmidt 1996) described a declining trend in coho escapement in Salmon Lake and an increasing trend in exploitation for this stock and suggested that the sustainability of Salmon Lake coho salmon *Oncorhynchus kisutch*, was at risk from overharvest. In March 2000, the Southeast Alaska Regional Advisory Council (SERAC) identified Sitka Sound coho and sockeye *O. 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 because of 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. In 2003 the Federal Subsistence Board implemented this fishery.

From 1983 to 1990, the Alaska Department of Fish and Game (ADF&G) conducted a coded wire tag (CWT) mark-recapture project at Salmon Lake to estimate annual smolt abundance, harvest, and escapement of coho salmon. Schmidt (1996) reported that exploitation rates for Salmon Lake coho increased from 35% in 1985 to 72% in 1989 and estimated 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.

Sockeye salmon returning to Redoubt and Salmon Lakes support the only 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 salmon escapement has been counted using a weir operated at the outlet of the lake. In 2000 and 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 raised the concern of a shift in fishing effort to the smaller stock at Salmon Lake, where no management program existed. 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 salmon stock.

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 index of abundance for sockeye and coho salmon in that system. Because 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 (Dangel and Jones 1988; Jones and McPherson 1997; Sharr et al. 1993; Tydingco 2003). 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; Jones and McPherson 1997; Neilson and Geen 1981). 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.

This multi-year study was designed to assess the status of both sockeye and coho salmon. The objectives of this study were:

1. Estimate the escapements of sockeye and coho salmon into Salmon Lake in 2001, 2002, and 2003.
2. Estimate the age, length, and sex composition of adult sockeye and coho salmon in Salmon Lake in 2001, 2002, and 2003.
3. Count the number of sockeye and coho salmon in Salmon Lake inlet streams using snorkel surveys in 2001, 2002, and 2003.
4. Estimate the abundance of coho salmon presmolt abundance in 2001.
5. Estimate the age, length, and weight composition of coho salmon presmolt in Salmon Lake in 2001.
6. Estimate sockeye salmon fry density in 2001 and 2002.
7. Estimate the age, length, and weight composition of sockeye fry in Salmon Lake in 2001 and 2002.
8. Estimate the productivity of Salmon Lake in 2001, 2002, and 2003 using established ADF&G limnological sampling procedures.
9. Estimate the marine harvest of coho salmon from Salmon Lake in 2003.
10. Estimate the commercial gillnet harvest of coho salmon from Salmon Lake in the Deep Inlet terminal harvest area such that the estimate is within 15 percentage points of the true value 95% of the time.

Tasks:

1. Compare snorkel surveys to estimated escapements.

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 *O. keta*, and coho salmon, Dolly Varden *Salvelinus malma*, cutthroat trout *O. clarki*, stickleback *Gasterosteus aculeatus*, sculpin *Cottus sp*.; and steelhead *O. mykiss*.

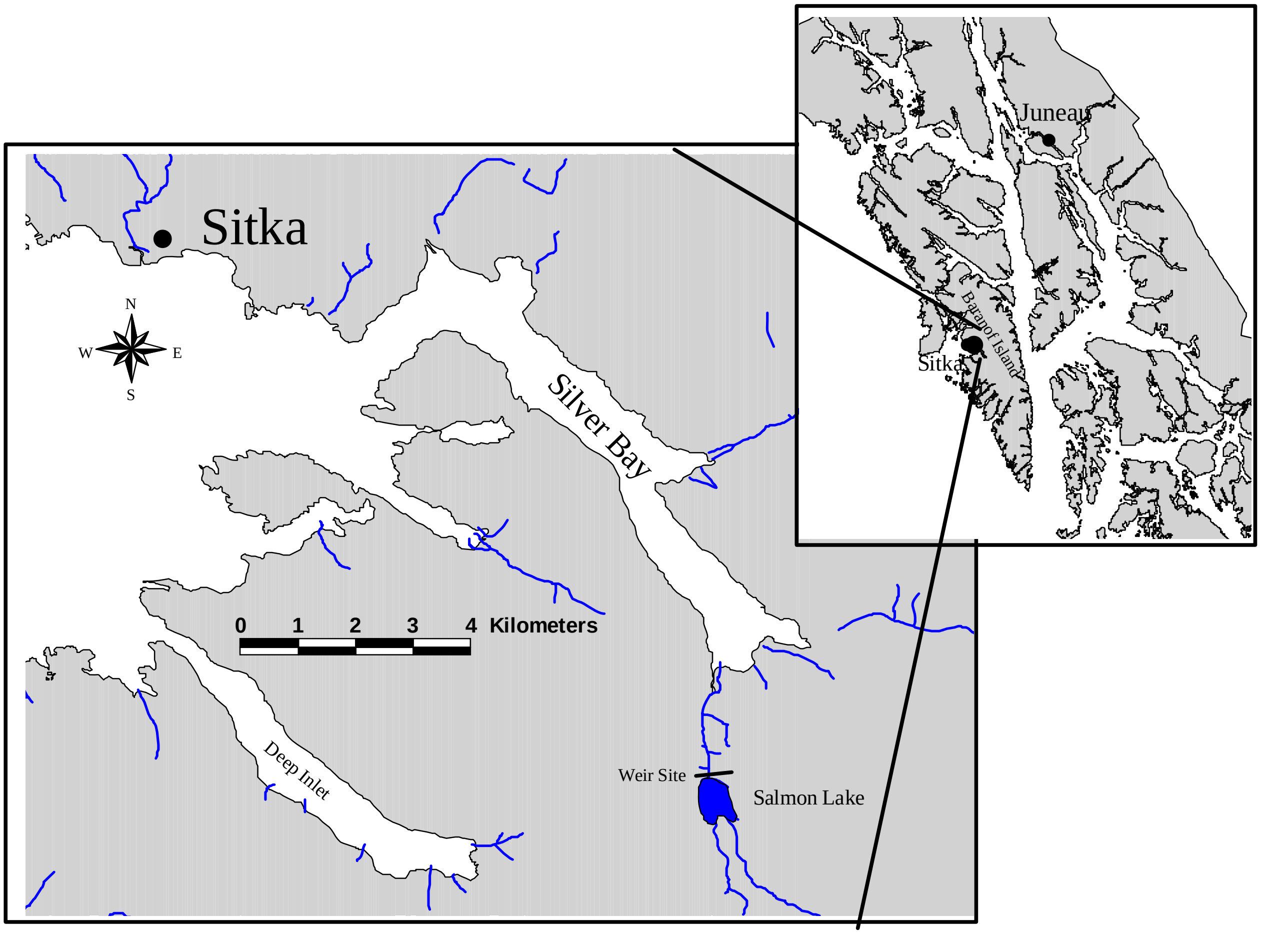


Figure 1.–Study area showing Salmon Lake, weir site and major tributaries.

METHODS

Sockeye and Coho Salmon Escapement Weir Counts and Tagging

A floating weir was installed in early June 2001-2003 to capture, count and tag, immigrating coho and sockeye salmon. Both adult and jack sockeye and coho were captured and sampled at the weir. Jack coho were identified as those fish ≤ 400 mm mid eye to tail fork (MEF) and were generally 0-ocean fish (fish that had matured and returned in less than a year in saltwater). Adult coho were 1-ocean fish greater that 400 mm MEF. Jack sockeye were identified as fish less than 445 mm MEF and were generally 1-ocean fish (fish that spent one year in saltwater). Adult sockeye were identified as fish > 445 mm MEF and generally had spend more than one year in saltwater. Fish were also tagged with individually numbered Floy™ tags to provide the means to estimate escapement with mark-recapture methods in the event of weir failure.

The weir, located at 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. In 2001 the picket spacing was 18 pickets per 4-ft panel that were 20 ft long. In 2002 and 2003, the picket spacing for the floating portion of the weir was reduced to 19 pickets per 4-ft panel. 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-in aluminum channel with a hole spacing of 49 per 8 ft. The pickets used for the rigid weir were ¾-in galvanized conduit.

All fish captured in the live box were enumerated. Sockeye and coho salmon 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. Tags were inserted immediately below the middle of the dorsal fin on the left side. Sockeye salmon were tagged with blue sequentially numbered tags and coho salmon 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. Each fish was allowed to safely recover in a holding box before release on the upstream side of the weir.

RECAPTURE EVENTS

Recapture events were scheduled on a biweekly basis. Coho and sockeye salmon were captured in the lake and two inlet streams using a 5 m by 40 m beach seine modified for use in the inlet streams. Carcasses were sampled opportunistically. During the recapture events, the lake perimeter was also surveyed by boat to locate areas where sockeye or coho were present. Each fish captured was examined for tags, operculum punch, and adipose fin clips. Date, tag numbers, and location were recorded for each fish. In 2001 and 2002 adipose fins were removed from untagged fish to prevent double sampling. In 2003, untagged fish were given a white individually numbered Floy™ tag in addition to an adipose fin clip (sockeye) or ventral fin clip (coho).

2001-2003 ESCAPEMENT ESTIMATION

The escapements of sockeye and coho salmon were estimated through mark recapture experiments because untagged fish were found above the weir.

Under ideal conditions, Chapman's modification of the Petersen Method (Seber 1982) would be used to estimate sockeye and coho salmon escapement:

$$\hat{N}_e = \frac{(M_e + 1)(C_e + 1)}{(R_e + 1)} - 1 \qquad (1)$$

$$\hat{V}[\hat{N}_e] = \frac{\hat{N}_e (M_e - R_e)(C_e - R_e)}{(R_e + 1)(R_e + 2)} \qquad (2)$$

where:

$\hat{N}_e$ = estimated abundance;

M_e = number of sockeye or coho salmon tagged and marked at the weir;

C_e = number of sockeye or coho salmon inspected for Floy™ tags and marks in the lake and inlet streams, and;

R_e = number of sockeye or coho salmon inspected that were tagged and/or marked.

The conditions for accurate use of this methodology were:

1. All fish had an equal probability of being marked at the weir; or
2. All fish had an equal probability of being inspected tags in the lake and inlet streams; or
3. Marked fish mixed completely with unmarked fish; and
4. There was no recruitment or mortality in the population between events; and
5. There was no tagging induced behavior; and
6. Fish did not lose their marks and all marks were recognizable and reported; and
7. Double sampling did not occur.

The experiments were designed to ensure these conditions could either be met by field procedures or evaluated with diagnostic testing so the appropriate model for estimating abundance could be selected.

Condition 1 required sampling that was independent of fish size, gender, and timing throughout the run. It is unlikely that condition 1 could be satisfied whenever fish passed the weir undetected, however some minor violations could be mediated for by fish mixing in the lake. Condition 2 was dependent on uniform efficiency of sampling gear for all size classes of fish and in deployment of sampling gear proportional to occurrence of fish in the lake. There were no obvious experimental limitations that could have resulted in unequal probabilities of inspection between marked and unmarked salmon in the lake. Similarly, there were no obvious experimental conditions that would have prevented complete mixing (condition 3) of marked and unmarked fish between sampling events. However, mixing was dependent on fish behavior.

Diagnostic testing was conducted to detect significant violations of conditions 1-3. Equal probability of capture was evaluated by size, sex, and time of sampling. The procedures to analyze sex and length data for statistical bias due to gear selectivity are described in Appendix A1, as well as recommended procedures to correct for bias when estimating abundance and composition. To further evaluate conditions 1-3, contingency table analyses, recommended by Seber (1982) and described in Appendix A2, were used to detect significant temporal or geographic violations of assumptions of equal probability of capture. If all of conditions 1-3 were not satisfied due to temporal violations and/or lack of complete mixing, the partially stratified estimator described by Darroch (1961) was used to estimate abundance (see also Seber 1982 and Arnason et al. 1996).

Condition 4 was satisfied because there was no meaningful recruitment added to the populations investigated and because the life history of sockeye and coho salmon isolates those fish returning to Salmon Lake as a “closed” population.

Trap-induced behavior (condition 5) was unlikely because different sampling gear types were used (weir and seine) and it is also unlikely that marking fish affected their catchability in the lake. Though a rare occurrence, marked fish were categorized as handling mortalities and censored from the experiment when tag numbers indicated tagging occurred within the previous 3 days. After accounting for these immediate deaths, it was assumed that mortality rates for marked and unmarked fish were similar.

It is unlikely that any previously marked fish were not detected (condition 6) during second event sampling because operculum punches, which were also given, were visible even if the Floy™ tag was missing. Double sampling (condition 7) was prevented by an additional mark during event 2 (adipose fin clip or Floy™ tag).

AGE, LENGTH, AND SEX COMPOSITION OF ADULT SOCKEYE AND COHO SALMON

All sockeye and coho salmon captured in the weir trap and untagged fish inspected in recapture events were sampled for scales, length, condition, and sex. Each fish was measured to the nearest 5 mm MEF. Four to five scales were removed from the preferred area on the left side of the fish; 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 per Scarnecchia (1979). Scales were mounted on gum cards and numbered consecutively. Scale impressions were transferred to acetate and read post-season to determine ages. Sex was determined from secondary maturation characteristics.

If stratification by size was not necessary, proportions and their variances were estimated according to procedures in Cochran (1977) and Appendix A1.

$$\hat{p}_k = \frac{n_k}{n} \qquad (3)$$

$$\hat{V}\left[\hat{p}_k\right] = \left(1 - \frac{n}{\hat{N}}\right)\frac{\hat{p}_k\left(1 - \hat{p}_k\right)}{n-1} \qquad (4)$$

where:

$\hat{p}_k$ = the proportion of the population in group *k;*

n_k = the number in the sample in group *k;*

n = the total number sampled; and

$\hat{N}$ = estimated population size.

If stratification by size was required, length and age proportions and their variances were again estimated according to the procedures in Cochran (1977) and Appendix A1.

$$\hat{p}_{jk} = \frac{n_{jk}}{n_j} \tag{5}$$

where:

n_j = the number sampled from size stratum *j* in the mark-recapture experiment,

n_{jk} = the number sampled from size stratum *j* that were in group *k*; and

$\hat{p}_{jk}$ = the estimated proportion of group *k* fish in size stratum *j*.

The variance calculation for $\hat{p}_{jk}$ was identical to equation 4 (with appropriate substitutions).

The estimated abundance of fish in size stratum *j* in the population was then:

$$\hat{N}_k = \sum_{j=1}^{i} \hat{p}_{jk}\hat{N}_j \tag{6}$$

where:

$\hat{N}_j$ = the estimated abundance in size stratum *j*; and

i = the number of size strata.

The variance for $\hat{N}_k$ in this case was estimated using the formulation for the exact variance of the product of two independent random variables (Goodman 1960).

$$\hat{V}\left[\hat{N}_k\right] = \sum_{j=1}^{s}\begin{pmatrix} \hat{V}\left[\hat{p}_{jk}\right]\hat{N}_j^2 + \\ V\left[\hat{N}_j\right]\hat{p}_{jk}^2 - \hat{V}\left[\hat{p}_{jk}\right]V\left[\hat{N}_j\right]\end{pmatrix} \tag{7}$$

The estimated proportion of the population in group $k\ (\hat{p}_k)$ was then:

$$\hat{p}_k = \hat{N}_k \big/ \hat{N} \tag{8}$$

where:

$$\hat{N} = \sum_{j=1}^{i}\hat{N}_j$$

Variance of the estimated proportion was approximated with the delta method (Seber 1982):

$$\hat{V}[\hat{p}_k] \approx \sum_{j=1}^{i}\left\{\left(\frac{\hat{N}_j}{\hat{N}}\right)^2 \hat{V}[\hat{p}_{jk}]\right\} + \frac{\sum_{j=1}^{s}\left\{V[\hat{N}_j](\hat{p}_{jk}-\hat{p}_k)^2\right\}}{\hat{N}^2} \tag{9}$$

SNORKEL SURVEY COUNTS OF SOCKEYE AND COHO SALMON IN SALMON LAKE INLET STREAMS

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

Habitat variables recorded at the beginning of each survey included: surface water temperature in °C and weather conditions (cloud cover, wind, precipitation). Underwater visibility was measured using a Secchi disk. Additionally, 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 and water level was recorded during each survey.

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

ABUNDANCE AND AGE, LENGTH, AND WEIGHT COMPOSITION OF COHO SALMON PRESMOLT

Baited minnow traps were deployed in the lake and lake inlet streams in fall 2001. Between 20 and 50 traps were baited with salmon eggs daily, fished continuously, and checked every 12 hrs or more often as needed. All captured coho salmon ≥85 mm FL without adipose fin clips were tranquilized with the alcohol/clove oil mixture described above, given a CWT following procedures in Koerner (1977), marked with an adipose fin clip, 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 490 coho salmon juveniles ≥ 85 mm FL were taken to estimate age, length, and weight composition of presmolt. Scales were scraped off a small area on the left side, near the preferred area (Scarnecchia 1979) of each presmolt and placed on slides for age analysis. Lengths were taken to the nearest mm FL and weights to the nearest 0.1 g. Coho presmolt ages were determined postseason.

The abundance of coho presmolt in 2001 and the associated variance were estimated using Chapman's modification of the Petersen Method (Seber 1982):

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1 \qquad (10)$$

$$\hat{V}[\hat{N}] = \frac{\hat{N}(M-R)(C-R)}{(R+1)(R+2)} \qquad (11)$$

where:

$\hat{N}$ = estimated presmolt abundance;

M = number of or coho presmolt tagged with coded wire tags in 2001;

C = number of adult coho salmon inspected for marks at Salmon Lake in 2003; and

R = number of adult coho salmon inspected in 2003 that contained a valid CWT.

The conditions for accurate use of this methodology were:

1. All presmolts had an equal probability of being marked in 2001; or
2. Adults had an equal probability of being inspected for marks in 2003; or
3. Marked fish mixed completely with unmarked fish in the population between years; and
4. There was no recruitment to the population between years; and
5. There was no tagging induced behavior or mortality; and
6. Fish did not lose their marks and all marks were recognizable.

There were no anticipated conditions that resulted in unequal probabilities of inspection between marked and unmarked returning adult salmon at the weir. While the potential existed to detect size, gender, or temporal variability in probability of capture tagging of adults at the weir to estimate escapement (as described above), these potential biases did not imply differential probability of capture between adults with and without coded wire tags. Additionally, no anticipated conditions would have prevented complete mixing of marked and unmarked fish between sampling events. Because almost all surviving salmon return to their natal stream as adults to spawn, there was no meaningful recruitment added to the population of "presmolt" while they were at sea. Trap-induced behavior was unlikely because different sampling gear types were used to capture smolt and adults. Results from other studies (Eliott and Sterritt 1990; Vincent-Lang 1993) indicate that excising adipose fins and implanting CWTs does not increase the mortality of marked salmon. When mortality occurs between sampling events during a mark recapture experiment and all other conditions are satisfied, the estimate of abundance is germane to the timing of the first sampling event – in this experiment, when presmolt were tagged.

In most cases where first or second event sampling data for individual fish was incompletely or ambiguously recorded, individual observations were removed when censoring did not clearly bias the abundance estimate. Where censoring may have resulted in bias, bootstrap estimation procedures (Efron and Tibshirani 1993) similar to those described by Buckland and Garthwaite (1991) were used in place of equations (10) and (11) to estimate abundance and variance so that uncertainty in M, C, and/or R could be modeled correctly.

DENSITY AND AGE, LENGTH, AND WEIGHT COMPOSITION OF SOCKEYE SALMON FRY

Hydroacoustic and midwater trawl sampling procedures were used to estimate the density 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 after-sunset in one night. A constant boat speed of about 2.0 m sec^{-1} 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^{-1} and pulse width at 0.4 ms. Data were analyzed using Biosonics Visual Analyzer © version 4.0.2 software postseason.

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. All sockeye captured in the midwater tow net were euthanized with MS-222, preserved in 10% alcohol, and transported to the ADF&G laboratory in Ketchikan. Mean length was measured to the nearest mm FL, and weight was measured to the nearest g. All sockeye salmon fry under 50 mm FL were assumed to be freshwater-age-0. Scales were collected from fish over 50 mm FL for aging as described for coho salmon presmolt. 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.

PRODUCTIVITY OF SALMON LAKE

Limnology sampling was conducted by the weir crew opportunistically from June through October using established ADF&G limnological sampling procedures. Physical and biological production data were 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 both sampling sites within the lake. Vertical zooplankton tows were collected from a standard depth of 1 m less than the sampling site depth to the surface. 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^{-1} and rinsed with lake water to remove all of the organisms collected. Specimens were preserved in a solution of 10% neutralized formalin. Samples were analyzed for genus abundance, density, body length, and biomass.

MARINE HARVEST OF COHO SALMON FROM SALMON LAKE IN 2003

Harvest in 2003 of coho salmon originating from Salmon Lake was estimated from fish sampled in commercial and marine sport fisheries. Fisheries personnel with the ADF&G, Division of Commercial Fisheries (CFD) port-sampling program examined commercially caught fish at processing locations and recovered coho with missing adipose fins (ADF&G *unpublished*). Similarly, the Division of Sport Fish (SFD) employed a creel survey program to examine fish caught in the sport fishery (e.g., Hubartt et al. 2001). When possible, heads of fish without an adipose fin were removed and sent to the ADF&G Mark, Tag and Age Laboratory (Tag Lab) for tag detection and decoding. Because multiple fisheries exploited coho salmon over several months in 2003, harvest was estimated over several strata, each a combination of time, area, and type of fishery. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics from the marine sport fishery were stratified bi-weekly.

A simulated data set, based on actual fishery data from past years, average survival, and anticipated sampling of sport and commercial harvests were used to anticipate precision for the harvest contribution estimate in 2003, using methodology outlined in Bernard et al. (1998).

The contribution (r_{ij}) of a release group (j) to a fishery stratum (i) was estimated as (Bernard and Clark 1996):

$$\hat{r}_{ij} = N_i \left[\frac{m_{ij}}{\lambda_i n_i} \right] \theta_j^{-1}; \qquad \lambda_i = \frac{a_i^{'} t_i^{'}}{a_i t_i} \qquad (12)$$

where:

N_i = total harvest in the fishery;

n_i = number of fish inspected (the sample); and

a_i = number of fish which were missing an adipose fin;

a_i' = number of heads that arrived at the lab;

t_i = number of heads with CWTs detected;

t_i' = number of CWTs that were dissected from heads and decoded;

m_{ij} = number of CWTs with code(s) of interest; and

θ_j = fraction of the cohort tagged with code(s) of interest.

When N_i and θ_j are known without error, an unbiased estimate of the variance of $\hat{r}_{ij}$ can be calculated as shown by Clark and Bernard (1987). However, N_i is estimated with error in sport fisheries, and θ_j was estimated with error because wild stocks were tagged. Because of these circumstances, unbiased estimates of the variance of $\hat{r}_{ij}$ were obtained using the appropriate equations in Table 2 of Bernard and Clark (1996), which show the formulations for large samples. The total harvest for a cohort was the sum of the $\hat{r}_{ij}$ terms.

Commercial catch data for the analysis was summarized by ADF&G statistical week and district (for gillnet and seine fisheries) or by period and quadrant for troll fisheries (e.g., see Clark et al. 1985). Sport fish CWT recovery data were obtained from Tag Lab reports and summarized by biweek and fishery (e.g., biweek 16 during the Sitka Marine Creel Survey). Harvest estimates were obtained from ADF&G reports (e.g., Suchanek and Bingham 1992) and ADF&G computer summaries.

2003 Commercial Gillnet Harvest of Coho Salmon in the Deep Inlet Terminal Harvest Area

Problems with harvest reporting and past attempts to sample in the Deep Inlet terminal harvest area gillnet fishery (Schmidt 1996), prompted an independent survey of the 2003 terminal area gillnet fishery to estimate harvest and CWT contribution. A one or two-person crew counted boats in the fishery, conducted interviews, observed gillnet operations, and sampled harvested coho for missing adipose fins and CWT recovery based on 2-stage survey design (Bernard et al. 1998). Sampling was conducted from July 23 through September 23, 2003.

Independent estimates of harvest were made for each week and these estimates summed to a total harvest during the July 23 to September 23 period. The gillnet fishery usually had four 15-hr openings per week. A random sample of two openings per week was selected (stage 1). A systematic sample consisting of at least 15 observations was collected during each opening (stage 2). The first observation in the systematic sample was initiated 30 minutes following the opening of the fishery, and each subsequent observation was initiated approximately one hour later than the previous. For each observation, the number of boats fishing was recorded. Each boat chosen for sampling was selected using a randomization scheme where each boat had equal probability of being selected. On boats selected for sampling, observers recorded harvest in numbers of fish by species and length of time spent fishing for that harvest.

For each observation, the number of boats participating in the fishery was recorded. One boat was chosen for sampling by assigning a unique integer to each boat on the fishing grounds and by selecting an integer value from a random number table. Upon boarding a boat selected for sampling, observers asked and recorded when the vessel began fishing for the catch on board. Observers sampled either the catch up to the current net set or the catch up to and including the current net set (if fishers were hauling or about ready to haul the net). If sampling up to the current net set, observers asked and recorded when the vessel finished hauling the last set, and then counted the salmon that were already on board by species. If sampling the catch up to and including the current net set, observers similarly counted all the salmon and recorded the time that the haul was completed.

The marine harvest of coho salmon in Deep Inlet $\hat{H}$ and its sampling variance was estimated as:

$$\hat{H} = \sum_{w=1}^{n_w} \hat{H}_w \qquad (13)$$

$$\hat{V}\left(\hat{H}\right) = \sum_{w=1}^{n_w} \hat{V}\left(\hat{H}_w\right) \qquad (14)$$

where $\hat{H}_w$ is the estimated harvest of coho during a specific week and n_w is the number of weeks the fishery was sampled.

Weekly estimates of harvest were estimated as:

$$\hat{H}_w = \frac{D_w}{d_w} \sum_{d=1}^{d_w} \hat{H}_{wd}$$

$$\hat{H}_{wd} = \sum_{i=1}^{n_{wd}} x_i CPUE_i \qquad (15)$$

where:

$\hat{H}_{wd}$ = the estimated harvest of coho salmon on day d during a week w;

D_w = number of openings (days) during week w available for sampling;

d_w = number of openings during week w selected for sampling;

n_{wd} = number of systematic observations taken for opening d during week w;

x_i = number of vessels counted during observation i; and

$CPUE_i$ = coho catch per hour for the boat observed during observation i.

The variance of $\hat{H}_w$ was estimated as (Bernard et al 1998):

$$\hat{V}(\hat{H}_w) = \left(1 - \frac{d_w}{D_w}\right) D_w^2 s_w^2 + \frac{D_w}{d_w} \sum_{d=1}^{d_w} n_{wd}^2 \, s_{wd}^2 \qquad (16)$$

where:

$$s_w^2 = \frac{\sum_{d=1}^{d_w} \left(\hat{H}_{wd} - \frac{\hat{H}_w}{D_w} \right)^2}{d_w (d_w - 1)} \quad \text{and}$$

$$s_{wd}^2 = \frac{\sum_{i=2}^{n_{wd}} \left(x_i CPUE_i - x_{i-1} CPUE_{i-1} \right)^2}{2 n_{wd} (n_{wd} - 1)}$$

Estimates of numbers of coho salmon with CWTs were calculated similarly by substituting the numbers of tagged coho for the total numbers of coho when calculating $CPUE_i$ for equations 15 and 16.

RESULTS

Sockeye and Coho Salmon Escapement

The floating weir was operational by the first week of June each year. The average date the first sockeye salmon were captured in the upstream trap was June 10. The annual sockeye migrations into Salmon Lake ended September 25 on average (Figure 2). Coho runs began on August 4 on average and proceeded through October 31 when the weir was dismantled each year (Figure 3).

2001 Escapement

In 2001, observations of untagged sockeye salmon above the weir each year revealed that not all sockeye had been captured and marked at the weir. It is likely that sockeye salmon passed through the weir undetected during periodic high water events that breached the weir. Each fall, high water events occurred topping the weir for up to one full day. In 2001 this occurred on October 12. As soon as practical after the high-water events, the weir was inspected for holes or scoured areas. Recapture events were conducted in the lake and inlet streams to estimate the total escapement. In 2001, the first sockeye was captured on June 10 and the run proceeded through October 1. In total, 1,134 individual sockeye were handled and released at the weir (Table 1; Appendix A3) of which 709 were classified as adult sockeye (> 445 MEF), 414 were jacks (≤ 445 MEF), and 11 had no length data collected but were recorded as adults. Of the 1,134 fish handled at the weir, 1,122 were used for estimating abundance using a mark-recapture model. Five fish were not included because they were released without a numbered tag, and seven fish were not included because fish marked during weeks 37-40 were not used in the analysis.

The Kolmogorov-Smirnov (K-S) two-sample test (Conover 1980) was used to determine if size-selective occurred (Appendix A1). The length frequency distributions of marked and recaptured fish were significantly different (D = 0.101, P = 0.012), so the null hypothesis that size selective sampling did not occur during second event was rejected. Because sampling of unmarked fish for length during the second event was incomplete, no further evaluation of size bias could be conducted. Further, this lack of length data would have precluded stratification by size prior to estimating abundance, if stratification was prescribed. Either a Case II or Case IV experiment occurred (Appendix A1), but analysis proceeded per Case II procedures because size stratification was not possible.

The sex ratios of all marked and all recaptured fish were marginally different (P = 0.081), suggesting that sampling during the second event was gender-biased. However, the sex ratios of all fish inspected during the second event and all recaptured fish were not significantly different (P = 0.301), i.e., sampling was not sex-selective during the first event. The sex ratios of all fish marked during the first event and all fish inspected during the second event were significantly different (P < 0.001), suggesting some gender bias sampling occurred, most likely during second event sampling.

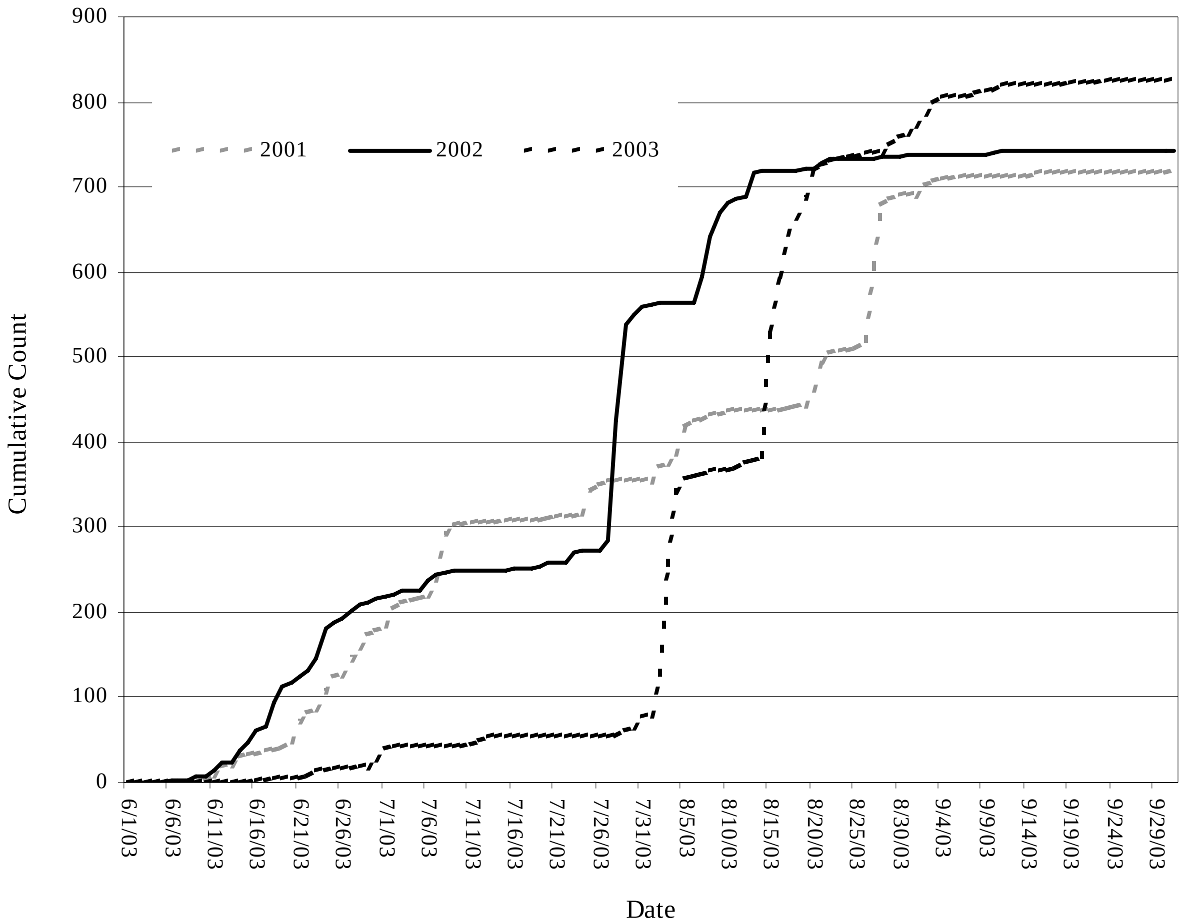


Figure 2.–Cumulative sockeye salmon counts at Salmon Lake weir, 2001-2003.

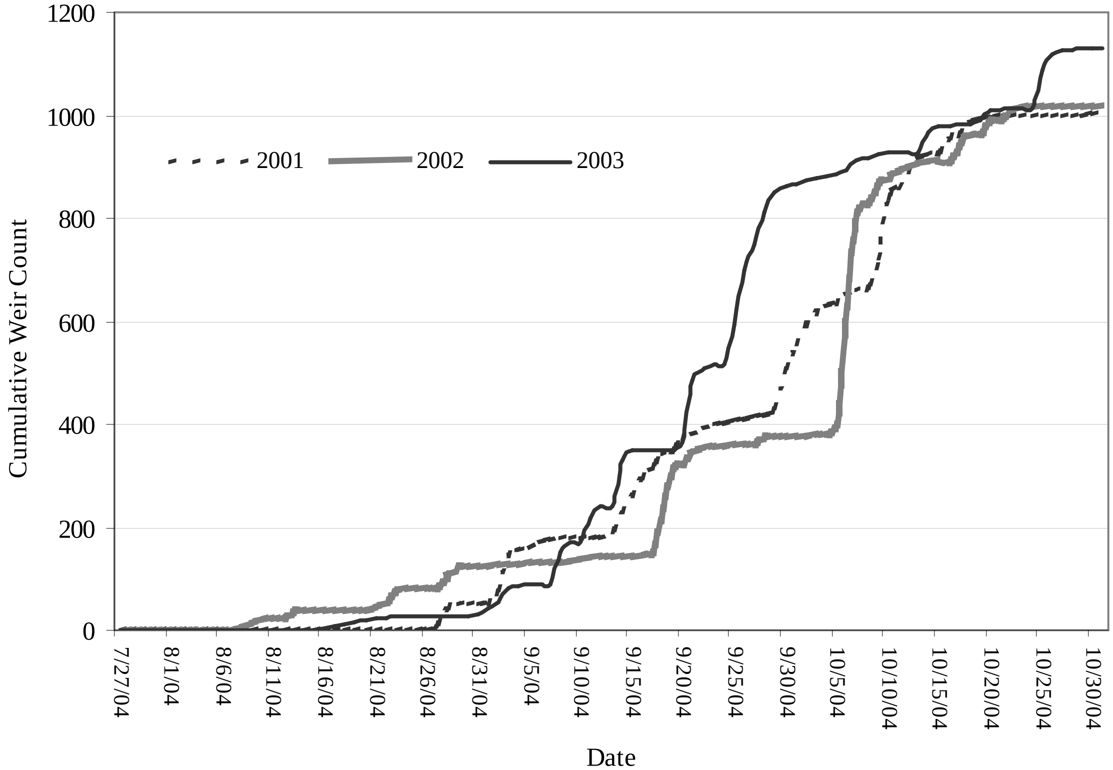


Figure 3.–Cumulative coho salmon counts at Salmon Lake weir, 2001-2003.

Table 1.–Salmon Lake weir counts and corresponding escapement estimates with standard error, 2001-2003.

		Weir counts		Mark-recapture events			Escapement estimates		Total combined escapement estimate			
Year	Species	Adults	Jacks	Marked	Examined	Recaptured	Adults, SW-age-2+	Jacks, SW-age-1	Jacks and adults	SE	Date of first capture	Date of last capture
2001	Sockeye	720	414	1,122	589	312	1,313	945	2,258	171	6/10	10/01
2002	Sockeye	743	204	921	226	203	840	211	1,051	20	6/06	9/21
2003	Sockeye	743	75	808	323	167	1,431	145	1,576	75	6/15	9/23
	Averages	735	231	950	379	227	1,195	434	1,628	89	6/10	9/25

		Weir counts		Mark-recapture events			Escapement estimates		Total combined escapement estimate			
Year	Species	Adults	Jacks	Marked	Examined	Recaptured	Adults. SW-age-1	Jacks SW-age-0	Jacks and Adults	SE	Date of first capture	Date of last capture
2001	Coho	1,002	58	1,027	354	236	1,338	182	1,521	71	7/27	10/30
2002	Coho	988	30	1,007	92	82	1,114	25	1,139	39	8/02	10/31
2003	Coho	787	345	1,112	204	126	832	843	1,675	78	8/15	10/31
	Averages	926	144	1,049	217	148	1,095	350	1,445	63	8/04	10/31

Note: SW = saltwater.

These results indicate this was a Case II experiment, and gender stratification was not necessary prior to estimating abundance.

When testing for temporal bias (Appendix A2), the null hypothesis that probability of capture was uniform throughout the second event ($P = 0.003$) was rejected as well as the null hypothesis that probability of capture was uniform throughout the first event ($P < 0.001$). The hypothesis marked and unmarked fish mixed completely between sampling events was rejected based on inspection of the raw data. As a result, the methods of Darroch (1961) were used to estimate the escapement of sockeye salmon. The model chosen to estimate abundance had 5-first event strata and 4-second event strata. While simpler models were identified that satisfied the criteria of relatively homogeneous probability of capture within strata, the simpler models fit that data poorly because of variability between first event strata and how recaptured fish were distributed among second event strata.

The estimated total escapement of sockeye salmon into Salmon Lake in 2001 was 2,258 (SE = 171; Table 1).

In 2001 the first coho were passed at the weir on July 27 and the run proceeded through October 30 when the weir was disassembled. In total 1,060 coho (1,002 classified as adults and 58 as jacks) were handled and released (Table 1; Appendix A3). Of the 1,060 coho captured at the weir, 1,027 were used for analysis. Thirty-three of these coho were excluded from the analysis because they either were not tagged at the weir or incomplete information was recorded during tagging.

When comparing the length frequency distributions of all marked fish and all recaptured fish, the null hypothesis that size selectivity sampling did not occur during the second event was rejected ($D = 0.153$, $P < 0.001$). The length frequency distributions of all fish inspected during the second event and all recaptured fish were also significantly different ($D = 0.198$, $P < 0.001$), so the null hypothesis that size selectivity did not occur during the first event sampling was rejected resulting (Case IV, size stratification required). When comparing the sex ratios of all marked fish and all recaptured fish, the null hypothesis that sex-selective sampling did not occur during second event was rejected ($P = 0.046$). The null hypothesis that sex-selective sampling did not occur during first event was also rejected ($P = 0.023$), indicating a Case IV experiment. Based on these results, the samples were divided into two size strata (fish ≤430 and >430 mm MEF) and tests were repeated for size and gender bias within each of these strata.

For coho salmon ≤430 mm MEF, the null hypothesis that size-selectivity sampling did not occur during the second event was not rejected ($D = 0.152$, $P = 0.874$). Also, sampling was not size-selective during first event ($D = 0.120$, $P = 0.975$), resulting in a Case I experiment with no further stratification required. Tests for gender bias determined that sex-selective sampling did not occur during the first ($P = 0.385$) or second events ($P = 0.741$), indicating a Case I experiment.

For coho salmon >430 MEF, the null hypothesis that size selectivity did not occur during second event sampling was rejected ($D = 0.163$, $P < 0.001$). However, sampling during the first event was not size selective ($D = 0.079$, $P = 0.386$), resulting in a Case II experiment with no further stratification required. When evaluating gender bias, that sex-selective sampling did not occur during the second event was rejected ($P = 0.035$). However, sampling was not sex-selective during first event ($P = 0.325$), resulting in a Case II experiment. Based on these results, no further stratification by size or gender was required prior to estimating abundance.

Temporal bias was tested and the null hypothesis that probability of capture was uniform throughout the first event was rejected ($P < 0.001$). However, the null hypothesis that probability of capture was uniform throughout the second event was not rejected ($P = 0.714$), indicating that a Petersen-type estimator was appropriate for estimating coho salmon abundance.

Coho salmon escapement into Salmon Lake in 2001 was estimated to be 1,521 (SE = 71; Table 1) after combining independent stratum estimates.

2002 Escapement

In 2002, sockeye first passed the weir on June 6 and the run proceeded through September 21. Nine-hundred forty-seven (947) sockeye salmon (743 classified as adults and 204 jacks) were counted, tagged, and passed through the weir, of which 26 were subsequently classified as handling mortalities and not included as marked fish in the mark-recapture analyses. Two-hundred twenty-six (226) fish were captured and inspected during the second event, of which 203 were recaptured fish (Table 1; Appendix A3).

Results from the K-S test indicated that size-selective sampling did not occur during the first (D=0.048, P = 0.945) or second events (D = 0.072, P = 0.332), resulting in a Case I experiment with no further stratification required. When evaluating gender bias, the null hypotheses that sex-selective sampling did not occur during the first (P = 0.736) or second events (P = 0.648) were not rejected, which also indicated a Case I experiment with no further stratification required. Evaluation of the temporal variability in probability of capture indicated that it was uniform throughout the first event (P = 0.791), which was sufficient to conclude that a Petersen-type estimator was appropriate for estimating sockeye salmon abundance.

In 2002, sockeye escapement was estimated using Chapman's modification to the Petersen estimator. Sockeye escapement was estimated to be 1,051 (SE = 20; Table 1).

In 2002, coho were first observed at the weir on August 2 and the run proceeded through October 31. One-thousand eighteen (1,018) coho salmon were passed at the weir (988 classified as adults and 30 as jacks; Table 1; Appendix A3). Eleven (11) of these fish were considered handling mortalities, so they were excluded from calculations to estimate abundance and later added to the final estimate.

Evaluation of size bias indicated that size-selective sampling did not occur during the first (D = 0.037, P = 0.999) or second events (D = 0.116, P = 0.242), resulting in a Case I experiment with no further stratification required. When evaluating gender bias, there was evidence to reject the null hypothesis that sex-selective sampling did not occur during second event sampling (P = 0.072). However, test results indicated that sex-selective sampling did not occur bias during the first event (P = 0.950), which suggested a Case II or potentially Case I experiment, so stratification by gender was not required prior to estimating abundance.

Evaluation of temporal variability in probability of capture indicated it was uniform throughout the first event (P = 0.805), which was sufficient to conclude that a Petersen-type estimator was appropriate for estimating coho salmon abundance.

Coho escapement was estimated using Chapman's modification to the Petersen estimator. A total of 92 coho salmon were inspected during the second event, 82 of which had been marked at the weir. The estimated escapement in 2002 was 1,139 (SE = 39; Table 1).

2003 Escapement

In 2003, sockeye first passed the weir on June 15 and the run proceeded through September 23. Eight hundred eighteen (818) sockeye salmon (743 classified as adults and 75 as jacks) were captured and tagged at the weir (Table 1; Appendix A3). Ten of these fish were considered handling mortalities, so they were excluded from calculations to estimate abundance and later added to the final estimate. During the recapture events, 318 clearly unique individual sockeye were recovered of which 162 had been tagged at the weir. Five additional previously marked sockeye were inspected, for which no clear determination of whether or not the fish had already been sampled during the second event was possible. These additional five fish were included in the diagnostic tests for size, gender, and temporal sampling bias.

Evaluation of size bias indicated that sampling was not size-selective during the second event (D = 0.049, P = 0.883), but it was during first (D = 0.217, P < 0.001), resulting in a Case III experiment with no stratification required. When evaluating gender bias, test results indicated that sex-selective sampling did not occur during the first (P = 0.543) or second events (P = 0.477), which indicated a Case I experiment. Evaluation of temporal variability in probability of capture suggested that capture probabilities were not uniform throughout the first event ($P = 0.083$). However, the null hypothesis that probability of capture was uniform throughout the second sampling event was not rejected ($P = 0.411$), which was sufficient to conclude that a Petersen-type estimator was appropriate for estimating sockeye salmon abundance.

Escapement was estimated by applying bootstrap procedures as a modification to Chapman's estimator. The five fish inspected during the second sampling event for which no determination could be made as to whether they had been previously examined necessitated bootstrap procedures. For each of these fish, the probability that it was a unique observation was modeled as a binomial probability based on second event observations of other fish tagged during the same time period (based on time specific opercular punches used during the tagging event). These probabilities were added to the multinomial modeling for mark-recapture experiments described by Buckland and Garthwaite (1991). An estimated 1,576 (SE = 75; Table 1) sockeye salmon escaped into Salmon Lake in 2003.

Coho salmon were first captured at the weir on August 15 and the run proceeded through October 31. High water topped the weir on September 24 for approximately 12 hours and coho salmon were observed entering Salmon Lake untagged. At the weir, 1,132 were tagged, 20 of which were subsequently classified as handling mortalities. In the recapture events 204 coho were recovered, of which 126 were tagged (Table 1; Appendix A3).

When evaluating size bias, the null hypothesis that size selectivity sampling did not occur during the second event was rejected ($D = 0.144$, $P = 0.016$). Further, the null hypothesis that size selectivity sampling did not occur during first event sampling was also rejected ($D = 0.224$, $P = 0.001$), resulting in a Case IV experiment, which required stratification by size. Evaluation of gender bias was not attempted with the 2003 coho salmon data because misclassification exceeding 10% was detected during first event; all 22 detected errors were males that were later reclassified as females during second event sampling. Samples were divided into two size strata (fish ≤410 and >410 mm MEF) and tests for size bias were repeated within each stratum.

Sampling of coho salmon ≤410 MEF was not size-selective during second event ($D = 0.150$, $P = 0.155$), but it was during the first ($D = 0.284$, $P < 0.001$), resulting in a Case III experiment with no further stratification required. For coho salmon >410 MEF, size-selective sampling did not occur during the first ($D = 0.049$, $P = 0.999$) or second events ($D = 0.119$, $P = 0.300$), resulting in a Case I experiment with no further stratification required. Based on these results, no further stratification by size was required prior to estimating abundance.

Tests for temporal bias for coho salmon ≤410 mm MEF suggested that capture probabilities were not uniform throughout the first event ($P = 0.075$), and some evidence existed to reject the null hypothesis that probability of capture was uniform throughout the second event ($P = 0.052$). However, the null hypothesis that mixing of marked and unmarked fish between events was complete was not rejected ($P = 0.202$). As a result of these tests, it was concluded that the potential for bias using a Petersen-type estimator would not be severe, and it was appropriate for estimating coho salmon abundance for this stratum. For coho salmon >410 mm MEF, the null hypothesis that probability of capture was uniform throughout the second event was rejected ($P < 0.001$). However, capture probabilities during the first event were uniform ($P = 0.168$), so a Petersen-type estimator was also deemed appropriate for estimating coho salmon abundance for this stratum.

Coho salmon escapement into Salmon Lake in 2003 was estimated to be 1,675 (SE = 78; Table 1) after combining independent stratum estimates and adding on handling mortalities.

AGE, LENGTH, AND SEX COMPOSITION OF ADULT SOCKEYE AND COHO SALMON

Sockeye salmon captured at the weir were comprised predominately of one of six age classes (Figure 4). A strong bimodal length distribution was also evident, which appears to be due to the presence of three strong saltwater year classes (Figures 5 and 6). The cutoff length for jack sockeye salmon (saltwater-age-1) was established at <446 mm MEF in 2001 and 2002 (Table 2). In 2003, the adult/jack cutoff length was established at <445 mm MEF. Based on analysis of scale patterns, jack sockeye salmon accounted for 41.8% (SE = 1.6%) of the escapement in 2001, however this estimate may be biased because of the inability to fully evaluate size-biased sampling and because no adjustments (stratification prior to estimation) were made. Jack salmon comprised an estimated 20.0% (SE = 1.3%) of the sockeye escapement in 2002, and an estimated 9.2% (SE = 1.1%) in 2003.

Based on sampling at the weir, coho salmon were predominately saltwater-age-1 fish in 2001 (95.4%). However, after stratifying the 2001 data to adjust for size bias sampling, the estimated proportion of saltwater-age-1 fish was 88.0% (SE = 2.2%; Table 3). In 2002, saltwater-age-1 fish comprised 97.8% (SE = 0.5%) of the run. In 2003, 70.4% of the coho captured at the weir were classified as adult (saltwater-age-1) fish. After stratification to adjust for size bias sampling, estimates of age distribution based on scale analyses were 49.7% (SE =2.8%) adult and 50.3% jack (saltwater-age-0) coho salmon. The mean lengths of adult coho examined at the weir ranged from 593 mm MEF in 2003 to 617 mm MEF in 2002 (Table 4). The mean length of jacks ranged between 350 mm MEF in 2001 and 370 mm MEF in 2003. The cutoff length for jack coho (age-.0) was established at <400 mm MEF (Table 2; Figure 7) in 2001 and 2002. In 2003, the cut-off length was established at <415 mm MEF.

SNORKEL SURVEY COUNTS OF SOCKEYE AND COHO SALMON IN SALMON LAKE INLET STREAMS

Snorkel counts were done approximately biweekly each year beginning in late August. The peak stream counts were compared to the estimated escapement for each species. Sockeye peak stream counts represented between 0.1% (2003) to 2.7% (2001) of the estimated escapement (Table 5). Coho peak stream counts represented between 2.8% (2003) to 5.4% (2002) of the estimated escapement. The coefficient of variation for sockeye stream counts was 96.1% and 37% for coho.

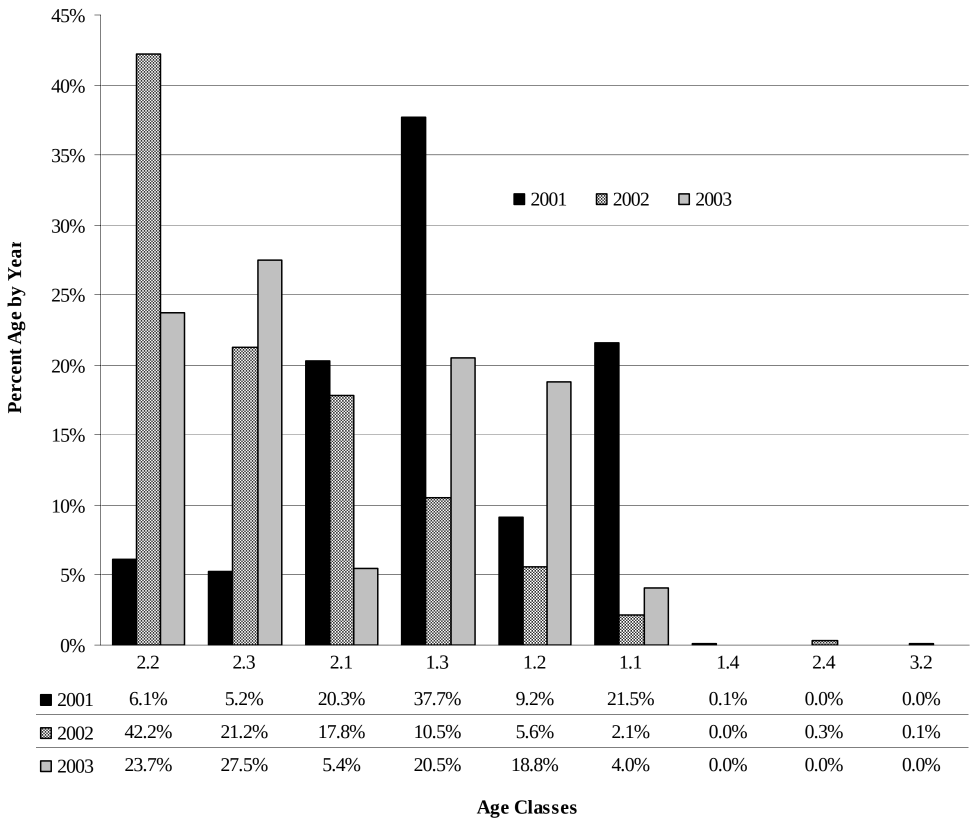
ABUNDANCE AND AGE, LENGTH, AND WEIGHT COMPOSITION OF COHO SALMON PRESMOLT

In October 2001, 4,903 coho presmolt ≥85 mm were captured and tagged with coded wire tags. Eight overnight mortalities resulted in a valid release of 4,895. Tag retention was 99.9%, which resulted in a valid tagged release of 4,888. The mean weight of freshwater-age-1 tagged coho salmon presmolt was 12.4 g (SE = 0.3) and their mean length was 103.9 mm FL (SE = 0.7) (Table 6). The mean weight of freshwater-age-0 tagged coho salmon presmolt was 8.8 g (SE = 0.4) and their mean length was 93.5 mm FL (SE = 1.2). Most presmolt were freshwater-age-1 (89.4%).

In 2003, 796 individual adult coho were examined for presence or absence of an adipose fin clip at the weir and again in recapture events. Of these, 35 were found to have a clipped fin, indicating the presence of a coded wire tag. The resulting tagged fraction was 4.4%. Estimated presmolt abundance in 2001 was 108,370 (SE = 17,347). Estimated presmolt to adult survival was 3.5% (SE = 0.30).

DENSITY AND AGE, LENGTH, AND WEIGHT COMPOSITION OF SOCKEYE SALMON FRY

In 2001, hydroacoustic data collected in August were used to estimate total lake populations of 44,000 sockeye salmon fry and 1,000 sticklebacks (Table 7). Estimated sockeye fry density was 0.140 fry m^{-2}. One hundred ten (110) fish were captured in two midwater trawl tows: 40 sockeye salmon fry from tow 1, which lasted 10 minutes at a depth of 10 m, and 68 sockeye salmon fry and 2 sticklebacks from tow 2, which lasted 15 minutes at a depth of 7 m. Ninety-five (95) sockeye salmon fry (88%) were less than 50 mm FL and assumed to be freshwater-age-0. Thirteen (13) sockeye salmon fry were greater than 50 mm, four (4%) were



	2.2	2.3	2.1	1.3	1.2	1.1	1.4	2.4	3.2
2001	6.1%	5.2%	20.3%	37.7%	9.2%	21.5%	0.1%	0.0%	0.0%
2002	42.2%	21.2%	17.8%	10.5%	5.6%	2.1%	0.0%	0.3%	0.1%
2003	23.7%	27.5%	5.4%	20.5%	18.8%	4.0%	0.0%	0.0%	0.0%

Figure 4.–Number of sockeye by age class observed at Salmon Lake weir, 2001-2003.

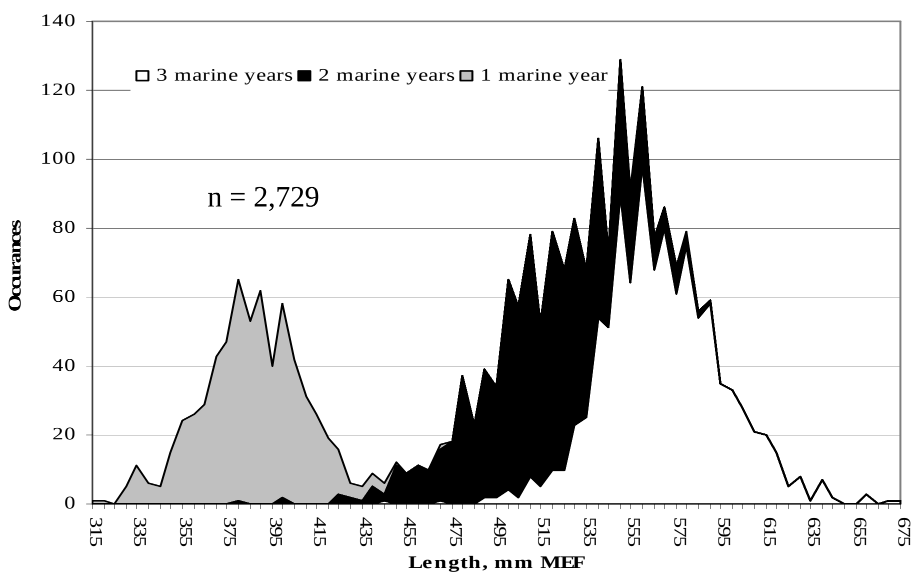


Figure 5.–Length distributions of sockeye captured at the Salmon Lake weir based on number of years spent in saltwater, 2001-2003.

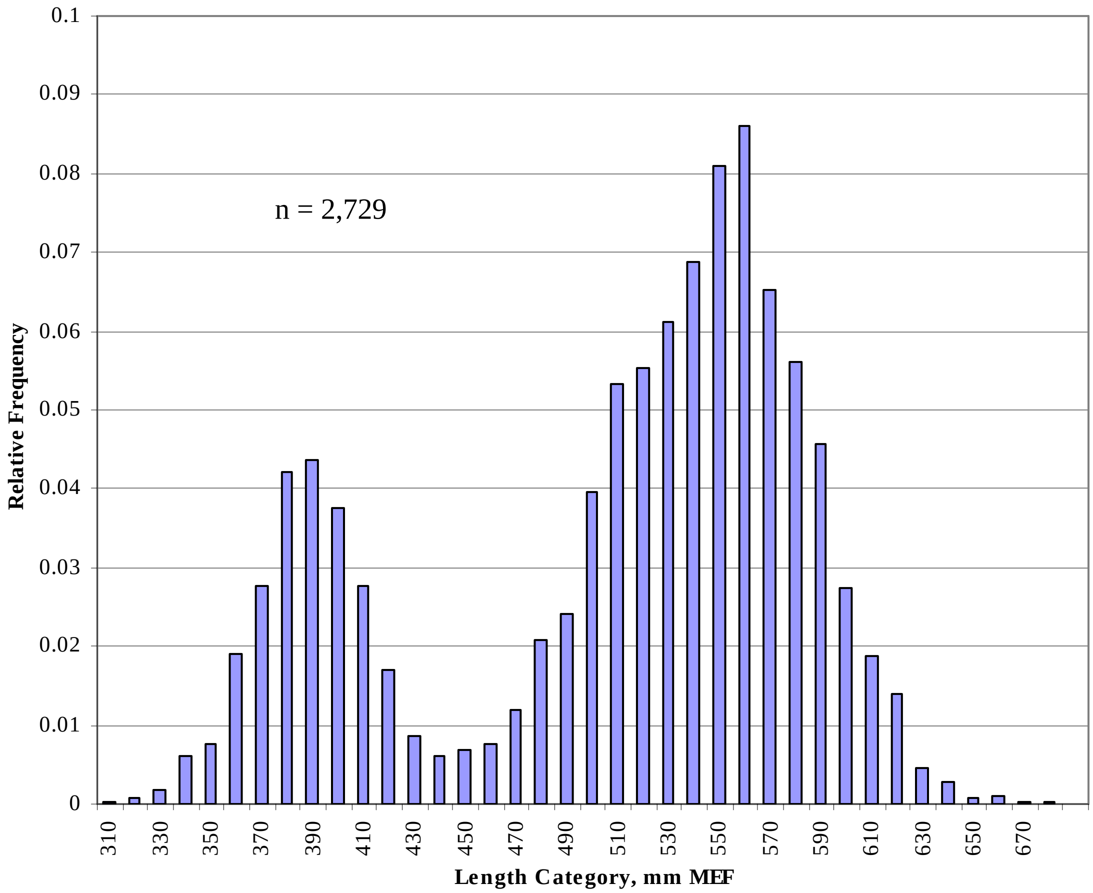


Figure 6.–Length distribution of sockeye captures at Salmon Lake, 2001-2003.

Table 2.–Adult/jack cutoff lengths (mm MEF) for sockeye and coho salmon at Salmon Lake, 2001-2003.

Cutoff sizes for jack sockeye salmon in Salmon Lake 2001-2003						
	Saltwater-age-1		Saltwater-age-2+			
Year	<446 MEF	≥446 MEF	<446 MEF	≥446 MEF	% saltwater-age-1 sockeye <446 MEF	% saltwater-age-2+ sockeye ≥446 MEF
2001	388	4	5	540	99.0%	99.1%
2002	178	0	9	700	100.0%	99.0%
	<445 MEF	≥445 mm MEF	<445 MEF	≥445 MEF	% age 1 sockeye <445 MEF	% age 1 sockeye ≥445 MEF
2003[a]	68	0	0	699	100.0%	100.0%

Cut off sizes for jack coho salmon in Salmon Lake 2001-2003						
	Saltwater-age-1		Saltwater-age-0			
Year	<400 mm MEF	≥400 mm MEF	<399 MEF	≥400 MEF	% saltwater-age-0 coho <399 MEF	% saltwater-age-1 coho ≥399 MEF
2001	10	924	44	1	97.8%	98.9%
2002	8	954	20	2	90.9%	99.2%
	<415 MEF	≥415 MEF	<415 MEF	≥415 MEF	% saltwater-age-0 coho <415 MEF	% saltwater-age-1 coho ≥415 MEF
2003[b]	7	720	372	27	98.2%	96.4%

[a] In 2003 the sockeye jack cut of length fell from <446 MEF to <445 mm MEF.

[b] In 2003 the coho jack cut off length was <415 MEF.

Table 3.–Age distribution of the coho salmon escapement at Salmon Lake, 2001-2003.

Year	Saltwater-age-1	Saltwater-age-0	% saltwater-age-1 (SE)
2001	934	45	88.0 (2.2)
2002	962	22	97.8 (0.5)
2003	727	399	49.7 (2.8)

Table 4.–Mean lengths (mm MEF) of coho salmon adults and jacks examined at the Salmon Lake weir, 2001-2003.

	2001		2002		2003	
	Jacks	Adults	Jacks	Adults	Jacks	Adults
Mean	350	598	355	617	370	593
Standard Error	4	3	4	2	2	3
Standard Deviation	26	84	24	77	22	78
Count	45	933	31	987	379	749

Note: The coho jack cutoff was <400 in 2001 and 2002 and <415 in 2003.

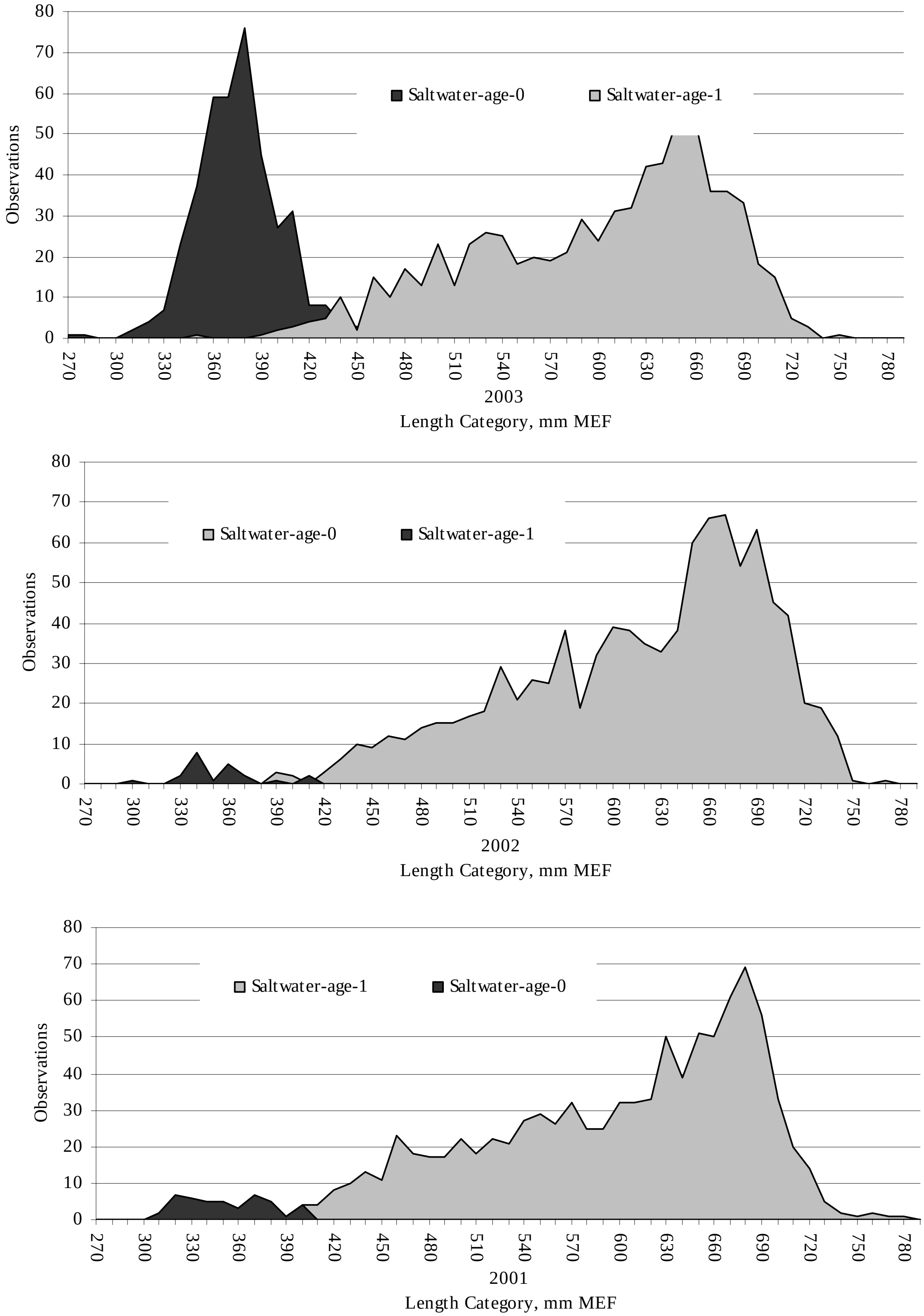


Figure 7.–Length frequency distributions of coho salmon measured at the Salmon Lake weir, 2001-2003.

Table 5.–Peak snorkel stream survey counts in Salmon Lake inlet streams and % of estimated escapement; 2001-2003.

Year	Peak survey count date	Peak survey count	Escapement estimate	% of Escapement estimate
		Sockeye		
2001	22-Aug	69	2,529	2.7%
2002	25-Aug	3	1,051	0.3%
2003	07-Aug	2	1,566	0.1%
	Average	25	1,715	1.0%
			%CV	96.1%
		Coho		
2001	20-Oct	83	1,717	4.8%
2002	19-Oct	61	1,139	5.4%
2003	20-Oct	47	1,675	2.8%
	Average	64	1,510	4.3%
			% CV	37.0%

Table 6.–Mean weight and length (mm FL) of tagged coho salmon presmolt in Salmon Lake 2001.

	Freshwater-age-0	
	Length (mm FL)	Weight (g)
Mean	93.5	8.8
Standard error	1.2	0.4
Sample variance	55.3	5.7
Count	39	38

	Freshwater-age-1	
	Length (mm FL)	Weight (g)
Mean	103.9	12.4
Standard error	0.7	0.3
Sample variance	177.0	26.4
Count	339	330

Table 7.–Species and age distribution from midwater trawl net in Salmon Lake, 2001-2002.

	Species	Freshwater-age	Sample size	Percent species	Percent of age	Population	Mean length (mm FL)	Mean weight (g)
2001	Sockeye	0	104	94%	96%	42,000	40.1	0.6
	Sockeye	1	4	4%	4%	2,000	63	2.5
	Stickleback	No age	2	2%	100%	1,000	54	1.7
2002	Sockeye	0	72	94%	100%	14,167	40.1	0.6
	Stickleback	No age	5	6%	100%	984	46.8	1.1

freshwater-age-1, and nine (8%) were freshwater-age-0. The freshwater-age-0 sockeye salmon had a mean length of 40.1 mm FL and a mean weight of 0.6 g. The mean length of freshwater-age-1 sockeye was 63.0 mm FL and mean weight of 2.5 g. The length frequency (Figure 8) shows that most sockeye fry captured were between 32 to 44 mm FL. All targets that fell within target strength range of –50 to –68 dB during hydroacoustics were assumed to be proportionally represented by 98% sockeye salmon fry and 2% stickleback. This population of sockeye salmon fry was expected to produce approximately 31,000 smolt in spring 2002 based on 70% overwinter survival.

In 2002, hydroacoustic data were used to estimate total lake populations of 14,167 sockeye salmon fry and 984 sticklebacks (Table 7). Estimated sockeye fry density was 0.0511 fry m^{-2}. Seventy-seven (77) fish were captured in four midwater trawl tows. Sixty-six (66) sockeye salmon fry (92%) were smaller than 50 mm FL and were assumed to be freshwater-age-0. Six salmon fry were greater than 50 mm, all of which also were freshwater-age-0. The sockeye salmon fry had a mean length of 40.1 mm FL and a mean weight of 0.57 g. Five sticklebacks (6.4% of total catch) were caught and had a mean length of 46.8 mm FL and a mean weight of 1.1 g. The length frequency shows that most sockeye fry captured were between 32-46 mm FL (Figure 9). This population of sockeye salmon fry was expected to produce approximately 9,900 smolt in spring 2003 based on 70% overwinter survival.

PRODUCTIVITY OF SALMON LAKE

Limnology samples were taken three times during the 2001 summer field season (Table 8). Over the course of the three sampling periods, *Cyclop* sp. dominated the species composition numerically (63.7%) and in biomass (71.2%). *Bosmina*, *Holopendium*, and *Chydorinae* were also present in the lake.

Limnology samples were taken three times during the 2002 summer field season (Table 9). Over the course of the three sampling periods, *Bosmina* sp. dominated the species composition numerically (71.2%) and in biomass (59.9%). *Cyclops*, *Holopendium*, and *Chydorinae* were also present in the lake.

Limnology samples were taken three times during the 2003 summer field season (Table 10). Over the course of the three sampling periods, *Bosmina* sp. Again dominated the species composition numerically (80.4%) and in biomass (77.0%). *Cyclops* were also present in the lake (Table 10).

MARINE HARVEST OF COHO SALMON FROM SALMON LAKE

In 2003, 35 CWTs from Salmon Lake were randomly recovered from 752,214 coho salmon sampled in commercial and sport fisheries. One additional CWT was recovered incidentally. Twenty-two (22) coho salmon bearing CWTs with a Salmon Lake code were recovered randomly from Southeast Alaska's commercial troll fisheries, which could be used to estimate commercial harvest. All of these fish were caught in the Northwest Quadrant (Figure 10) of Southeast Alaska between July 3 and September 17, 2003. Thirteen (13) coho salmon bearing CWTs with a Salmon Lake code were recovered in the Sitka sport fishery between July 24 and August 28, 2003. Coho salmon bearing CWTs with a Salmon Lake code recovered in the commercial and sport fisheries in 2003 averaged 639 mm FL (SE = 8.36).

In 2003, The estimated harvest of Salmon Lake coho salmon in sampled marine fisheries was 2,973 (SE = 570; Table 11) or less than 1% of the combined sport and commercial troll harvest. The total contribution to the sport fishery by Salmon Lake coho was estimated at 1,156 fish. The total contribution to the commercial fishery was estimated at 1,817. Sport-caught Salmon Lake coho comprised 38.9% of the harvest of that stock in the sampled marine fisheries, and contributions relative were higher for the sport harvest (2.2%) than the troll harvest (0.26%). Estimates of freshwater harvest of coho salmon in Salmon Lake are not available because of the low number of respondents. This is indicative of low effort and negligible harvest.

Given an estimated escapement in 2003 of 832 (SE =44) and a marine harvest of 2,973, the estimated total return of Salmon Lake coho

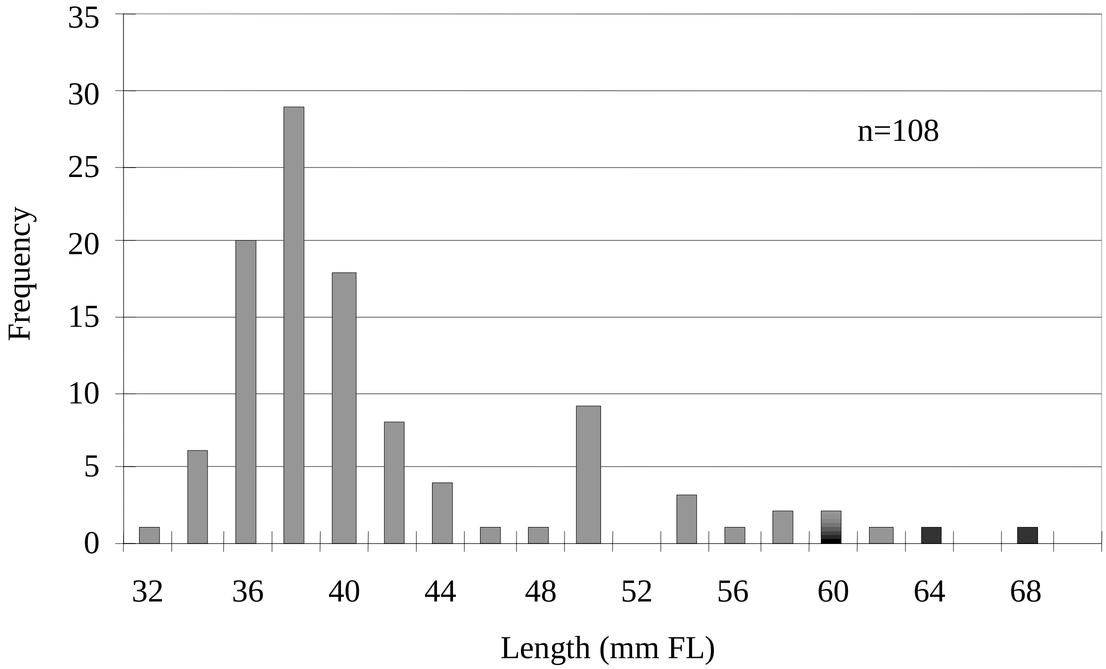


Figure 8.–Length frequency distribution of sockeye fry captured in Salmon Lake in 2001. All but three fish were freshwater-age-0.

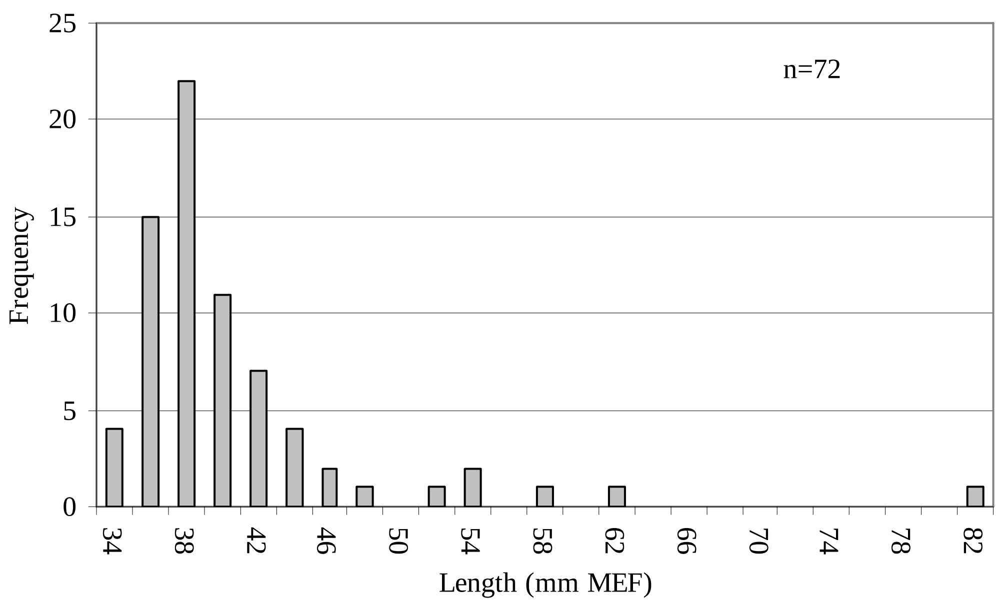


Figure 9.–Length frequency distribution of sockeye fry captured in Salmon Lake in 2002. All fish were freshwater-age-0.

Table 8.–Macrozooplankton length, biomass and density in Salmon Lake in 2001. Seasonal mean values are for three samples from station A, and two samples from station B.

Macrozooplankton Length and Biomass

	Mean length (mm)					Seasonal mean												
Station	A			B		A				B				Combined				
Species	12-Jul	27-Sep	18-Nov	12-Jul	18-Nov	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^2)	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^2)	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	%
Cyclops	0.54	0.67	0.79	0.68	0.57	0.67	0.68	9	10	0.63	0.58	0	0	0.65	0.63	5	5	71.2%
Ovig. Cyclops	1.20		1.24			1.22	1.20	0	0					0.61	0.60	0	0	0.0%
Bosmina	0.42	0.32	0.37	0.32	0.38	0.37	0.36	2	2	0.35	0.33	2	2	0.36	0.35	2	2	28.5%
Ovig. Bosmina	0.40	0.34	0.42	0.39	0.38	0.39	0.39	0.00	0.00	0.39	0.39	0	0	0.39	0.39	0	0	0.0%
Holopedium	0.54			0.44		0.54	0.54	0.02	0.02	0.44	0.44	0	0	0.49	0.49	0	0	0.1%
Ovig. Holopedium	0.57					0.57	0.57	0.02	0.02					0.29	0.29	0.01	0.01	0.1%
Chydorinae		0.32	0.30		0.28	0.31	0.31	0	0	0.28	0.28	0	0					0.0%
Total	3.67	1.65	3.12	1.83	1.61	Total:		11	12	Total:		3	2			7	7	

Macrozooplankton Density (No./m^2)

Station	A						B				Seasonal mean (No/m^2)					
Date:	12-Jul		27-Sep		18-Nov		12-Jul		18-Nov		A		B		Combined	
Species	Count	%	Count	%	Count	%	Count	%	Count	%	Seasonal mean	%	Seasonal mean	%	Seasonal mean	%
Cyclops	3,714	65.4%	8,694	76.6%	6,045	70.6%	46	1.4%	713	50.0%	6,167	64.2%	7,750	63.1%	6,959	63.7%
Ovig. Cyclops	5	0.1%		0.0%	0	0.0%		0.0%		0.0%	2	0.0%		0.0%	1	0.0%
Bosmina	642	11.3%	1,800	15.9%	1,970	23.0%	3,051	93.9%	560	39.3%	2,488	25.9%	3,691	30.0%	3,090	28.0%
Ovig. Bosmina	25	0.4%	170	1.5%	272	3.2%	76	2.3%	51	3.6%	181	1.9%	285	2.3%	233	2.1%
Holopedium	20	0.4%		0.0%		0.0%	5	0.2%		0.0%	8	0.1%	3	0.0%	6	0.1%
Ovig. Holopedium	20	0.4%		0.0%		0.0%		0.0%		0.0%	7	0.1%		0.0%	4	0.1%
Copepod nauplii	1,253	22.1%	577	5.10%	204	2.40%	71	2.20%	76	5.30%	702	7.30%	464	3.80%	583	5.6%
Total	5,679		11,343		8,559		3,249		1,425		9,611		12,290		10,874	

Table 9.–Macrozooplankton length, biomass and density in Salmon Lake in 2002. Seasonal mean values for two samples from station A, and three samples from station B.

Macrozooplankton Length and Biomass																		
	Mean length (mm)					Seasonal mean												
Station	A		B			A				B				Combined				
Species	30-Aug	19-Oct	24-Jul	30-Aug	19-Oct	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	%
Cyclops	0.50	0.60	0.47	0.53	0.59	0.55	0.50	5	4	0.53	0.51	1	1	0.54	0.51	3	2	6.5%
Bosmina	0.31	0.32	0.33	0.31	0.35	0.32	0.32	27	27	0.33	0.31	21	19	0.32	0.31	24	23	59.9%
Ovig. Bosmina	0.37	0.40	0.35	0.36	0.40	0.39	0.39	21	22	0.37	0.36	4	4	0.38	0.38	12	13	33.1%
Holopedium	0.44					0.44	0.44	0.10	0.10					0.22	0.22	0	0	0.1%
Ovig. Holopedium	0.53					0.53	0.53	0.05	0.05					0.27	0.27	0	0	0.1%
Chydorinae	0.27			0.32		0.27	0.27	0.10	0.10	0.32	0.32	0.16	0.16	0.30	0.30	0.13	0.13	0.3%
Polyphemus																		0.0%
Total	2.42	1.32	1.15	1.52	1.34	Total:		53	53	Total:		27	24			40	39	

Macrozooplankton Density (no./m^2)																
Station	A				B						Seasonal mean (No/m^2)					
Date:	30-Aug		19-Oct		24-Jul		30-Aug		19-Oct		A		B		Combined	
Species	Count	%	Count	%	Count	%	Count	%	Count	%	Seasonal mean	%	Seasonal mean	%	Seasonal mean	%
Cyclops	9,976	24.1%	357	0.6%	883	6.3%	1,528	2.5%	41	1.3%	5,167	10.2%	817	3.1%	2,992	6.7%
Bosmina	24,155	58.3%	35,965	60.2%	7,641	54.2%	55,120	89.8%	2,557	79.2%	30,060	59.4%	21,773	83.0%	25,916	71.2%
Ovig. Bosmina	6,835	16.5%	23,383	39.2%	5,570	39.5%	4,228	6.9%	621	19.2%	15,109	29.9%	3,473	13.2%	9,291	21.6%
Holopedium	127	0.3%		0.0%		0.0%		0.0%		0.0%	64	0.1%	0	0.0%	32	0.1%
Ovig. Holopedium	42	0.1%		0.0%		0.0%		0.0%		0.0%	21	0.0%	0	0.0%	11	0.0%
Chydorinae	297	0.7%		0.0%		0.0%	509	0.8%	10	0.3%	149	0.3%	173	0.7%	161	0.5%
Total	41,432		59,705		14,094		61,385		3,229		50,569		26,236		38,402	

Table 10.–Macrozooplankton length, biomass and density in Salmon Lake in 2003. Seasonal mean values are for three samples from station A, and three samples from station B.

Macrozooplankton Length and Biomass																			
	Mean length (mm)						Seasonal mean												
Station	A			B			A				B				Combined				
Species	30-Jun	23-Aug	28-Sep	30-Jun	23-Aug	28-Sep	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	Mean length (mm)	Weighted length (mm)	Biomass (mg/m^2)	Weighted biomass (mg/m^^{2})	%
Cyclops	0.48	0.52	0.59	0.55	0.5	0.51	0.53	0.54	4	4	0.52	0.51	2	2	0.53	0.53	3	3	2.2%
Bosmina	0.31	0.31	0.35	0.31	0.33	0.35	0.32	0.32	137	135	0.33	0.33	77	79	0.33	0.33	107	107	77.0%
Ovig. Bosmina	0.39	0.36	0.38	0.38	0.37	0.36	0.38	0.36	41	38	0.37	0.37	20	20	0.38	0.37	31	29	20.9%
Total	1.18	1.19	1.32	1.24	1.2	1.22	Total:		183	178	Total:		99	101	Total:		140.5	139	

Macrozooplankton Density $(no./m^2)$																		
Station	A						B						Seasonal mean (No/m^2)					
Date:	30-Jun		23-Aug		28-Aug		30-Jun		23-Aug		28-Aug		A		B		Combined	
Species	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Seasonal Mean	%	Seasonal Mean	%	Seasonal mean	%
Cyclops	2,038	3.4%	6,792	1.9%	4,924	3.6%	1,019	1.8%	1,630	1.50%	3,736	3.10%	4,788	2.20%	2,128	2.20%	3,458	2.2%
Bosmina	52,063	86.9%	268,636	76.7%	116,658	85.8%	54,101	93.8%	81,100	72.70%	100,866	83.20%	173,499	79.40%	78,689	81.30%	126,094	80.4%
Ovig. Bosmina	5,807	9.7%	74,716	21.3%	14,434	10.6%	2,547	4.4%	28,799	25.80%	16,641	13.70%	40,165	18.40%	15,996	16.50%	28,081	17.5%
Total	59,908		350,144		136,016		57,667		111,529		121,243		218,453		96,813			

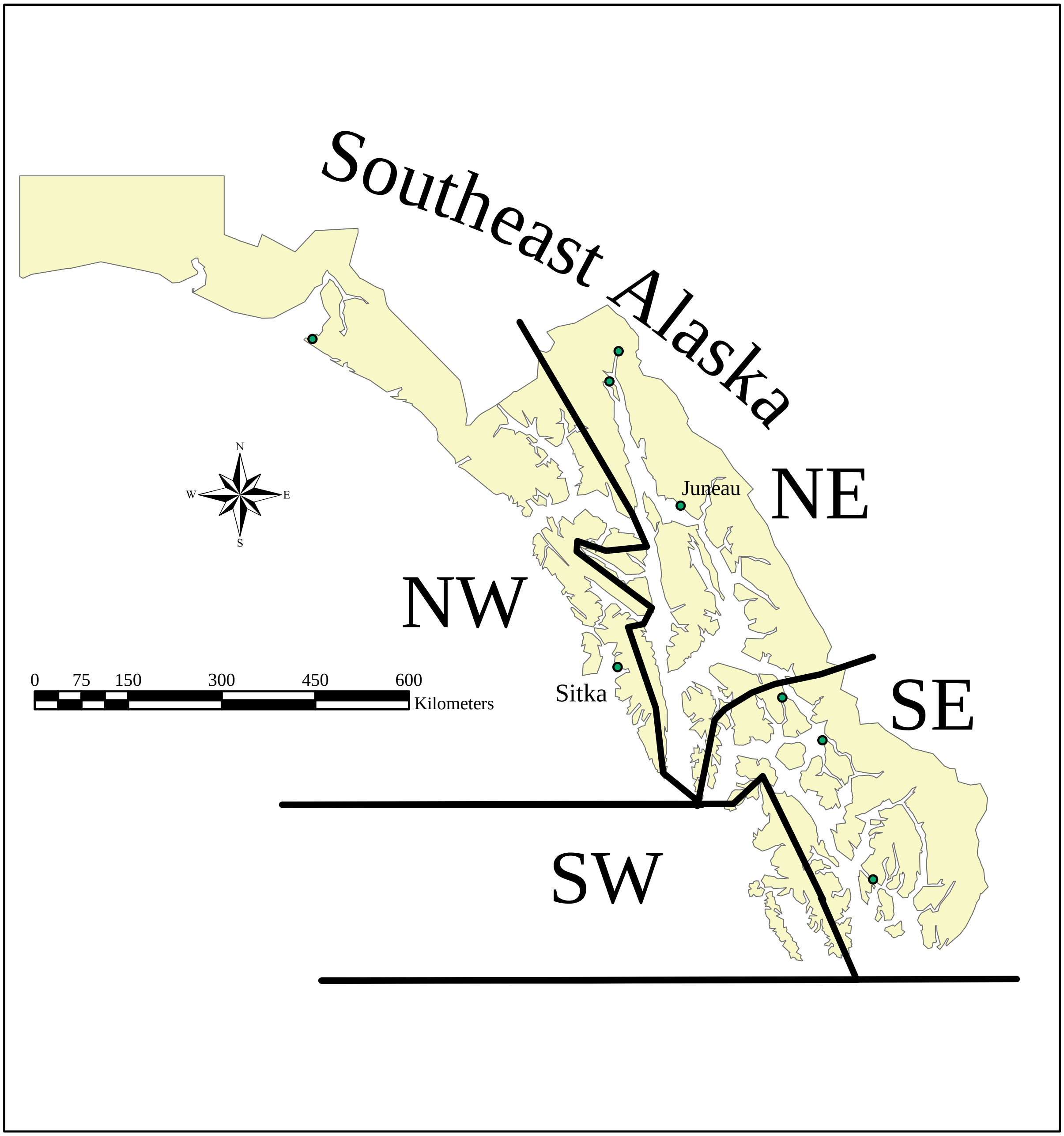


Figure 10.–Map of Southeast Alaska showing the troll quadrant boundaries.

Table 11.–Estimated marine harvest of adult Salmon Lake coho salmon (tag codes 04-07-12) in sampled sport and commercial fisheries, 2003.

TROLL FISHERY

Period	Dates	Quadrant	Harvest	Inspected	a	a'a	t	t't	m	r	SE{r}
3	6/30-8/10	NW	259,598	73,397	1,389	1,377	1,142	1,142	14	1,169	368
4	8/11-10/5	NW	440,235	128,461	3,480	3,452	2,961	2,959	8	647	251
Subtotal troll fishery			699,833	201,858	4,869	4,829	4,103	4,101	22	1,817	619

SPORT FISHERY

Biweek	Dates	Area	Harvest	Inspected	a	a'a	t	t't	m	r	SE{r}
15	7/21-8/3	SITKA	15,148	4,196	121	121	105	104	4	341	187
16	8/4-8/17	SITKA	17,850	4,407	134	132	123	123	5	481	240
17	8/18-8/31	SITKA	19,383	5,439	173	173	151	151	4	334	183
		Subtotal sport fishery	52,381	14,042	428	426	379	378	13	1,156	610
		Total All Fisheries	752,214	215,900	5,297	5,255	4,482	4,479	35	2,973	570

salmon was 3,805 (SE = 572). Total exploitation was estimated to be 78.1% (SE = 3.4%).

COMMERCIAL GILLNET HARVEST OF COHO SALMON IN THE DEEP INLET TERMINAL HARVEST AREA

In 2003, 219 coho salmon were reported harvested in the Deep Inlet commercial drift gillnet fishery from fish ticket data. Through independent sampling of this fishery the estimated harvest was 534 (SE = 172) for a reporting rate of about 41%. The marked fraction (coho carrying adipose fin clips) was estimated at 14%, or 73 of 534. Only 11 of the estimated 73 coho with adipose fin clips coho were recovered, none of which originated from Salmon Lake.

DISCUSSION

ADULT SOCKEYE AND COHO ESCAPEMENT IN 2001-2003

The study design provided adequate opportunities to investigate size related and/or temporal violations of the three components of the first assumption. Diagnostic tests and criteria for choosing the correct model for estimating abundance have been described in appendices. The failure to record length information on all sockeye salmon inspected during the second sampling event in 2001 precluded both the ability to evaluate size-biased sampling during the marking event and to stratify by length prior to abundance estimation as a conservative measure (size-biased sampling was detected during second event sampling). While selection of the Darroch (1961) model to estimate sockeye salmon abundance did accommodate temporal variability in probability of capture, it will not, generally, adjust for size-biased sampling unless the size bias is well confounded with the temporal bias.

Floy™ tag loss was low and sampling rates were high. Additionally, 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 study. Because fish were given a uniquely numbered Floy tag and fin clipped, double sampling was largely prevented in the recapture events. However, the minor tag loss was problematic when fish sampled during the second event were not given an additional mark to clearly indicate they had already been inspected, as with sockeye salmon in 2003.

Thirty-three (3.9%) of the 848 marked fish recaptured with a secondary mark had actually lost their primary (Floy™ tag) mark. Additionally, 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.

Each year the number of fish captured at the weir only represented a portion of the total escapement, as some fish were able to pass through the weir undetected during high water events. Because the proportion of fish captured at the weir varied in relation to estimated escapement, weir counts should be viewed as a minimum escapement count rather than an index of escapement. The floating weir was designed to allow water to pass over it without damage. Experience has shown that although the periodic high water events are short and infrequent, a 100-fold increase in discharge can occur. In addition to high water events that provide an opportunity for fish to pass, picket spacing allows smaller resident fish to swim through the weir unimpeded.

COHO PRESMOLT ABUNDANCE IN 2001 AND ADULT HARVEST IN 2003

All presmolt had the same probability of capture regardless of location in the lake or size. Presmolt capture and tagging occurred throughout the lake and tributaries, within most of the available habitat, and was also accomplished with minnow traps that capture a wide range of presmolt sizes.

Although the assumption about mixing cannot be tested, coho salmon most likely mixed within or across stocks during their extended time (14 months) at sea. This should provide adequate mixing of the population of tagged and untagged fish.

Another assumption requires that there was no recruitment to the population between years. Because almost all wild coho salmon return to their natal streams and sampling only occurred in the river, there was probably no appreciable recruitment to the stock between marking and recovery. The presence of stray coho salmon reared at Medvejie hatchery is possible but unlikely because no coho from Medvejie hatchery were recovered in Salmon Lake in 2001 and 2002.

It is unlikely that presmolt regenerated the clipped adipose fin that identified the fish as containing a tag. In conjunction with tag retention and overnight mortality tests, adipose fin clips on presmolt were examined. All presmolt examined appeared to have good fin clips. Also, all adult coho examined had well defined or a complete absence of an adipose fin.

The results of an instream sampling event that occurred in spring 2002 suggest a need for caution when interpreting many of the statistics for Salmon Lake coho salmon harvested in 2003. In April and May 2002, NSRAA staff sampled coho salmon smolt during the outmigration. Smolt were captured using an incline plane trap. Of 309 smolt observed, 53 had missing adipose fins. Using these data to calculate the abundance of fall 2001 presmolts yields an estimate of 28,101 (SE = 3,425), which is much smaller than the estimate of 108,370 that was based on the proportion of marked adults observed at the weir. This smaller number, when used in calculations of marine harvest in sport and commercial fisheries, provides an estimated harvest of 740 (SE = 277), compared to the estimate of 2,973. Subsequently, the smaller harvest estimate produces a total return size of 1,608 (SE = 280) with an estimated exploitation rate of 46.0% (SE = 9.4%), which is smaller than our estimates, respectively, of 3,805 and 78.1%.

The contrast in these results is dramatic and if one (if not both) set of results is inaccurate, most likely it is a result of an unidentified source of bias during sampling. It is unlikely that presmolt-to-smolt survival of tagged fish was significantly lower than that of untagged fish because results from other studies (Elliott and Sterritt 1990; Vander Haegen et al. 2005; Vincent-Lang 1993) indicate that excising adipose fins and implanting CWT's does not increase the mortality of marked salmon. It is also extremely unlikely that tagged fish were more susceptible to being captured and sampled during spring 2002, again because the tagging event occurred several months earlier and used different capture gear.

It is likely that the proportion of marked fish observed at the weir is more representative of the proportion of marked fish available during outmigration. The spring sample was a discrete sample that did not encompass the entire out-migration and may have been biased toward marked fish. The statistics calculated based on escapement data (as presented in the Results) should be used to guide fishery management until additional information indicates otherwise.

OBSERVER COUNTS

Although Salmon Lake inlet streams are similar to other clearwater streams in the area, the ratio between the peak observer count and the estimated total escapement (sockeye average 2001-2003 = 1.03%, coho average 2001-2003 = 4.33%) is lower than that found in either Nakwasina River (average 22.5%: Tydingco 2003, 2005a, 2005b) or Steep Creek (21%) near Juneau, Alaska (Jones and McPherson 1997). The ability to count spawning salmon depends on many factors, including the observer, weather, water clarity, canopy cover, pool-to-riffle ratio, the density of fish, the amount of undercut banks, and the ecology, behavior, size, and color of salmon (Jones 1995). Stream counts of both sockeye and coho may be low because both sockeye and coho use the lake to hold in prior to spawning. Both sockeye and coho are likely only in the inlet streams to spawn, and this is probably a short time period. In addition to the inlet streams, sockeye were found to spawn on the lakeshore.

HYDROACOUSTICS

Hydroacoustic data were collected on only 180 sockeye fry were captured during tows. The results from hydroacoustic analysis should be used only as an index of total sockeye fry abundance. Additionally, replicate sample were not taken during the hydroacoustic transects or midwater tows. Because of the lack of replicate sampling, a measure of reliability of the hydroacoustic estimates was not available.

HARVEST SAMPLING

Sampling rates in the troll fisheries in the Northwest Quadrant ranged from 21% (District 114) to 34% (District 113). Because not all fisheries were sampled, it is likely that Salmon Lake coho salmon harvest was underestimated in some fisheries.

The reported subsistence harvest of both coho and sockeye salmon are likely underestimated. On July 4, 2001, Sitka Tribe and ADF&G staff observed approximately 400 sockeye taken at the mouth of the Salmon Lake outlet stream in the subsistence fishery. The total reported subsistence harvest for the year was 255 fish. To fully understand the harvest of both sockeye and coho salmon from Salmon Lake, a sampling protocol should be developed and implemented that addresses this harvest.

DEEP INLET COHO HARVEST

Although the Deep Inlet coho harvest estimated through independent on-site survey found reporting rate to be approximately 41%, it's coefficient of variation was 32%. No adipose-clipped coho salmon originating from Salmon Lake were recovered in the Deep Inlet fishery. In 1995, an estimated 123 fish originating from Salmon Lake were harvested in this fishery (Schmidt 1996). This represented approximately 5.2% of the Salmon Lake coho salmon harvested in 1995. In 2003, participation in the Deep Inlet terminal harvest fishery was low. Only 57 boats participated in the fishery compared to 166 in 2000.

CONCLUSIONS AND RECOMMENDATIONS

ESCAPEMENT ESTIMATION

To minimize the number of fish passing through the weir undetected, the weir should be closely inspected and reinforced during times of low water in order to prepare the weir for high water events. A picket spacing of 20 pickets per 4-ft panel may also reduce the number of salmon passing through the weir while still allowing smaller resident fish to move through unimpeded.

As an alternate form of estimating escapement, inlake mark recapture methods to estimate escapement without the use of the weir should be explored. To do this, fish would need to be captured and tagged with individually numbered Floy™ tags in Salmon Lake periodically throughout the escapement migration.

Because such a relatively small number of fish may be present in the inlet streams during stream counts, stream counts are not a reliable tool for estimating escapement and should be discontinued.

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APPENDIX A

Appendix A1.–Detection of size and/or sex selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather than observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two-sample test (e.g., Student's t-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:

Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:

Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:

Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:

Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences that have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), then rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event, which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), then rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event, which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

-continued-

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), then rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events, which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{j=1}^{i} \frac{\hat{N}_j}{\hat{N}_\Sigma} \hat{p}_{jk} \text{ ; and,} \tag{1}$$

$$\hat{V}\left[\hat{p}_k\right] \approx \frac{1}{\hat{N}_\Sigma^2}\left(\sum_{j=1}^{i} \hat{N}_i^2 \hat{V}\left[\hat{p}_{jk}\right] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}\left[\hat{N}_j\right]\right). \tag{2}$$

where: i = the number of sex/size strata;

$\hat{p}_{jk}$ = the estimated proportion of fish that were age or size k among fish in stratum j;

$\hat{N}_j$ = the estimated abundance in stratum j; and,

$\hat{N}_\Sigma$ = sum of the $\hat{N}_j$ across strata.

Appendix A2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

Tests of consistency for Petersen estimator

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic was used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needed to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests were rejected, a geographically stratified estimator (Darroch 1961) was used to estimate abundance.

I.-Test For Complete Mixing[a]

Area Where Marked	Area Where Recaptured				Not Recaptured
	1	**2**	**…**	**t**	$(n_1\text{-}m_2)$
1					
2					
…					
s					

II.-Test For Equal Probability of capture during the first event[b]

	Area Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked $(n_2\text{-}m_2)$				

III.-Test for equal probability of capture during the second event[c]

	Area Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured $(n_1\text{-}m_2)$				

[a] This tests the hypothesis that movement probabilities (θ) from area i (i = 1, 2, ...s) to area j (j = 1, 2, ...t) are the same among areas: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among areas: H_0: $\Sigma_i a_i\theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among the river areas: H_0: $\Sigma_j\theta_{ij}p_j$ = d, where p_j is the probability of capturing a fish in area j during the second event, and d is a constant.

Appendix A3.–Daily fish passing and cumulative percent of run for fish captured at the Salmon Lake weir 2001-2003.

	2001						2002						2003					
Date	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run
01-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
02-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
03-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
04-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
05-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
06-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	3	0.3%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
07-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.3%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
08-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.3%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
09-Jun	-	0.0%	-	0.0%	-	0.0%	-	0.0%	3	0.6%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
10-Jun	-	0.0%	3	0.3%	-	0.0%	-	0.0%	1	0.7%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
11-Jun	-	0.0%	6	0.8%	-	0.0%	-	0.0%	7	1.5%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
12-Jun	-	0.0%	10	1.7%	-	0.0%	-	0.0%	9	2.4%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
13-Jun	-	0.0%	1	1.8%	-	0.0%	-	0.0%	-	2.4%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
14-Jun	-	0.0%	11	2.7%	-	0.0%	-	0.0%	15	4.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
15-Jun	-	0.0%	2	2.9%	-	0.0%	-	0.0%	10	5.1%	-	0.0%	-	0.0%	1	0.1%	-	0.0%
16-Jun	-	0.0%	-	2.9%	-	0.0%	-	0.0%	13	6.4%	-	0.0%	-	0.0%	2	0.4%	-	0.0%
17-Jun	-	0.0%	4	3.3%	-	0.0%	-	0.0%	4	6.9%	-	0.0%	-	0.0%	-	0.4%	-	0.0%
18-Jun	-	0.0%	1	3.4%	-	0.0%	-	0.0%	29	9.9%	-	0.0%	-	0.0%	2	0.6%	-	0.0%
19-Jun	-	0.0%	1	3.4%	-	0.0%	-	0.0%	19	11.9%	-	0.0%	-	0.0%	-	0.6%	-	0.0%
20-Jun	-	0.0%	8	4.1%	-	0.0%	-	0.0%	6	12.6%	-	0.0%	-	0.0%	-	0.6%	-	0.0%
21-Jun	-	0.0%	27	6.5%	-	0.0%	-	0.0%	6	13.2%	-	0.0%	-	0.0%	-	0.6%	-	0.0%
22-Jun	-	0.0%	10	7.4%	-	0.0%	-	0.0%	7	13.9%	-	0.0%	-	0.0%	2	0.9%	-	0.0%
23-Jun	-	0.0%	2	7.6%	-	0.0%	-	0.0%	15	15.5%	-	0.0%	-	0.0%	6	1.6%	-	0.0%
24-Jun	-	0.0%	25	9.8%	-	0.0%	-	0.0%	34	19.1%	-	0.0%	-	0.0%	-	1.6%	-	0.0%
25-Jun	-	0.0%	18	11.4%	-	0.0%	-	0.0%	8	20.0%	-	0.0%	-	0.0%	3	2.0%	-	0.0%
26-Jun	-	0.0%	5	11.8%	-	0.0%	-	0.0%	5	20.5%	-	0.0%	-	0.0%	1	2.1%	-	0.0%
27-Jun	-	0.0%	19	13.5%	-	0.0%	-	0.0%	9	21.4%	-	0.0%	-	0.0%	-	2.1%	-	0.0%
28-Jun	-	0.0%	13	14.6%	-	0.0%	-	0.0%	7	22.2%	-	0.0%	-	0.0%	1	2.2%	-	0.0%
29-Jun	-	0.0%	14	15.9%	-	0.0%	-	0.0%	2	22.4%	-	0.0%	-	0.0%	1	2.3%	-	0.0%
30-Jun	-	0.0%	7	16.5%	-	0.0%	-	0.0%	7	23.1%	-	0.0%	-	0.0%	9	3.4%	-	0.0%
01-Jul	-	0.0%	6	17.0%	-	0.0%	-	0.0%	2	23.3%	-	0.0%	-	0.0%	12	4.9%	-	0.0%
02-Jul	-	0.0%	27	19.4%	-	0.0%	-	0.0%	3	23.7%	-	0.0%	-	0.0%	2	5.1%	-	0.0%
03-Jul	-	0.0%	8	20.1%	-	0.0%	-	0.0%	5	24.2%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
04-Jul	-	0.0%	7	20.7%	-	0.0%	-	0.0%	-	24.2%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
05-Jul	-	0.0%	6	21.3%	-	0.0%	-	0.0%	1	24.3%	-	0.0%	-	0.0%	-	5.1%	-	0.0%

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	2001						2002						2003					
Date	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run
06-Jul	-	0.0%	4	21.6%	-	0.0%	-	0.0%	14	25.8%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
07-Jul	-	0.0%	26	23.9%	-	0.0%	-	0.0%	7	26.5%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
08-Jul	-	0.0%	62	29.4%	-	0.0%	-	0.0%	4	26.9%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
09-Jul	-	0.0%	11	30.3%	-	0.0%	-	0.0%	3	27.2%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
10-Jul	-	0.0%	2	30.5%	-	0.0%	-	0.0%	3	27.6%	-	0.0%	-	0.0%	-	5.1%	-	0.0%
11-Jul	-	0.0%	10	31.4%	-	0.0%	-	0.0%	-	27.6%	-	0.0%	-	0.0%	1	5.3%	-	0.0%
12-Jul	-	0.0%	1	31.5%	-	0.0%	-	0.0%	-	27.6%	-	0.0%	-	0.0%	5	5.9%	-	0.0%
13-Jul	-	0.0%	1	31.6%	-	0.0%	-	0.0%	-	27.6%	-	0.0%	-	0.0%	4	6.4%	-	0.0%
14-Jul	-	0.0%	-	31.6%	-	0.0%	-	0.0%	1	27.7%	-	0.0%	-	0.0%	1	6.5%	-	0.0%
15-Jul	-	0.0%	7	32.2%	-	0.0%	-	0.0%	-	27.7%	-	0.0%	-	0.0%	1	6.6%	-	0.0%
16-Jul	-	0.0%	-	32.2%	-	0.0%	-	0.0%	1	27.8%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
17-Jul	-	0.0%	1	32.3%	-	0.0%	-	0.0%	2	28.0%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
18-Jul	-	0.0%	10	33.2%	-	0.0%	-	0.0%	1	28.1%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
19-Jul	-	0.0%	1	33.2%	-	0.0%	-	0.0%	4	28.5%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
20-Jul	-	0.0%	7	33.9%	-	0.0%	-	0.0%	6	29.1%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
21-Jul	-	0.0%	4	34.2%	-	0.0%	1	0.0%	2	29.4%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
22-Jul	-	0.0%	6	34.7%	-	0.0%	1	0.0%	-	29.4%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
23-Jul	-	0.0%	1	34.8%	-	0.0%	-	0.0%	23	31.8%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
24-Jul	-	0.0%	9	35.6%	-	0.0%	-	0.0%	1	31.9%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
25-Jul	-	0.0%	83	42.9%	-	0.0%	-	0.0%	-	31.9%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
26-Jul	-	0.0%	21	44.8%	-	0.0%	1	0.0%	2	32.1%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
27-Jul	1	0.0%	11	45.8%	1	0.1%	-	0.0%	11	33.3%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
28-Jul	-	0.0%	1	45.9%	-	0.1%	5	0.0%	208	55.2%	-	0.0%	-	0.0%	-	6.6%	-	0.0%
29-Jul	-	0.0%	-	45.9%	-	0.1%	1	0.0%	141	70.1%	-	0.0%	-	0.0%	6	7.3%	-	0.0%
30-Jul	1	0.0%	1	45.9%	-	0.1%	-	0.0%	20	72.2%	-	0.0%	-	0.0%	5	7.9%	-	0.0%
31-Jul	-	0.0%	-	45.9%	-	0.1%	-	0.0%	12	73.5%	-	0.0%	1	0.0%	12	9.4%	-	0.0%
1-Aug	-	0.0%	4	46.3%	-	0.1%	-	0.0%	6	74.1%	-	0.0%	-	0.0%	-	9.4%	-	0.0%
2-Aug	12	0.1%	59	51.5%	-	0.1%	-	0.0%	2	74.3%	1	0.1%	-	0.0%	48	15.3%	-	0.0%
3-Aug	10	0.2%	40	55.0%	-	0.1%	-	0.0%	-	74.3%	-	0.1%	63	0.4%	126	30.7%	-	0.0%
4-Aug	5	0.2%	29	57.6%	-	0.1%	-	0.0%	-	74.3%	-	0.1%	19	0.5%	87	41.3%	-	0.0%
5-Aug	7	0.2%	84	65.0%	-	0.1%	-	0.0%	-	74.3%	-	0.1%	142	1.2%	14	43.0%	-	0.0%
6-Aug	8	0.3%	17	66.5%	-	0.1%	-	0.0%	1	74.4%	-	0.1%	38	1.5%	2	43.3%	-	0.0%
7-Aug	22	0.5%	7	67.1%	-	0.1%	131	0.3%	50	79.7%	-	0.1%	33	1.6%	2	43.5%	-	0.0%
8-Aug	14	0.5%	11	68.1%	-	0.1%	1,403	3.4%	57	85.7%	8	0.9%	46	1.9%	5	44.1%	-	0.0%
9-Aug	27	0.7%	2	68.3%	-	0.1%	3,174	10.5%	37	89.7%	6	1.5%	118	2.5%	-	44.1%	-	0.0%

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	2001						2002						2003					
Date	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run
10-Aug	26	0.9%	5	68.7%	-	0.1%	982	12.7%	18	91.6%	8	2.3%	77	3.0%	-	44.1%	-	0.0%
11-Aug	9	1.0%	1	68.8%	-	0.1%	140	13.0%	6	92.2%	1	2.4%	63	3.3%	2	44.4%	-	0.0%
12-Aug	58	1.4%	6	69.3%	-	0.1%	34	13.1%	3	92.5%	-	2.4%	49	3.6%	8	45.4%	-	0.0%
13-Aug	47	1.7%	-	69.3%	-	0.1%	366	13.9%	34	96.1%	15	3.8%	24	3.7%	2	45.6%	-	0.0%
14-Aug	18	1.8%	-	69.3%	-	0.1%	172	14.3%	4	96.5%	1	3.9%	78	4.2%	6	46.3%	-	0.0%
15-Aug	29	2.0%	3	69.6%	-	0.1%	85	14.5%	-	96.5%	-	3.9%	203	5.3%	145	64.1%	1	0.1%
16-Aug	-	2.0%	-	69.6%	-	0.1%	-	14.5%	-	96.5%	-	3.9%	1,796	15.2%	64	71.9%	2	0.3%
17-Aug	29	2.2%	6	70.1%	-	0.1%	51	14.6%	-	96.5%	-	3.9%	681	19.0%	50	78.0%	4	0.6%
18-Aug	47	2.5%	8	70.8%	-	0.1%	16	14.6%	-	96.5%	-	3.9%	979	24.4%	21	80.6%	6	1.1%
19-Aug	268	4.4%	3	71.1%	-	0.1%	9	14.6%	1	96.6%	-	3.9%	1,253	31.3%	19	82.9%	2	1.3%
20-Aug	327	6.6%	37	74.3%	-	0.1%	41	14.7%	1	96.7%	-	3.9%	270	32.8%	33	86.9%	6	1.9%
21-Aug	548	10.4%	49	78.7%	-	0.1%	3,566	22.7%	10	97.8%	7	4.6%	349	34.8%	9	88.0%	4	2.2%
22-Aug	432	13.4%	11	79.6%	-	0.1%	2,800	28.9%	3	98.1%	9	5.5%	135	35.5%	4	88.5%	-	2.2%
23-Aug	130	14.3%	3	79.9%	-	0.1%	2,940	35.4%	2	98.3%	20	7.5%	73	35.9%	2	88.8%	1	2.3%
24-Aug	176	15.5%	-	79.9%	-	0.1%	985	37.6%	-	98.3%	4	7.9%	73	36.3%	2	89.0%	1	2.4%
25-Aug	167	16.6%	1	80.0%	-	0.1%	243	38.2%	-	98.3%	-	7.9%	61	36.7%	-	89.0%	1	2.5%
26-Aug	1,721	28.4%	13	81.1%	-	0.1%	138	38.5%	1	98.4%	1	8.0%	87	37.1%	5	89.6%	-	2.5%
27-Aug	2,247	43.9%	93	89.4%	8	0.8%	117	38.7%	-	98.4%	1	8.1%	82	37.6%	-	89.6%	-	2.5%
28-Aug	2,450	60.7%	75	96.0%	39	4.5%	2,923	45.2%	2	98.6%	28	10.8%	87	38.1%	1	89.7%	-	2.5%
29-Aug	693	65.5%	8	96.7%	7	5.2%	4,327	54.9%	3	98.9%	14	12.2%	114	38.7%	8	90.7%	-	2.5%
30-Aug	228	67.0%	4	97.1%	-	5.2%	540	56.1%	-	98.9%	-	12.2%	220	39.9%	9	91.8%	-	2.5%
31-Aug	88	67.6%	-	97.1%	1	5.3%	360	56.9%	3	99.3%	-	12.2%	1,468	48.0%	6	92.5%	5	2.9%
01-Sep	338	70.0%	1	97.2%	1	5.4%	919	58.9%	-	99.3%	1	12.3%	848	52.7%	8	93.5%	10	3.8%
02-Sep	632	74.3%	13	98.3%	25	7.7%	782	60.7%	1	99.4%	3	12.6%	1,525	61.2%	15	95.4%	11	4.8%
03-Sep	1,001	81.2%	7	99.0%	77	15.0%	492	61.8%	-	99.4%	2	12.8%	1,647	70.3%	13	96.9%	26	7.1%
04-Sep	367	83.7%	2	99.2%	7	15.7%	408	62.7%	-	99.4%	-	12.8%	786	74.6%	6	97.7%	7	7.7%
05-Sep	97	84.4%	-	99.2%	4	16.0%	371	63.5%	-	99.4%	1	12.9%	415	76.9%	-	97.7%	1	7.8%
06-Sep	665	88.9%	1	99.3%	14	17.4%	534	64.7%	-	99.4%	-	12.9%	140	77.7%	-	97.7%	-	7.8%
07-Sep	512	92.4%	1	99.4%	4	17.7%	905	66.7%	1	99.5%	1	13.0%	86	78.2%	1	97.8%	-	7.8%
08-Sep	255	94.2%	-	99.4%	2	17.9%	779	68.4%	-	99.5%	-	13.0%	809	82.7%	3	98.2%	62	13.3%
09-Sep	171	95.4%	-	99.4%	-	17.9%	921	70.5%	-	99.5%	4	13.4%	629	86.2%	2	98.4%	21	15.1%
10-Sep	74	95.9%	-	99.4%	1	18.0%	1,490	73.8%	2	99.7%	4	13.8%	269	87.6%	2	98.7%	-	15.1%
11-Sep	34	96.1%	-	99.4%	-	18.0%	1,068	76.2%	1	99.8%	2	13.9%	425	90.0%	5	99.3%	47	19.3%
12-Sep	-	96.1%	1	99.5%	2	18.2%	879	78.1%	-	99.8%	1	14.0%	403	92.2%	1	99.4%	22	21.2%
13-Sep	-	96.1%	-	99.5%	10	19.2%	560	79.4%	1	99.9%	-	14.0%	97	92.8%	-	99.4%	2	21.4%

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	2001						2002						2003					
Date	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run
14-Sep	24	96.3%	-	99.5%	40	22.9%	327	80.1%	-	99.9%	1	14.1%	321	94.5%	1	99.5%	88	29.2%
15-Sep	110	97.0%	4	99.8%	35	26.2%	2,049	84.7%	-	99.9%	1	14.2%	338	96.4%	-	99.5%	18	30.7%
16-Sep	205	98.4%	-	99.8%	42	30.2%	565	85.9%	-	99.9%	2	14.4%	87	96.9%	-	99.5%	1	30.8%
17-Sep	92	99.1%	-	99.8%	22	32.3%	612	87.3%	-	99.9%	3	14.7%	57	97.2%	-	99.5%	-	30.8%
18-Sep	77	99.6%	-	99.8%	28	34.9%	1,835	91.4%	-	99.9%	86	23.2%	35	97.4%	-	99.5%	-	30.8%
19-Sep	16	99.7%	-	99.8%	7	35.6%	2,110	96.1%	-	99.9%	80	31.0%	70	97.8%	1	99.6%	1	30.9%
20-Sep	-	99.7%	-	99.8%	33	38.7%	440	97.0%	-	99.9%	6	31.6%	175	98.8%	-	99.6%	16	32.3%
21-Sep	16	99.8%	-	99.8%	6	39.2%	572	98.3%	1	100.0%	22	33.8%	73	99.2%	1	99.8%	121	43.0%
22-Sep	5	99.9%	-	99.8%	14	40.6%	241	98.9%	-	100.0%	12	35.0%	39	99.4%	-	99.8%	20	44.8%
23-Sep	2	99.9%	-	99.8%	8	41.3%	82	99.0%	-	100.0%	-	35.0%	36	99.6%	2	100.0%	9	45.6%
24-Sep	6	99.9%	-	99.8%	5	41.8%	61	99.2%	-	100.0%	1	35.1%	-	99.6%	-	100.0%	-	45.6%
25-Sep	8	100.0%	-	99.8%	8	42.5%	63	99.3%	-	100.0%	4	35.5%	16	99.7%	-	100.0%	78	52.5%
26-Sep	-	100.0%	-	99.8%	2	42.7%	39	99.4%	-	100.0%	-	35.5%	11	99.7%	-	100.0%	104	61.7%
27-Sep	2	100.0%	-	99.8%	9	43.6%	65	99.5%	-	100.0%	-	35.5%	8	99.8%	-	100.0%	52	66.3%
28-Sep	1	100.0%	-	99.8%	2	43.8%	76	99.7%	-	100.0%	15	36.9%	10	99.8%	-	100.0%	61	71.6%
29-Sep	-	100.0%	-	99.8%	16	45.3%	31	99.8%	-	100.0%	-	36.9%	10	99.9%	-	100.0%	40	75.2%
30-Sep	1	100.0%	-	99.8%	78	52.6%	17	99.8%	-	100.0%	1	37.0%	8	99.9%	-	100.0%	11	76.1%
01-Oct	-	100.0%	2	100.0%	50	57.4%	6	99.8%	-	100.0%	-	37.0%	2	99.9%	-	100.0%	5	76.6%
02-Oct	-	100.0%	-	100.0%	43	61.4%	34	99.9%	-	100.0%	-	37.0%	4	100.0%	-	100.0%	6	77.1%
03-Oct	-	100.0%	-	100.0%	20	63.3%	13	99.9%	-	100.0%	2	37.2%	2	100.0%	-	100.0%	4	77.5%
04-Oct	-	100.0%	-	100.0%	12	64.4%	4	99.9%	-	100.0%	3	37.5%	-	100.0%	-	100.0%	4	77.8%
05-Oct	-	100.0%	-	100.0%	9	65.3%	4	100.0%	-	100.0%	19	39.4%	5	100.0%	-	100.0%	3	78.1%
06-Oct	-	100.0%	-	100.0%	14	66.6%	4	100.0%	-	100.0%	230	62.0%	1	100.0%	-	100.0%	8	78.8%
07-Oct	-	100.0%	-	100.0%	11	67.6%	5	100.0%	-	100.0%	179	79.6%	-	100.0%	-	100.0%	20	80.6%
08-Oct	-	100.0%	-	100.0%	4	68.0%	3	100.0%	-	100.0%	23	81.8%	-	100.0%	-	100.0%	5	81.0%
09-Oct	-	100.0%	-	100.0%	57	73.4%	2	100.0%	-	100.0%	35	85.3%	-	100.0%	-	100.0%	9	81.8%
10-Oct	-	100.0%	-	100.0%	116	84.3%	1	100.0%	-	100.0%	8	86.1%	-	100.0%	-	100.0%	1	81.9%
11-Oct	-	100.0%	-	100.0%	25	86.7%	2	100.0%	-	100.0%	16	87.6%	-	100.0%	-	100.0%	-	81.9%
12-Oct	-	100.0%	-	100.0%	25	89.1%	1	100.0%	-	100.0%	10	88.6%	-	100.0%	-	100.0%	-	81.9%
13-Oct	-	100.0%	-	100.0%	29	91.8%	-	100.0%	-	100.0%	8	89.4%	-	100.0%	-	100.0%	-	81.9%
14-Oct	-	100.0%	-	100.0%	8	92.5%	-	100.0%	-	100.0%	1	89.5%	-	100.0%	-	100.0%	41	85.5%
15-Oct	-	100.0%	-	100.0%	2	92.7%	1	100.0%	-	100.0%	1	89.6%	-	100.0%	-	100.0%	10	86.4%
16-Oct	-	100.0%	-	100.0%	35	96.0%	-	100.0%	-	100.0%	-	89.6%	-	100.0%	-	100.0%	1	86.5%
17-Oct	-	100.0%	-	100.0%	5	96.5%	-	100.0%	-	100.0%	36	93.1%	-	100.0%	-	100.0%	2	86.7%
18-Oct	-	100.0%	-	100.0%	20	98.4%	-	100.0%	-	100.0%	14	94.5%	-	100.0%	-	100.0%	-	86.7%

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	2001						2002						2003					
Date	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run	Pink	Pink cumulative % of run	Sockeye	Sockeye cumulative % of run	Coho	Coho cumulative % of run
19-Oct	-	100.0%	-	100.0%	7	99.1%	-	100.0%	-	100.0%	1	94.6%	-	100.0%	-	100.0%	10	87.5%
20-Oct	-	100.0%	-	100.0%	3	99.3%	-	100.0%	-	100.0%	27	97.2%	-	100.0%	-	100.0%	20	89.3%
21-Oct	-	100.0%	-	100.0%	1	99.4%	-	100.0%	-	100.0%	-	97.2%	-	100.0%	-	100.0%	-	89.3%
22-Oct	-	100.0%	-	100.0%	1	99.5%	-	100.0%	-	100.0%	21	99.3%	-	100.0%	-	100.0%	3	89.6%
23-Oct	-	100.0%	-	100.0%	-	99.5%	-	100.0%	-	100.0%	5	99.8%	-	100.0%	-	100.0%	1	89.7%
24-Oct	-	100.0%	-	100.0%	-	99.5%	-	100.0%	-	100.0%	-	99.8%	-	100.0%	-	100.0%	-	89.7%
25-Oct	-	100.0%	-	100.0%	-	99.5%	-	100.0%	-	100.0%	1	99.9%	-	100.0%	-	100.0%	71	95.9%
26-Oct	-	100.0%	-	100.0%	-	99.5%	-	100.0%	-	100.0%	-	99.9%	-	100.0%	-	100.0%	33	98.9%
27-Oct	-	100.0%	-	100.0%	-	99.5%	-	100.0%	-	100.0%	-	99.9%	-	100.0%	-	100.0%	7	99.5%
28-Oct	-	100.0%	-	100.0%	-	99.5%	1	100.0%	-	100.0%	-	99.9%	-	100.0%	-	100.0%	2	99.6%
29-Oct	-	100.0%	-	100.0%	2	99.7%	-	100.0%	-	100.0%	-	99.9%	-	100.0%	-	100.0%	2	99.8%
30-Oct	-	100.0%	-	100.0%	2	99.9%	-	100.0%	-	100.0%	1	100.0%	-	100.0%	-	100.0%	1	99.9%
31-Oct	-	100.0%	-	100.0%	1	100.0%	-	100.0%	-	100.0%	-	100.0%	-	100.0%	-	100.0%	1	100.0%
Total-	**14,556**	**-**	**1,134**	**-**	**1,060**	**-**	**44,926**	**-**	**947**	**-**	**1,018**	**-**	**18,069**	**-**	**818**	**-**	**1,132**	**-**

Appendix A4.–Computer files used to estimate spawning abundance of sockeye and coho salmon and coho harvest in Salmon Lake 2001-2003.

File Name	Description
1Overtc.exe	Program to estimate variance of adipose fin clipped mark fraction
WinBUGS1.4.exe	Program to approximate bootstrap distributions of parameter estimates
2001_Salmon_Lake.xls	Excel Spreadsheets containing raw data from weir and recapture events and information on each Salmon Lake sockeye and coho sampled including age, length, and sex in 2001
2001_Sockeye_Coho_KS_Tests.xls	Excel Spreadsheet detailing Kolmogorov-Smirnov size-selectivity tests for Salmon Lake Coho and Sockeye in 2001
2001_Hyrroacoustic_Data	Excel Spreadsheet with raw hydroacoustic data from Salmon Lake 2001
2001_Coho_Bias.xls	Excel Spreadsheet with Salmon Lake coho diagnostic tests and escapement estimate 2001
2001_5x4Sock_SPAS.out	Data file containing data on Salmon Lake sockeye salmon in 2001 used in SPAS.exe
2001_5x4Sock_SPAS.dat	Output from SPAS.exe on Salmon Lake sockeye in 2001
2002_Salmon_Lake.xls	Excel Spreadsheets containing raw data from Salmon Lake weir and recapture events and information on each sockeye and coho sampled including age, length, and sex in 2002
2002_Sockeye_Coho_KS_Tests.xls	Excel Spreadsheet detailing Kolmogorov-Smirnov size-selectivity tests for Salmon Lake Coho and Sockeye in 2002
2002_Salmon_Lake_Sockeye_Coho_ Estimators_and_Tests	Excel spreadsheet with Salmon Lake sockeye and coho escapement estimates and diagnostic tests in 2002
2002_Hyrroacoustic_Data	Excel Spreadsheet with raw hydroacoustic data from Salmon Lake 2002
2003_Sockeye_Coho_KS_Tests.xls	Excel Spreadsheet detailing Kolmogorov-Smirnov size-selectivity tests for Salmon Lake Coho and Sockeye in 2003
2003_Coho_Estimate.xls	Excel spreadsheet with Salmon Lake coho raw data and escapement estimate in 2003
2003_Coho_Estimate_Bias_Tests.xls	Excel spreadsheet with 2003 Salmon Lake coho diagnostic tests for escapement estimate
2003_Salmon_Lake_Coho_Harvest	Excel Spreadsheet with 2003 data from coho salmon in sampled sport and commercial marine fisheries, estimated harvest, and returns of coded wire tags originating from Salmon Lake
2003_Deep_Inlet_Coho_Harvest.xls	Excel spreadsheet raw data from Deep Inlet coho fishery sampling, fish ticket information, and coho harvest estimate in 2003
2003_Sockeye_Estimate.xls	Excel spreadsheet with Salmon Lake sockeye raw data and escapement estimate in 2003