Fishery Data Series No. 01-14

Production of Coho Salmon from the Unuk River, 1999–2000

by

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and

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August 2001

Alaska Department of Fish and Game **Division of Sport Fish**

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
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
Inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

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

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
And	&
At	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
Exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

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ABSTRACT

In 2000, a full stock assessment study of coho salmon *Oncorhynchus kisutch* was conducted on the Unuk River near Ketchikan, Alaska. A smolt coded-wire-tagging and an adult mark-recapture study were conducted to estimate a number of population parameters. Information based on recoveries of adult coho salmon with coded wire tags placed in smolt during the spring of 1999 was used to estimate smolt abundance and adult exploitation rate and production from the Unuk River. Baited G-40 minnow traps were fished daily on the Unuk River from 8 April through 1 May 1999. During this period, 10,877 coho salmon smolt ≥70 mm fork length (FL) were marked with valid coded wire tags having code 04-01-43. Sampled smolt averaged 87 mm FL and 5.7 g in weight. In 2000, 72 adult coho salmon were recovered bearing coded wire tags, 71 of which were random fishery recoveries. These random recoveries represent an estimated harvest of 14,541 (SE = 3,303) coho salmon in U.S. marine waters. Of this harvest, the troll fishery took an estimated 65%, drift gillnet fisheries took 16%, purse seine fisheries took 13%, and recreational fisheries took 6%. An estimated 15,677 (SE = 5,167) adults escaped into the Unuk River, as determined by a mark-recapture study coupled with a radiotelemetry study, and 69 fish were considered handling mortalities as a result of the mark-recapture experiment. Estimated total run (i.e., escapement, harvest, and inriver handling mortality) in 2000 for all coho salmon bound for the Unuk River was 30,287 (SE = 6,132); marine exploitation rate on this run was estimated at 48% (SE = 9.9%). Smolt abundance in 1999 was 802,762 (SE = 252,342), determined using Chapman's modification of the Peterson estimator, and the estimated marine survival rate was 3.8% (SE = 1.4%).

Key words: coho salmon, *Oncorhynchus kisutch*, Unuk River, harvest, troll fishery, seine fishery, drift gillnet fishery, recreational fishery, mark-recapture, radiotelemetry, escapement, total run, exploitation rate, marine survival

INTRODUCTION

The Unuk River originates in a heavily glaciated area of northern British Columbia and flows for 129 km where it empties into Burroughs Bay 85 km northeast of Ketchikan, Alaska; the lower 39 km of the river are in Southeast Alaska (Figure 1). The percentage of coho salmon *Oncorhynchus kisutch* production originating from the Canadian portion of the river has not been estimated directly; however, information gathered during the first two years of study indicates that at least 25% of the production likely occurs in Canada (Jones et al. 1999, 2000). Field observations from juvenile coded-wire-tagging (CWT) projects lead us to believe that most rearing takes place in the lower 39 km of the river (Dave Magnus, Alaska Department of Fish and Game, Juneau, personal communication), yet no substantial trapping has occurred above the border. The primary spawning tributary within Canada is at Boundary Lake, located approximately 2 km upriver of the border. While this lake itself offers rearing habitat, any movement by juvenile fish out of the lake and downriver will essentially mean the fish have moved into the U.S. portion of the Unuk. Several coho salmon systems are surveyed annually for estimates of spawning abundance. One such system is the Eulachon River, the lowermost spawning tributary on the Unuk River, and the only one surveyed annually for spawning abundance. Peak counts of coho salmon spawning abundance in the Eulachon River have ranged from 235 to 860 fish with an average of 487 fish since 1990.

We first placed CWTs on coho salmon in the Unuk River in 1983 and continued through 1986 (Hubartt and Kissner 1987). These efforts, combined with recent efforts (1996–2000), indicate that Unuk River coho salmon contribute significantly to commercial and recreational fisheries in Southeast Alaska. Coho salmon returning to the Unuk River swim through the commercial troll fishery in Southeast Alaska and then through the commercial seine and drift gillnet fisheries. They also contribute to the recreational fisheries in Sitka and Ketchikan before entering the Unuk River (Figure 2). There is also a small freshwater sport fishery on the Unuk River in which approximately 100 coho salmon are harvested annually. In 1998 and 1999, coho salmon originating from the Unuk River produced total runs of 57,811 and 55,147

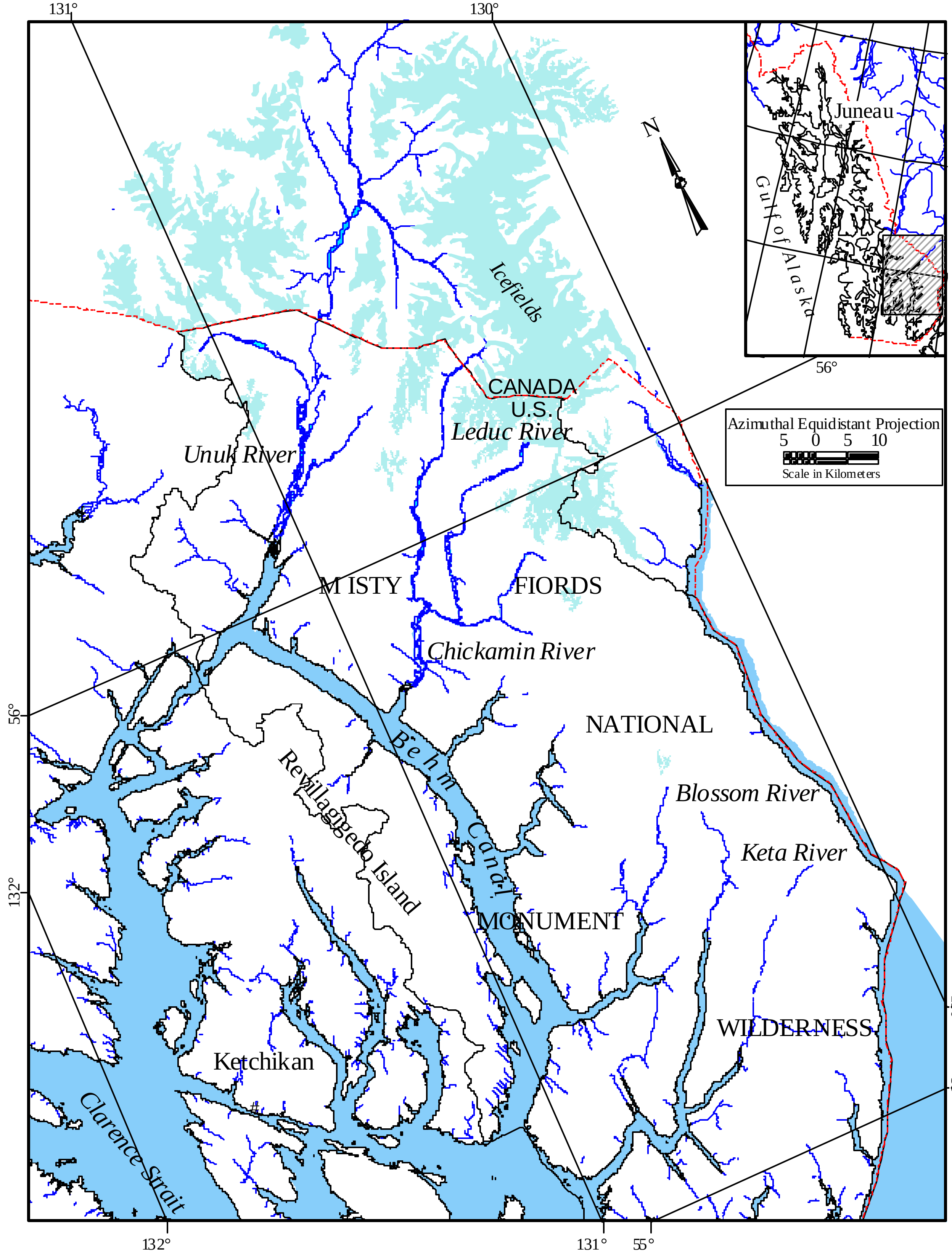

Figure 1.–Behm Canal area in Southeast Alaska and location of major coho salmon systems.

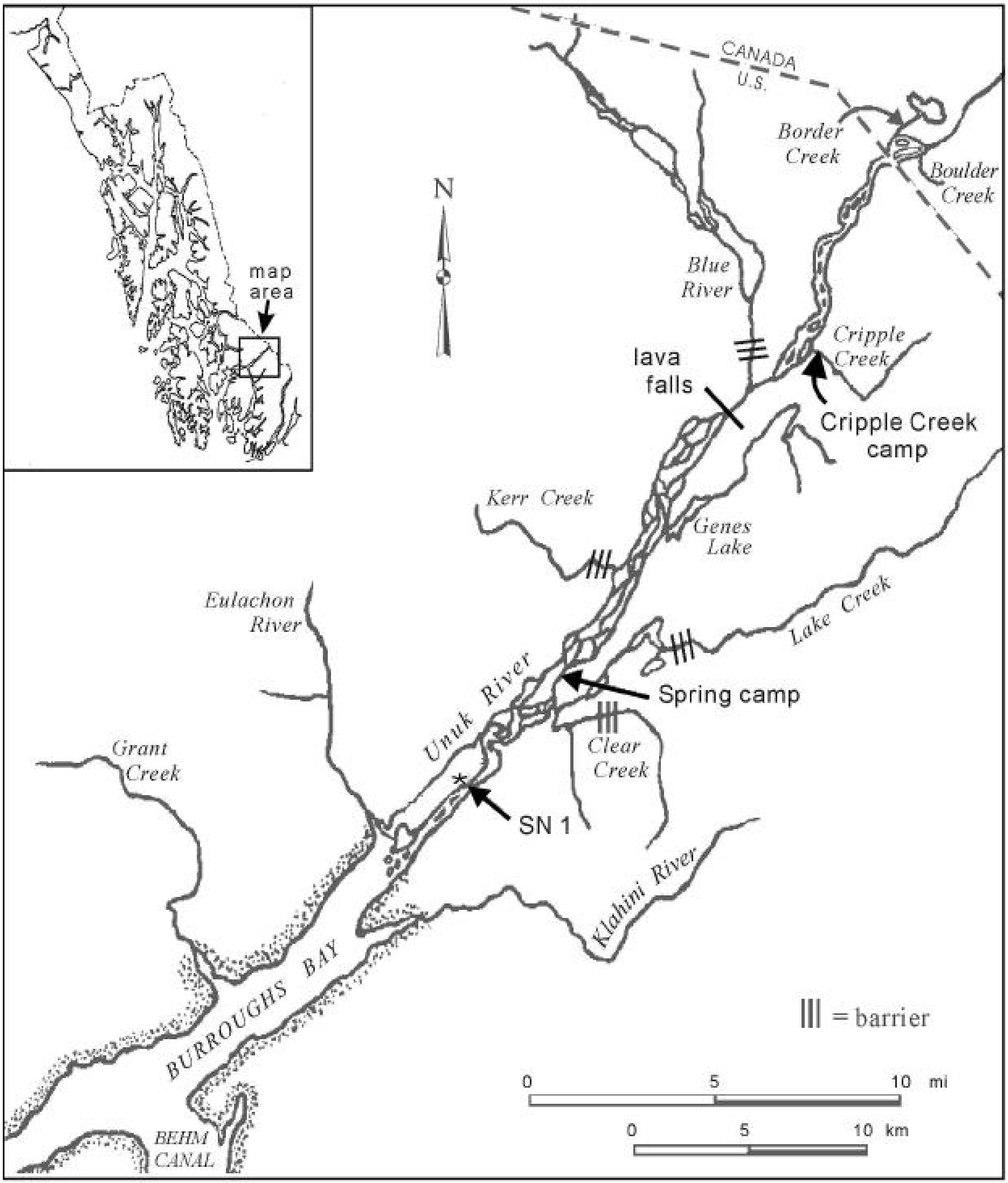

Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to salmon migration, and location of ADF&G research sites.

adult coho salmon and contributed an estimated 7.3% and 2.2% of the District 101 gillnet catch and 19.5% and 4.3% of the Ketchikan marine recreational fishery (Jones et al. 1999, 2000). This is the third year of a full stock assessment study designed to estimate production of coho salmon from the Unuk River. The objectives of the 1999–2000 study were to estimate the following fishery parameters: (1) abundance, mean length, and age composition of coho salmon smolt leaving the Unuk River in 1999; (2) harvest of adult coho salmon intercepted in the fisheries that were bound for the Unuk River in 2000; and (3) escapement and age composition of returning adult coho salmon in 2000. These objectives were accomplished by tagging and sampling smolt in the spring of 1999 and through the operation of an adult coho salmon mark-recapture study in 2000.

METHODS

SMOLT CAPTURE, CODED-WIRE-TAGGING, AND LENGTH-WEIGHT SAMPLING

Between 20 and 125 G-40 minnow traps, baited with salmon roe, were fished daily for 24 hours from 8 April to 1 May between approximately river km 10 and 26 along both sides of the Unuk River. Traps were located along mainstem banks and in some backwater areas, depending on river levels. Minnow traps were checked daily when water levels were stable and more frequently when water levels were unstable. Two teams consisting each of two personnel were used to set and fish traps on a regular basis. Generally, one crew was responsible for traps set upstream of Spring Camp located at river km 14 and one crew was responsible for traps downstream of camp. Early in the season, water levels were low and ice and snow restricted fishing to the mainstem banks. These conditions slowly changed within the first few weeks, and after that time, most suitable habitat was accessible.

Juvenile fish were removed from minnow traps during each visit, transported to holding pens at camp, and CWTd each day. Coho and chinook salmon *O. tshawytscha* smolt were separated by inspection from other species of salmon and Dolly Varden *Salvelinus malma*. Smolt were carefully examined and separated by species, using a combination of external morphological characteristics. A lack of pigmentation, or a clear 'window' in the adipose fin (Meehan and Vania 1961; McConnell and Snyder 1972), indicates a chinook salmon smolt whereas a coho salmon smolt has a mottled or speckled adipose fin. In addition, chinook salmon smolt generally appear silvery when viewed from the side in contrast to coho salmon smolt which are often darker and purplish. In addition, coho salmon smolt have narrower par marks, a greater number of small, darkly pigmented spots when viewed dorsally, and have longer anterior rays on their anal fins (Pollard et al. 1997). All live coho salmon smolt ≥70 mm FL were tranquilized in a water solution of tricain methane-sulfonate (MS 222) buffered with sodium bicarbonate. To alleviate stress on fish, effort was made to keep the MS 222 solution at a constant river temperature by frequent water changes, and tranquilized fish were kept at small numbers for quick sampling and tagging. All fish were tagged with a CWT and externally marked by removal of the adipose fin as described in Koerner (1977). All chinook salmon smolt =50 mm FL were also tagged but with different tag codes.

Tagged fish were held overnight and then released the following morning after being checked for tag retention and mortality. The number of fish tagged, number of holding pen mortalities, and the number of fish that had shed their tags were compiled and recorded on *ADF&G CWT Tagging Summary and Release Information Form*. These forms are submitted to the Commercial Fisheries Division (CFMD) Tag Lab in Juneau after the field season. Length and weight composition of emigrating coho salmon smolt in 1999 was estimated by systematically sampling every 25th smolt captured. Each sampled smolt was measured to the nearest mm FL and weighed to the nearest 0.1 g.

ESTIMATE OF SMOLT ABUNDANCE

Abundance of Unuk River coho salmon smolt in 1999 was estimated with a two-event mark-recapture study using Chapman's modification of the Petersen estimate (Chapman 1951):

$$\hat{N}_s = \frac{(n_c+1)\,(n_e+1)}{(m_a+1)} - 1 \qquad (1)$$

$$\mathrm{var}\left[\hat{N}_s\right] = \frac{(n_c+1)(n_e+1)(n_c-m_a)(n_e-m_a)}{(m_a+1)^2(m_a+2)} \quad (2)$$

where N_s is number of smolt emigrating in 1999, n_c is the number of smolt tagged in 1999, n_e the number of adults sampled during Event 1 in 2000, and m_a the number of adults in that sample missing adipose fins. The general assumptions (Seber 1982) that must hold for $\hat{N}$ to be a suitable estimate of abundance follow:

(a) every fish has an equal probability of being marked in Event 1, or every fish has an equal probability of being captured in Event 2, or marked fish mix completely with unmarked fish;

(b) both recruitment and death (emigration) do not occur between sampling events;

(c) marking does not affect the catchability of an animal;

(d) animals do not lose their marks in the time between the two events;

(e) all marks are reported on recovery in Event 2; and

(f) double-sampling does not occur.

The validity of these assumptions is evaluated in the Discussion section below.

RADIOTELEMETRY

In 2000, the rate of mortality associated with capturing, handling, and marking mature coho salmon using set gillnets was estimated by means of a radiotelemetry study. Between 28 August and 2 October, Advanced Telemetry Systems (ATS) radio transmitters (150-151 MHz) were inserted esophageally into the stomachs (Eiler 1990) of healthy adult coho salmon. Radio tags were placed in one out of approximately every 15 coho salmon captured in the set gillnet in an effort to distribute them in proportion to the immigration. Every fish that received a radio transmitter was also tagged with a spaghetti tag, given secondary marks, and sampled for age, sex, and length (ASL).

Aerial tracking flights were conducted 5 and 19 September and 3 and 24 October to locate each radio transmitter. The pilot and an experienced member of the crew surveyed the entire U.S. portion of the Unuk River and as far into Canada as river km 56 searching for transmitters. In addition to aerial surveys, two remote radio towers were placed just upstream of camp on each bank directly across from the other at approximately river km 15. Radio tagged fish that swam past these towers were recorded on remote data loggers. The radio towers were constructed and operated as described in Eiler (1995), except that they did not have satellite uplink capabilities. A reference tag was used to check whether or not each tower was operational and data loggers were checked periodically for the indication of fish movement. Fates of the radio tagged fish were determined by whether they were tracked upstream of the tagging site above river km 6 or to the Eulachon River by aerial survey or by a positive reading at one of the radio towers. Fish “not found” by either method or located below the set gillnet site (SN1; Figure 3, 4), or located outside the system, were considered mortalites.

ESTIMATE OF ESCAPEMENT

A two-event mark-recapture study was used to estimate the escapement of adult coho salmon into the Unuk River in 2000. In Event 1, fish were captured in the lower river at SN1 in set gillnets between 3 August and 7 October. Gillnets were 37 m (120 ft) long by 4 m (14 ft) deep with 14 cm (5? ?) stretch mesh. In the 1998 and 1999 coho salmon studies (Jones et al. 1999, 2000) and in previous studies on chinook salmon (Jones et al. 1998; Jones and McPherson 1999, 2000), sufficiently high numbers of fish have been caught by using gillnets fished at SN1. SN1 is located on the south channel of the lower Unuk River at approximately river km 3 and is downstream of all known coho salmon spawning tributaries, with the exception of the Eulachon River (Figure 3). Later, during Event 2, fish were sampled on the spawning grounds for primary and secondary marks and sampled for ASL using a variety of gear types.

In Event 1, a two-member crew fished set gillnets at SN1 (Figure 4) six hours per day, six days per week. One net (a cross net) was attached to the

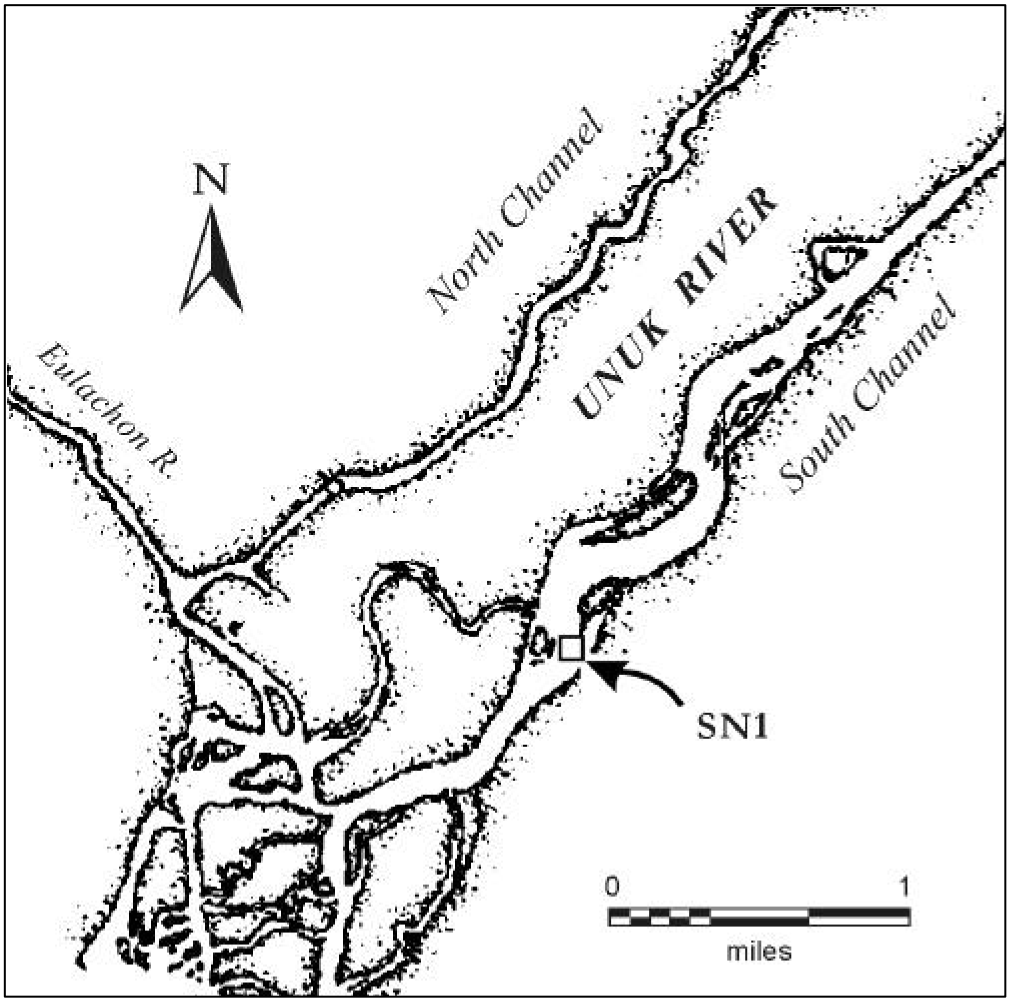

Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River in 2000.

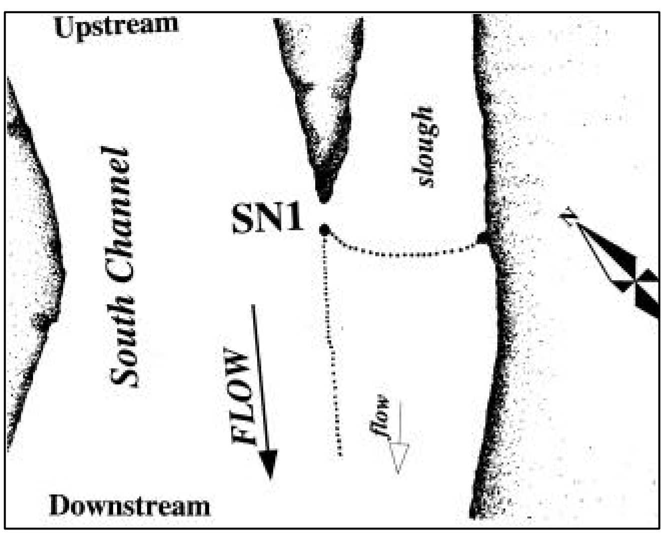

Figure 4.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River in 2000.

shore and ran directly across a small slough to a fixed buoy placed just downstream of a small island (perpendicular to the main flow of the Unuk River). Another net (a lead net) was attached to the same buoy and fished downstream along the eddy line created between the mainstem flow and the side slough.

All fish captured, regardless of condition and not including recaptures, were sampled for age, sex, and length (ASL) prior to their release. Length in MEF was measured to the nearest 5 mm and sex was determined from secondary maturation characteristics. Four scales approximately 2 cm apart were taken from the preferred area on the left side of the fish. The preferred area is two to three rows above the lateral line and between the posterior terminus of the dorsal fin and the anterior margin of the anal fin (Scarnecchia 1979). Scales were mounted on gum cards capable of holding scales from ten fish as described in ADF&G (1993). The age of each fish was later determined from the pattern of circuli as seen on images of scales impressed into acetate cards (Clutter and Whitesel 1956; Moser 1968) under 70 power magnification. Fish missing adipose fins were noted as such and then sacrificed by having their heads removed and sent to the Tag Lab in Juneau for detection and decoding of the CWTs.

Each captured fish possessing an adipose fin and not previously sampled was given three different marks: a uniquely numbered solid-core spaghetti tag, a clip of the left axillary appendage (LAA), and a left upper operculum punch (LUOP) ¼? in diameter. The two secondary marks enable detection of primary tag loss. The spaghetti tag (primary tag) consisted of a 5.71-cm (2¼?) section of laminated Floy tubing shrunk onto a 38-cm (15?) piece of 80-lb test monofilament fishing line. The monofilament was sewn through the back just behind the dorsal fin and secured by crimping both ends of the monofilament in an aluminum line crimp and excess line was cut off. Each spaghetti tag was printed with an individual number and an ADF&G contact phone number.

In Event 2, salmon were sampled for the presence of spaghetti tags and secondary marks on the spawning grounds, specifically at the Eulachon River, Lake, Boundary, Hell Roaring, Gene's Lake, Kerr, and Clear creeks, and Cutthroat, Grizzly, and Rock Face sloughs located (Figure 2). Various gear types, such as rod and reel snagging, bait and lures, and pieces of gillnet were used to sample fish. The use of multiple gear types has been shown to reduce bias in estimates of age, sex, and length composition when sampling chinook salmon (Jones et al. 1998; Jones and McPherson 1999, 2000). All fish inspected during Event 2 were given a left lower operculum punch (LLOP) to prevent double-sampling of fish. Sampled fish were closely examined for the presence of adipose fins, the primary tag, LUOPs, LLOPs, and LAAs. All fish were sampled for ASL data using the same techniques applied at SN1.

Escapement of Unuk River coho salmon adults in 2000 was estimated by using Chapman's modification of the Petersen etstimate (Seber 1982):

$$\hat{N}_e = \frac{(\hat{n}_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \qquad (3)$$

where $\hat{N}_e$ is the number of adult coho salmon immigrating into the Unuk River in 2000, $\hat{n}_1$ is the estimated number of fish marked during Event 1 that immigrated into the river, n_2 is the number inspected for marks during Event 2, and m_2 is the number of n_2 that possessed marks applied during Event 1. To adjust for the loss of tags from the study area associated with Event 1 capture and tagging (i.e., determined by the radiotelemetry study), $\hat{n}_1$ was estimated:

$$\hat{n}_1 = n_1(1 - \hat{y}) \qquad (4)$$

where $\hat{y}$ is the loss of tags expressed as a proportion. The general assumptions of the Petersen estimate are shown above, under the Estimate of Smolt Abundance section. To provide evidence that assumption *a* was met, two ?² tests were performed: (1) for equal marked fractions by sampling location in Event 2; and (2) equal probabilities of recapture in Event 2 independent of the stratum of origin. If the null hypothesis of either test was accepted, the pooled Petersen estimator (equation 3) would be used to model the mark-recapture data;

otherwise a temporally or spatially stratified estimator would be employed. Separate tests were made with the SPAS software program (Arnason et al. 1996). We also tested the hypothesis that the marked fraction sampled in Event 2 did not vary with time. If this were the case, stratification of the experiment by time might be appropriate if the first ?² test above was rejected.

The possibility of size- and sex-selective sampling was also investigated, because assumption *a* can be violated in this manner. We tested the hypothesis that fish of different sizes were captured with equal probabilities by using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.1$) (Appendix A1). We investigated the possibility of sex-selective sampling by using a ?² test to compare the number of males and females caught in the lower river to those caught on the spawning grounds. If significant differences in recorded sex compositions were observed, the abundance estimate could be further stratified by sex to reduce bias. If sex compositions differed significantly, either marking or spawning ground samples alone could be used to estimate sex composition, although sex determination is known to be more difficult early in the season while marking fish (Ericksen 1998).

Because sampling in the lower river spanned the known immigration of coho salmon into the Unuk River and continued without interruption, the study is essentially closed to recruitment (assumption *b*). Assumption *c* was tested using a radiotelemetry study described earlier in the Radiotelemetry section. The effect of tag loss (assumption *d*) is virtually eliminated by using the two secondary marks, and all fish captured during Event 2 were inspected for all marks (assumption *e*). Double sampling (assumption *f*) was avoided by marking all fish captured in Event 2 with the LLOP.

Variance, bias, and confidence intervals for $\hat{N}_e$ were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991). First, a stochastic value for $\hat{n}_1$ was obtained by drawing a value for $\hat{q} = (1-\hat{y})$ using the distribution binomial (t; s, $\hat{q}$), where t is the number of radios associated with successful spawning and s is the sample size (= 39) to compute $\hat{q} = t/s$.

Table 1.–Capture histories for coho salmon in the population spawning in the Unuk River in 2000 (notation explained in text)**.**

Capture history	Sample size	Source of statistics
Number that died due to capture and tagging	69	$n_1\hat{y}$
Marked and not sampled in tributaries	376	$\hat{n}_1 - m_2$
Marked and recaptured in tributaries	11	m_2
Not marked, but captured in tributaries	473	$n_2 - m_2$
Not marked and not sampled in tributaries	14,817	$\hat{N}_e - \hat{n}_1 - n_2 + m_2$
Effective population for simulations	15,746	$\hat{N}_e^+ = \hat{N}_e + n_1\hat{y}$

Then a bootstrap sample was drawn with replacement from a sample of size $\hat{N}_e^+$ using the empirical distribution defined by the capture histories (Table 1).

A new set of statistics was generated from each bootstrap sample $\{\hat{n}_1^*, n_2^*, m_2^*\}$, along with a new estimate for abundance $\hat{N}_e^*$. One thousand such bootstrap samples were drawn, creating the empirical distribution $\hat{F}(\hat{N}^*)$, which is an estimate of $\hat{F}(\hat{N}_e)$. The difference between the average $\hat{N}_e^*$ of bootstrap estimates and $\hat{N}_e$ is an estimate of statistical bias in the latter statistic (Efron and Tibshirani 1993, Section 10.2). Confidence intervals were estimated from $\hat{F}(\hat{N}_e^*)$ with the percentile method (Efron and Tibshirani 1993, Section 13.3). Variance was estimated as

$$\mathrm{var}(\hat{N}_e^*) = (B-1)^{-1}\sum_{b=1}^{B}(\hat{N}_{eb}^* - \overline{\hat{N}}_e^*)^2 \qquad (5)$$

where B is the number of bootstrap samples.

AGE, SEX, AND LENGTH COMPOSITION

The proportion of the spawning population ($\hat{N}_e$) composed of a given age was estimated as a binomial variable from fish sampled during Event 1 by set gillnets:

$$\hat{p}_j = \frac{n_j}{n} \qquad (6)$$

$$\text{var}(\hat{p}_j) = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1} \qquad (7)$$

where $\hat{p}_j$ is the estimated proportion of the sample of age j, n_j is the number of coho salmon of age j, and n is the number of coho salmon sampled during Event 1 that were successfully aged.

Sex composition and age-sex composition for the escapement and its associated variances were also estimated with the equations above by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes gender (male or female), such that $\sum_k \hat{p}_k = 1$, and by age-sex $\hat{p}_{jk}$, such that $\sum_{jk} \hat{p}_{jk} = 1$. Average lengths by age and sex were calculated using standard procedures.

ESTIMATE OF HARVEST

The harvest of coho salmon in 2000 originating from the Unuk River was estimated from catch samples in the U.S. and Canadian marine commercial and U.S. recreational fisheries and from the escapement. Because several fisheries harvested coho salmon bound for the Unuk River over several months in 2000, 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 drift gillnet and seine fisheries were stratified by week and by fishing district. Statistics from the recreational fishery were stratified by fortnight. Estimates of harvest $\hat{r}_i$ were calculated for each stratum and summed across strata and across fisheries to obtain an estimate of the total $\hat{T}$:

$$\hat{T} = \sum_i \hat{r}_i \qquad (8)$$

$$\text{var}[\hat{T}] = \sum_i \text{var}[\hat{r}_i] \qquad (9)$$

Variance of the sum of estimates was estimated as the sum of variances across strata, because sampling was independent across strata and across fisheries. A subset n_i of the catch (H) in each stratum was counted and inspected to find fish missing their adipose fins. Of those a_i salmon in this sample without the adipose fin, heads were retrieved from a subset, marked, and sent to Juneau for dissection. Of the a_i' heads that arrived in Juneau, all were passed through a magnetometer to detect a CWT. Of the t_i tags detected, t_i' were successfully decoded under a microscope, after dissection of which m_i had come from the Unuk River. Oliver (1990) and Hubartt et al. (1999) present details of sampling commercial and recreational fisheries, respectively. The marked fraction with tags that returned to the Unuk River was estimated as $q_h = m_e / n_e$, where m_e is the number of adults sampled at SN1 in 2000 that possessed valid detectable CWTs, and n_e is the total number of adults sampled at SN1 in 2000. Information from catch and field sampling programs was expanded to estimate harvest and the associated variance of coho salmon bound for the Unuk River for each stratum, using methods and equations from Bernard and Clark (1996, Table 2).

MEAN DATE OF HARVEST

Estimates of the mean dates of harvest for commercial and sport fisheries were calculated from the time series of estimated proportions of catches by strata within a fishery following the methods of Mundy (1982)

$$\hat{P}_d = \frac{\hat{H}_d}{\sum_i H_i} \qquad (10)$$

where P_d is the fraction of Unuk River coho salmon in a fishery on day d. The mean date of harvest $\bar{d}$ in each fishery was calculated as

$$\hat{\bar{d}} = \sum_d d\hat{P}_d \qquad (11)$$

ESTIMATES OF TOTAL RUN, EXPLOITATION, AND MARINE SURVIVAL

Estimates of total run (i.e., harvest and escapement) for coho salmon returning to the Unuk River in 2000 and the associated exploitation rate in commercial and sport fisheries are based on the sum of the estimated harvest and escapement

$$\hat{N}_R = \hat{T} + \hat{N}_e \tag{12}$$

The variance of the estimated run was calculated as the sum of the variances for estimated escapement and harvest:

$$\text{var}[\hat{N}_R] = \text{var}[\hat{T}] + \text{var}[\hat{N}_e] \tag{13}$$

The estimate of exploitation rate was calculated as

$$\hat{U} = \frac{\hat{T}}{\hat{N}_R} \tag{14}$$

$$\text{var}[\hat{U}] \approx \frac{\text{var}[\hat{T}]\hat{N}_e^2}{\hat{N}_R^4} + \frac{\text{var}[\hat{N}_e]\hat{T}^2}{\hat{N}_R^4} \tag{15}$$

The estimated survival rate of smolt to adults was calculated using

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \tag{16}$$

$$\text{var}[\hat{S}] \approx \hat{S}^2 \left[\frac{\text{var}[\hat{N}_R]}{\hat{N}_R^2} + \frac{\text{var}[\hat{N}_s]}{\hat{N}_s^2} \right] \tag{17}$$

Variances in equations (14) and (16) were approximated by the delta method (Seber 1982).

RESULTS

SMOLT CAPTURE, CODED-WIRE-TAGGING, AND SAMPLING

From 8 April to 1 May 1999, 10,888 coho salmon smolt ≥ 70 mm FL were captured and tagged with CWT code 04-01-43. These fish were held overnight for 24 h then tested the following morning for mortality and presence of valid tags. Numbers of coho salmon smolt tagged increased slowly over time, with peak numbers occurring on 17, 23, and 26 April (Table 2; Figure 5). The water level remained stable until 12 April, after which time snow melt and associated runoff increased dramatically during a warm spring rain. The water steadily rose until 19 April and then continued to taper off thereafter. The water temperature remained consistent but dropped dramatically at the same time the water level began to rise due to spring runoff on 12 April. Shortly thereafter the water temperature stabilized and remained consistent throughout the duration of the study (Table 2). Of the coho salmon smolt tagged, 11 overnight mortalities were seen and none had lost their tags; in total, 10,877 valid tags were released (Table 2; Figure 5). Tagged coho salmon smolt length averaged 87 mm FL; weight averaged 6.5 g (Table 2; Figure 6).

In addition, 7,954 chinook salmon smolt were captured and tagged with CWT code 04-01-44; six died overnight and none lost their tags, for a total of 7,948 valid tags released (Table 2; Figure 5). The average size of chinook salmon smolt tagged was 71 mm FL; weight averaged 3.7 g (Table 2; Figure 6). Detailed analysis of the chinook data will be reported in a separate document in future years.

ESTIMATE OF SMOLT ABUNDANCE

The fraction of fish with adipose finclips that returned to the Unuk River was estimated as $q_s = m_a / n_e$, where m_a is the number of adults sampled in the Unuk River in 2000 during Event 1 that possessed adipose finclips. The estimate of q_s was 0.0121 (SE = 0.004) and the estimate of smolt abundance $\hat{N}_s$ for 1999 is 803,762 (SE = 252,342). Both estimates are based on the 663 unique adult coho salmon handled during Event 1 and on the samples gathered above Lava Falls, which is located 25 km up the Unuk River, during Event 2 of the two-event mark-recapture study (Appendix A2). Eight (8) of the fish inspected were missing adipose fins, and all were sacrificed to determine the tag codes present; 8 contained valid Unuk River tags.

Table 2.–Number of salmon smolt caught and coded-wire-tagged using baited minnow traps on the Unuk River in 1999. Coho and chinook salmon totals include and estimated 0 and 54 shed tags, respectively.

		Coho salmon			**Chinook salmon**			**Water conditions**	
Date	**Traps checked**	Number	Avg. length (mm)	Weight (g)	Number	Avg. length (mm)	Weight (g)	Temp. (°C)	Depth (cm)
5-Apr	34								
6-Apr	52								
7-Apr	58								
8-Apr	58	532			1,344	69.31	3.64	4.0	5.5
9-Apr	55	279				66.68	2.94	4.0	4.8
10-Apr	43				617			4.0	4.5
11-Apr	14								
12-Apr	37	949	87.42	6.09	866			2.0	7.0
13-Apr	54								
14-Apr	51								
15-Apr	74								
16-Apr	29				2,330	72.68	4.13		9.0
17-Apr		1,502	86.12	5.13					
18-Apr	55								
19-Apr	12	590			310			4.0	26.0
20-Apr	33								
21-Apr	40								
22-Apr	57	660	84.63	5.13	519	68.50	3.26	3.0	22.0
23-Apr		1,621						4.0	22.0
24-Apr	52								
25-Apr									
26-Apr	46	1,582			544	69.64	3.42	4.5	22.0
27-Apr	56								
28-Apr	64		86.84	6.35		73.00	4.12		
29-Apr	25	1,387			656			4.0	22.0
30-Apr	52	1,086	89.95	7.28	430	71.76	3.91	4.0	19.0
1-May	52	699	85.68	6.83	334	77.75	5.13	4.0	18.0
Total tagged	1,103	10,887			7,950				
Max	74	1,621			2,330			4.5	26.0
Min	12	279			310			2.0	4.5
Average	46	990	86.47	6.51	795	70.57	3.73	3.8	15.1
Total weighed and measured:			328	328		267	267		
		SD	10.22	2.33		8.21	1.30		
		SE	0.56	0.13		0.50	0.08		

RADIOTELEMETRY

Thirty-three (33) fish were tagged with radio tags. These fish were tracked from the Eulachon River to river km 43 on the Unuk River in Canada (Figure 7; Appendix A4). Out of the 33 radio tags released, 28 fish were found in areas of the Unuk River (Appendix A4). Thus, we estimate $\hat{y}$ = 5/33 to adjust for the rate of mortality described in equation 4. Fifty-eight percent (58%) of the radio tagged fish were found in the main channel, 31% in Boundary Creek, 8% in the Eulachon River, and 4% in Kerr Creek. Twenty-five (25) fish were found passing river km 15 where the radio towers were located. Twenty (20) fish were recorded at the remote radio towers, and 21 were seen during

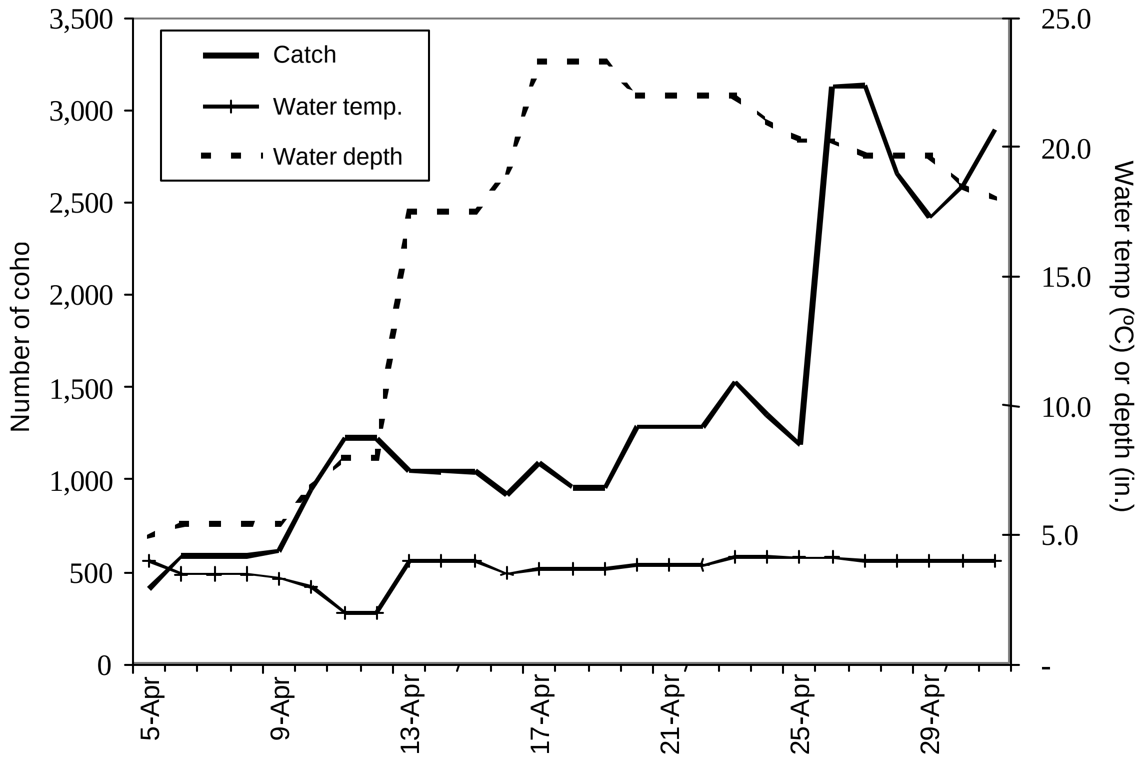

Figure 5.–Catch of coho salmon smolt ^{3}70 mm FL, daily water temperature, and water depth in the Unuk River in 1999.

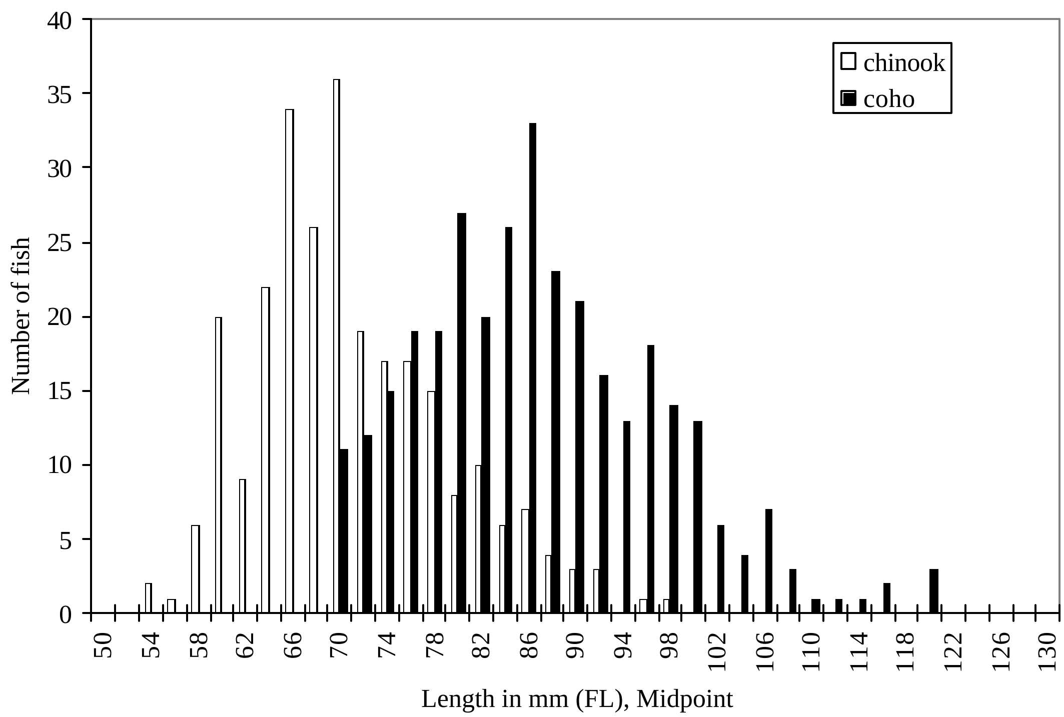

Figure 6.–Length frequency of coho salmon smolt ^{3}70 mm FL and chinook salmon smolt captured and measured in the spring in the Unuk River in 1999.

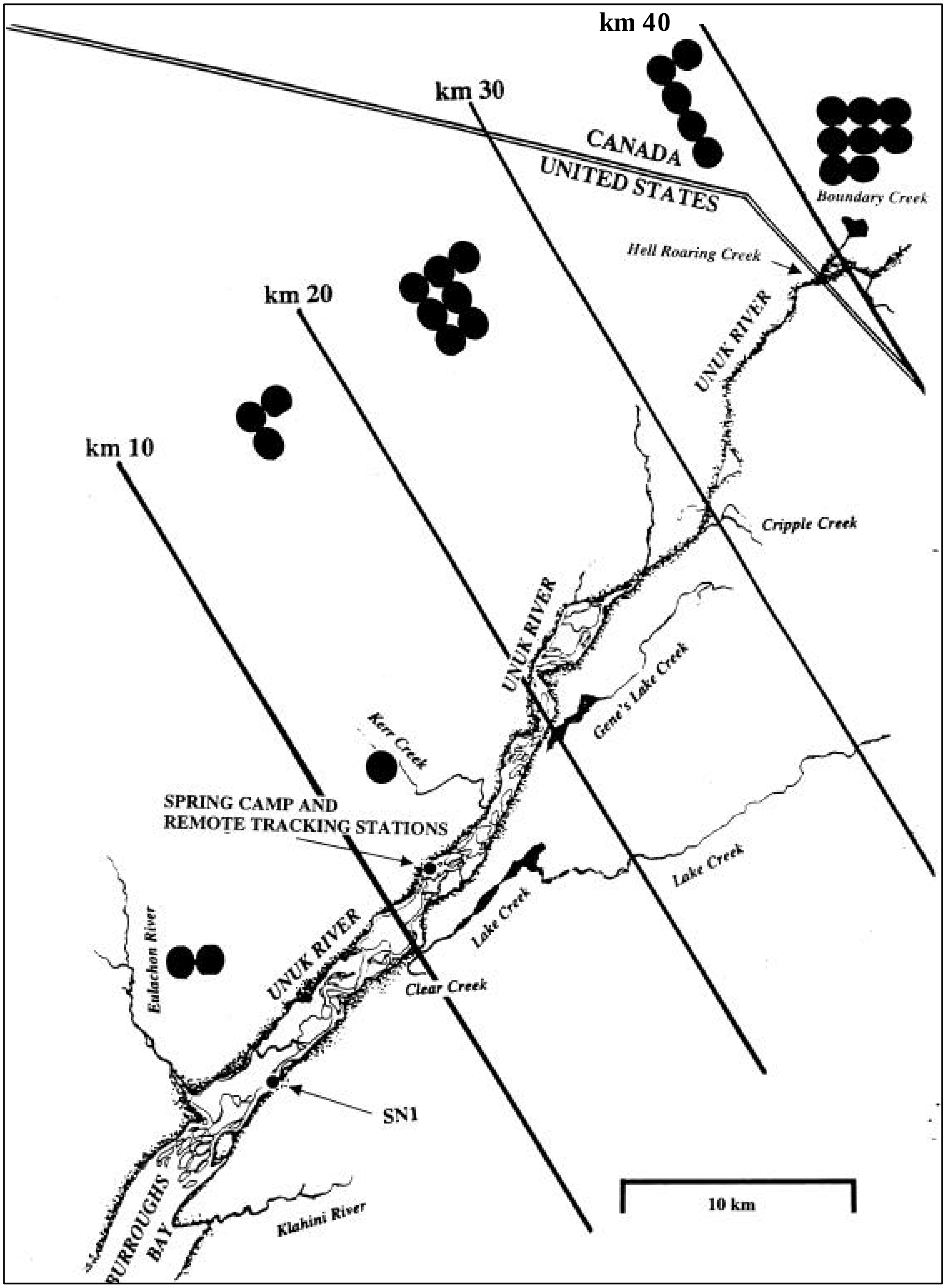

Figure 7.–Radiotelemetry index map showing the Unuk River (measured per 10 river km) and the main coho salmon spawning tributaries. Each circle refers to the farthest upstream location identified for a radio tagged fish in 2000; dots on top indicate mainstem spawning and dots below refer to spawning in tributaries.

aerial survey upriver of the radio towers. Twenty percent (20%) of the 20 fish recorded at the towers were never seen during an aerial survey; moreover, 24% of the 21 fish seen by aerial survey upriver of the towers were not recorded at the towers. Thus, neither tracking method is fail-safe. For the 5 fish that did not spawn in the Unuk River, 3 were located at or near SN1, 1 was tracked to the mouth of the Eulachon River, and 1 was not found at all.

ESTIMATE OF ESCAPEMENT

We captured 477 and 519 fish, respectively, in Events 1 and 2. Of these, only 1 fish in Event 1 and 35 fish in Event 2 were small fish (i.e., 450 mm MEF or less in length). To correct for this size-selective sampling difference, each event was truncated to exclude small fish; this yielded a total sample of 476 fish from Event 1 and 484 from Event 2.

Of the total coho salmon sampled during Event 1, 456 were tagged and released (n_1), and 387 were estimated to survive and spawn (Table 3). Ninety-five percent (95%) of the catch occurred between 26 August and 28 September (Figure 8). Twenty (20) fish were not tagged: 14 were in poor condition, 1 escaped, and 5 more were sacrificed for CWTs. Of the 5 fish sacrificed for CWTs in Event 1, all carried valid tags applied during smolt tagging operations on the Unuk River in the spring of 1999 (Appendix A2).

We sampled coho salmon by various methods during Event 2 at the Eulachon River and Lake, Boundary, Hell Roaring, Genes Lake, and Kerr creeks and Cutthroat, Grizzly, and Rock Face sloughs (Table 3). Of all fish sampled in Event 2, 484 were greater than 450 mm MEF in length. Of these fish, 11 possessed spaghetti tags applied during Event 1 and all 11 had easily identifiable secondary marks. The largest samples were obtained using various gear types at the Eulachon River (148 fish with 1 recovery), Lake Creek (119 fish with 5 recoveries), Boundary Creek (94 fish with 3 recoveries), and Hell Roaring Creek (81 fish with 2 recoveries). Fish were sampled 18 August through the 23 October (Figure 9). Nine (9) fish were missing adipose fins and were sacrificed, and all of these fish carried CWTs from smolt tagging on the Unuk River in 1999.

The length distributions for fish >450 mm MEF in length marked in Event 1 were not significantly different than the length distributions for fish recaptured in Event 2 (P = 0.61, Figure 10). Furthermore, the length distributions of marked

Table 3.–Number of marked coho salmon released in the lower Unuk River and recaptured, by marking period and recovery location, and number examined for marks at each recovery location, 2000.

Marking dates	Estimated number marked[a]	Estimated fraction recovered	RECOVERY LOCATION		
			Downriver	Upriver	Total
8/1 to 9/4	236	0.025	4	2	6
9/5 to 10/23	151	0.033	2	3	5
Total/Average	387	0.028	6	5	11
Number inspected			297	187	484
Fraction marked			0.020	0.026	0.022

[a] Number marked discounted by the rate of mortality (y = 5/33) as determined by the radiotelemetry study, to derive the actual number available for sampling during Event 2.

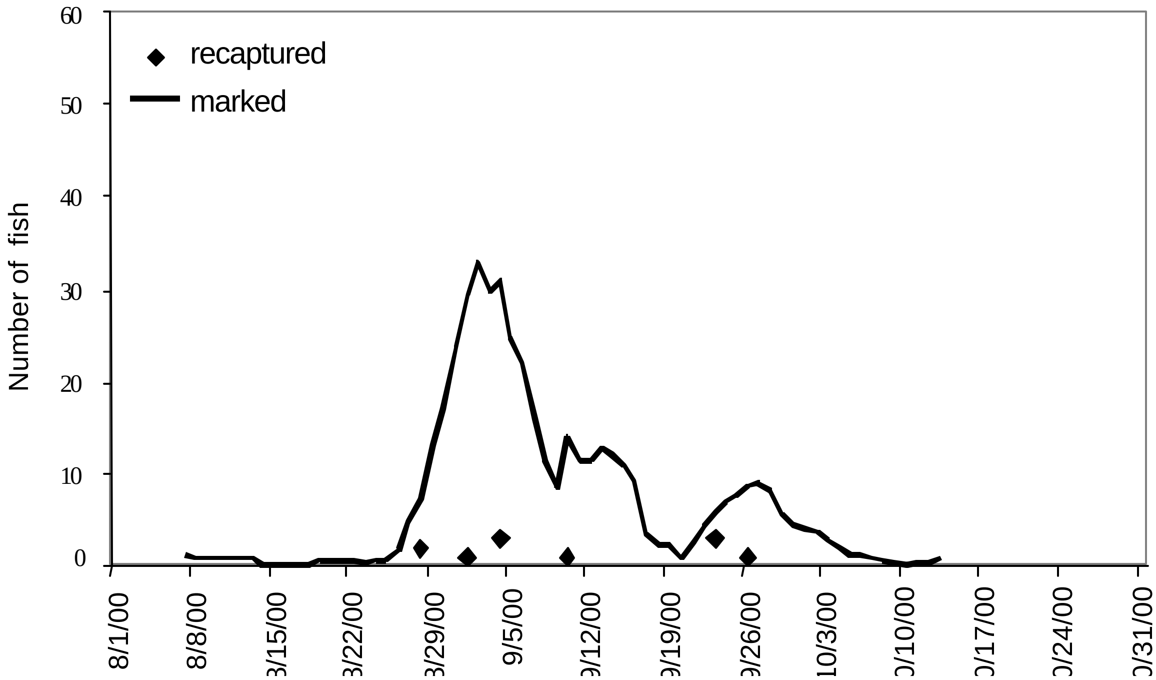

Figure 8.–Event 1 samples of coho salmon marked (line**) by date and the subset recaptured in Event 2 (**dots**) in the Unuk River in 2000.** There were 11 recaptures in 2000.

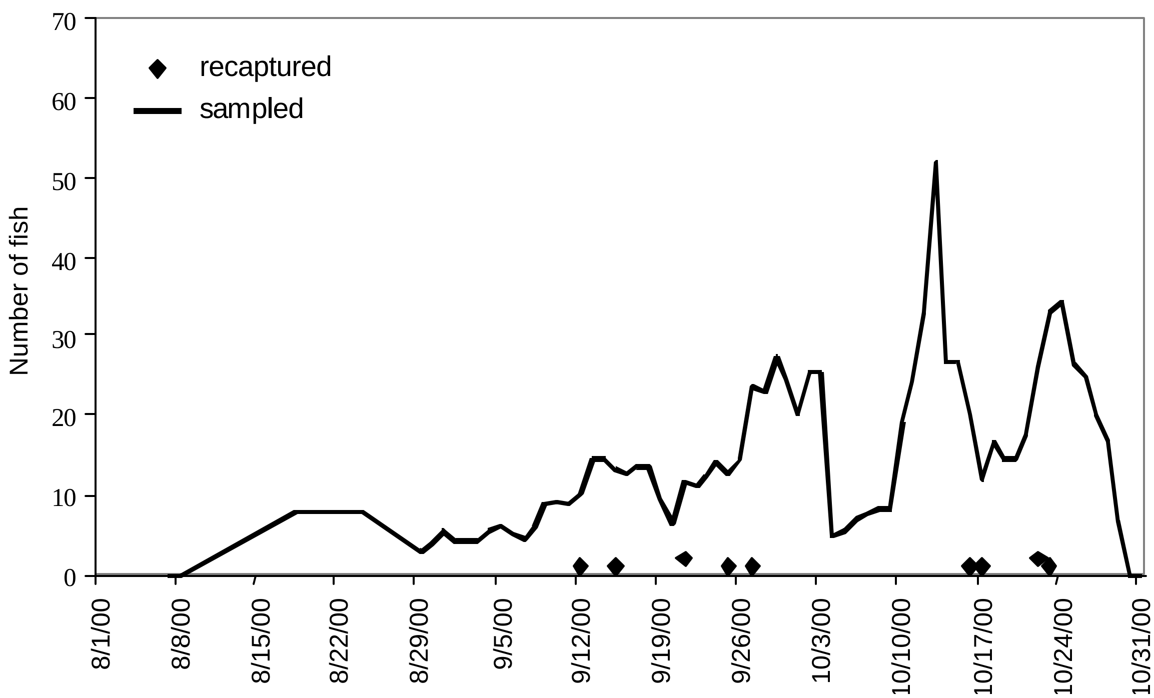

Figure 9.–Event 2 samples of coho salmon recaptured (dots**) and the weekly moving average sampled (**line**) by date.**

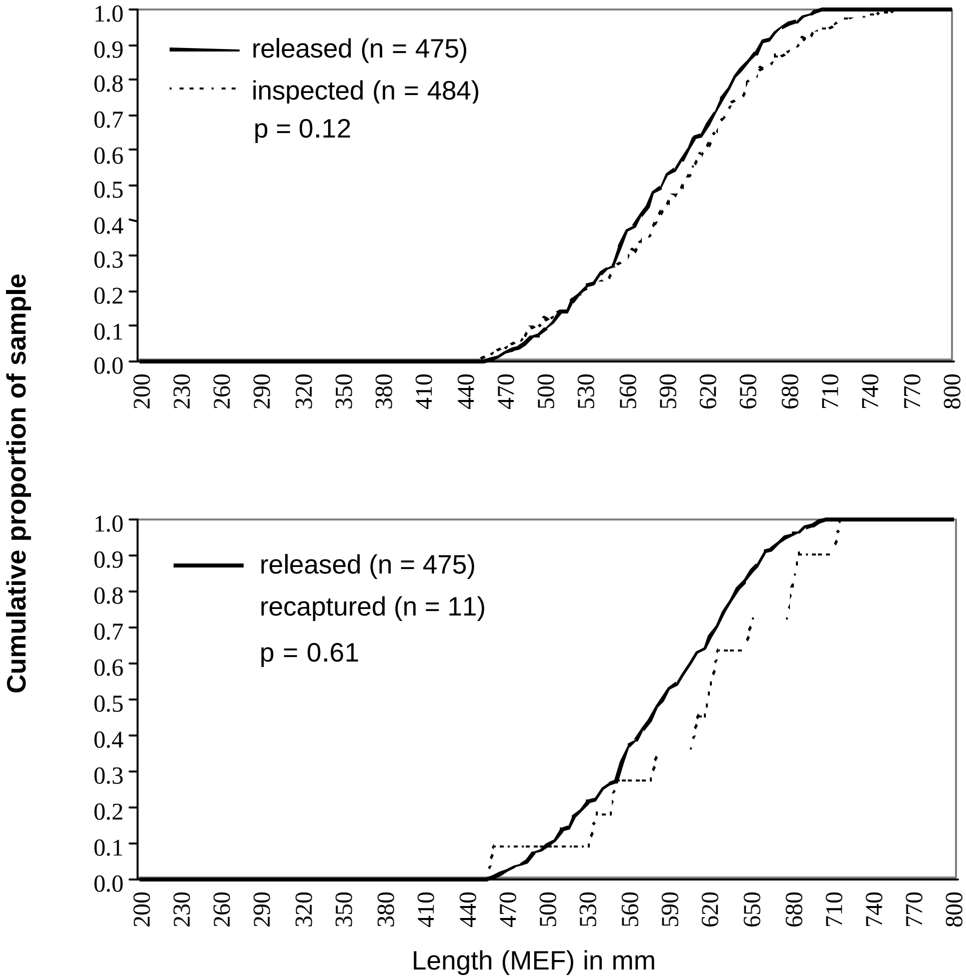

Figure 10.–Cumulative relative frequencies of adult coho salmon marked in the lower Unuk River in 2000 compared to those inspected and recaptured on the spawning grounds.

fish were marginally not significantly different than that of fish inspected on the spawning grounds (P = 0.12, Figure 10).

Coho salmon marked early in the experiment (before 4 September) and late in the experiment were equally likely to be recaptured (?^{2} = 0.19, df = 1, P = 0.66). Similarly, the recapture rate during Event 2 did not vary by sampling date (before or after 16 September; ?^{2} = 0.10, df = 1, P = 0.75), or sampling location (downstream or upstream—i.e., Eulachon River vs. Boundary, Lake, Gene's Lake, and Kerr creeks; ?^{2} = 0.22, df = 1, P = 0.64).

There is some indication that Event 2 sampling was not in proportion to abundance. For instance, 8% of the radio tagged fish were tracked to the Eulachon River; however, the Eulachon River constituted 29% of the total Event 2 sample. In addition, more than half of the radio tagged fish were tracked to mainstem spawning locations not sampled during Event 2.

Escapement was estimated using the Petersen model and the number of marked coho salmon (n_1 = 456) was discounted by the rate of mortality (y = 5/33) as determined by the radiotelemetry study to get the actual number of marked fish escaping ($\hat{n}_1$ = 387). Fish were divided into five capture histories (Table 1) and bootstrap procedures were performed to estimate variance, bias, and confidence intervals for $\hat{N}$. The estimated escapement of coho salmon in the Unuk River in 2000 was 15,677 (SE = 5,167). From bootstrapping, statistical bias in $\hat{N}$ was estimated at 4.6% and the 90% confidence interval for the estimate is 10,000 to 26,006 with a RP of ± 54%.

ESTIMATES OF AGE, SEX, AND LENGTH COMPOSITION

Tests for sex-selective sampling indicate that sex-selective sampling did not occur between events (?² = 0.02, df = 1, P = 0.88). No differences were found in the age composition between events (?² = 2.75, df = 1, P = 0.10). We found no reason to suspect disproportional sampling during Event 1, so Event 1 samples were used to estimate the age, sex, and length composition (Table 4). Of the 476 fish greater than 450 mm MEF sampled in Event 1, all but two had scales sampled and 410 (86%) were successfully aged.

Of the aged scales, 86% (SE = 1.7%) were age-1.1 and 14% (SE = 1.7%) were age-2.1. Males composed 59% (SE = 2.4%) of the aged sample in Event 1 (Table 4; Appendix A5). The largest fish sampled in Event 1 was 760 mm and the mean was 589 mm (SE = 3.1 mm) MEF in length. For the total run, an estimated 26,045 (SE = 5,298) were age-1.1 and 4,242 (SE = 999) were age-2.1; we estimated 17,785 (SE = 4,699) to be males (Table 4).

For comparison purposes, of the 484 fish greater than 450 mm MEF sampled in Event 2, all had scales sampled and 422 (87%) of those were successfully aged. Of the scales successfully aged, 82% (SE = 1.9%) were age-1.1 and 18% (SE = 1.9%) were age-2.1 and males consisted of 59% (SE = 2.4%) of the sample (Appendix A5). In Event 2, the largest fish sampled was 785 mm and the mean was 599 mm (SE = 3.4 mm) MEF in length (Appendix A5). For Events 1 and 2 combined, age-1.1 fish accounted for 84% (SE = 1.3%), age-2.1 fish for 16% (SE = 1.3%), and 59% (SE = 1.7%) of the escapement were males (Appendix A5).

ESTIMATES OF HARVEST, MEAN DATE OF HARVEST, TOTAL RUN, EXPLOITATION RATE, AND MARINE SURVIVAL

In 2000, 71 coho salmon with CWTs released in the Unuk River in 1999 were recovered from various fisheries as random recoveries in the port and creel census sampling programs and another 14 were from escapement sampling (Table 5; Appendix A3). There were no recoveries reported for marine commercial fisheries in Canada. Recoveries in 2000 were primarily from troll gear (65%) and to a lesser extent from drift gillnet (16%), purse seine (13%), and sport (6%) gear. These recoveries were mostly

Table 4.–Age and sex composition of Unuk River coho salmon escapement, harvest, and run in 2000 based on samples gathered during Event 1 sampling on the spawning grounds.

		Age		
		1.1	2.1	**Total**
Females	n	143	25	168
	%	35.1	6.1	41.3
	SE of %	2.4	1.2	2.4
	Escapement	5,508	963	6,471
	SE	1,849	363	3,319
	Harvest	5,109	893	6,002
	SE	1,208	264	2,122
	Total run	10,641	1,860	12,502
	SE	2,266	517	3,940
Males	n	207	32	239
	%	50.9	7.9	58.7
	SE of %	2.5	1.3	2.4
	Escapement	7,973	1,233	9,206
	SE	2,653	452	3,959
	Harvest	361	194	8,539
	SE	1,716	321	2,531
	Total run	15,404	2,381	17,785
	SE	3,204	624	4,699
Total	n	350	57	407
	%	86.0	14.0	100.0
	SE of %	1.7	1.7	
	Escapement	13,481	2,196	15,677
	SE	4,450	767	5,167
	Harvest	12,504	2,036	14,541
	SE	2,850	523	3,303
	Total run	26,045	4,242	30,287
	SE	5,298	999	6,132

Table 5.–Estimated marine harvest of adult coho salmon bound for the Unuk River in 2000, where $\hat{q}_h = 0.027$ and $G(\hat{q}_h^{-1}) = 0.0420$.

TROLL FISHERY

Stat.wk	Dates (period)	Quad	H	var(H)	n	a	a'	t	t'	m	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
33-34	8/6-8/19 (4)	NE	10,424	0	6,329	102	99	79	79	2	282	233	162%
27-32	6/25-8/5 (3)	NE	72,318	0	21,282	311	309	243	243	3	852	650	150%
38	9/10-9/16 (6)	NW	19,731	0	13,043	504	499	442	440	1	127	127	196%
35-37	8/20-9/9 (5)	NW	149,167	0	52,283	1,735	1,720	1,501	1,497	2	479	397	162%
33-34	8/6-8/19 (4)	NW	72,144	0	45,686	1,147	1,338	945	944	5	562	397	138%
27-32	6/25-8/5 (3)	NW	572,653	0	146,027	3,167	3,130	2,579	2,570	12	3,966	2,593	128%
33-37	8/20-9/9 (4,5)	SE	27,110	0	18,304	393	389	333	333	9	1,118	745	131%
27-32	6/25-8/5 (3)	SE	51,172	0	32,143	562	552	441	440	6	809	560	136%
27-34	6/25-8/19 (3,4)	SW	129,204	0	98,356	1,820	1,800	1,452	1,447	11	1,217	800	129%
Subtotal troll fishery			1,103,923	0	433,453	9,741	9,836	8,015	7,993	51	9,412	3,006	63%

SEINE FISHERY

Stat.wk	Date	District	H	var(H)	n	a	a'	t	t'	m	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
30	7/16-7/22	101	1,969	0	568	34	34	29	29	1	288	287	196%
38	9/10-9/16	102	1,989	0	899	10	9	7	7	1	204	204	196%
30	7/16-7/22	104	7,205	0	2,613	37	35	23	23	1	242	242	196%
33	8/6-8/12	104	12,370	0	2,081	29	29	22	22	1	493	493	196%
34	8/20-8/26	106	1,794	0	400	7	7	4	4	1	372	372	196%
33	8/27-9/2	109	6,417	0	1,540	34	34	29	29	1	346	346	196%
Subtotal seine fishery			31,744	0	8,101	151	148	114	114	6	1,945	827	83%

SPORT FISHERY

Biweek	Date	Area	H	var(H)	n	a	a'	t	t'	m	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
16	7/31-8/13	Craig	16,459	0	3,135	55	52	49	49	1	461	461	196%
17	8/13-8/26	Sitka	7,208	3,126,084	2,907	85	85	76	76	2	412	346	165%
Subtotal sport fishery			23,667	3,126,084	6,042	140	137	125	125	3	872	576	129%

GILLNET FISHERY

Stat.wk	Date	District	H	var(H)	n	a	a'	t	t'	m	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
31	7/23-7-29	106	7,453	0	3,460	56	55	43	43	1	182	182	196%
33	8/6-8-12	106	6,718	0	2,166	32	32	24	24	2	515	427	162%
34	8/13-8/19	106	4,276	0	2,085	19	19	15	14	1	182	182	196%
35	8/20-8/26	106	8,206	0	2,420	47	47	41	41	1	281	281	196%
36	8/27-9/2	106	6,327	0	2,609	63	63	61	61	5	1,006	711	139%
39	9/17-9/23	101	3,462	0	1,989	28	28	26	26	1	144	144	196%
Subtotal gillnet fishery			36,442	0	14,729	245	244	210	209	11	2,312	924	78%
TOTAL ALL FISHERIES			1,195,776	3,126,084	462,325	10,277	10,365	8,464	8,441	71	14,541	3,303	45%

from the Southeast (42%) and Northwest (32%) quadrants with the remainder being from the Southwest (20%) and Northeast (6%) quadrants. Of the 51 CWTs recovered in the commercial troll fishery, 39%, 29%, 22%, and 10% were from the Northwest, Southeast, Southwest, and Northeast quadrants, respectively. In the commercial gillnet fisheries, all 11 CWTs recovered were from the Southeast Quadrant and offloaded in Ketchikan (6), Petersburg (4), or Metlakatla (1). They were harvested in District 106 (10) and in District 101 (1). Three CWTs were recovered in the marine recreational fishery, 2 from Sitka and 1 from Craig. Six CWTs were recovered in seine fisheries, 3 from the Southeast, 2 from the Southwest, and 1 from the Northeast quadrants.

An estimated 14,541 (SE = 3,303) coho salmon originating from the Unuk River were harvested in marine commercial and sport fisheries in 2000 throughout Southeast Alaska (Tables 5, 6). Fish were harvested primarily in the troll fishery in the Northwest Quadrant (16%) and in the gillnet fishery in District 106 (7%)(Table 6). The troll harvest was spread over a long period (i.e., July

Table 6.–Estimated harvest, exploitation, and total run of Unuk River coho salmon in 2000.

Fishery	Area	Estimated harvest	SE	Percent of marine harvest	Percent of total run
U. S. TROLL FISHERY	NE Quadrant	1,133	883	7.8	3.7
	NW Quadrant	5,135	3,514	35.3	17.0
	SE Quadrant	1,927	1,305	13.3	6.4
	SW Quadrant	1,217	800	8.4	4.0
	Subtotal	9,412	3,006	64.7	31.1
SEINE	District 101	288	287	2.0	0.9
	District 102	204	204	1.4	0.7
	District 104	735	549	5.1	2.4
	District 106	372	372	2.6	1.2
	District 109	346	346	2.4	1.1
	Subtotal	1,945	827	13.4	6.4
SPORT	Craig	461	461	3.2	1.5
	Sitka	412	346	2.8	1.4
	Subtotal	872	576	6.0	2.9
GILLNET	District 101	144	144	1.0	0.5
	District 106	2,167	913	14.9	7.2
	Subtotal	2,312	924	15.9	7.6
Total marine harvest		14,541	3,303	100.0	48.0
Mark-recapture tagging mortality		69			
Total escapement		15,677	5,167		51.8
Total run		30,287	6,132		100.0
Estimated marine survival		3.8%	1.4%		
Estimated exploitation rate		48.0%	9.9%		

through October) and 45% of the gillnet harvest occurred during one week (i.e., 27 August through 2 September) (Figure 11). Estimated mean date of harvest in the troll fishery was 30 July, compared to 20 August for the gillnet fishery (Appendix A6). Coho salmon originating from the Unuk River contributed an estimated 2.0% (2,167 fish; SE = 913) of the District 106 gillnet catch (96,207 fish). Over seventy percent of the estimated total gillnet harvest occurred by 26 August.

An estimated 30,287 (SE = 6,132) coho salmon bound for the Unuk River returned in 2000. The estimated marine survival rate was 3.8% (SE = 1.4%) (Table 6), substantially lower than what was seen in 1998 (7.1%; SE = 2.0%) and 1999 (9.8%; SE = 2.9%) on the Unuk River (Jones et al. 1999, 2000) and for the average (1984-1997) seen at nearby Hugh Smith Lake (13.4%) located approximately 100 km south (Shaul 1998).

The estimated exploitation rate in marine commercial and recreational fisheries was 46.0% (SE = 10.1%) (Table 6), lower than what was seen in 1998 (78.5%; SE = 5.3%), 1999 (53.1%; SE = 12.7%), and in recent years from Hugh Smith Lake (70%)(Jones et al. 1999, 2000; Shaul 1998).

DISCUSSION

Results from 1998 and 1999 on coho salmon (Jones et al. 1999, 2000) and since 1997 with chinook salmon (Jones et al. 1998; Jones and McPherson et al. 1999, 2000) suggest that fish bound for the various spawning tributaries of the Unuk River could be proportionately sampled during Event 1 using set gillnets operated at SN1.

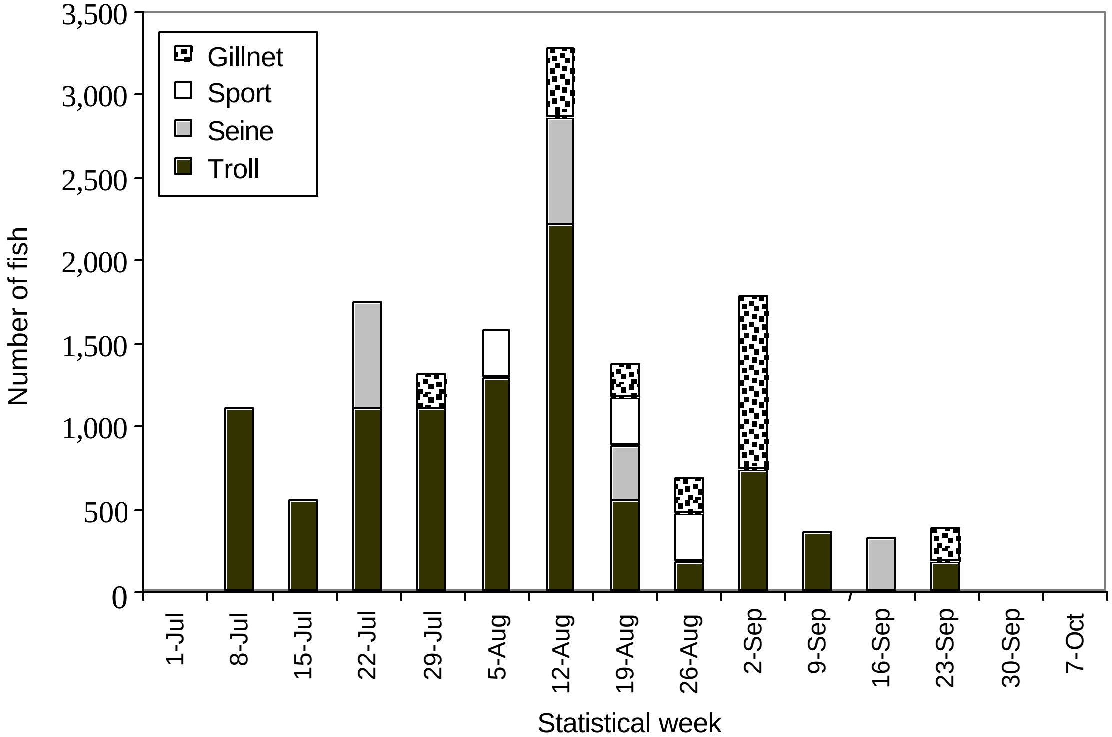

Figure 11.–Estimated harvest of coho salmon bound for the Unuk River, by statistical week, in marine commercial and recreational fisheries in 2000. Weekly estimates of harvest in the troll fishery are approximated.

The radiotelemetry data (Appendix A4; Figure 7) show that fish are distributed throughout the drainage after marking and fish marked throughout Event 1 are recovered in all segments of Event 2 (Figure 8). Because of the difficulties associated with gathering samples from all segments of Event 2, the data gathered this year was not necessarily in proportion to abundance. For instance, the Eulachon River is reasonably accessible and affords several good locations for capturing fish. As a result, the Eulachon River constituted 31% of the Event 2 sample. Radiotelemetry data showed that 8% of the radio tagged fish were found in the Eulachon River. Loss of primary tags in this study was not a problem, as none of the recoveries were missing their primary tags and secondary marks were clearly visible on all recaptured fish.

An obvious lull in Event 2 sampling occurred around the first week of October (Figure 9). This might be the result of heavy fishing pressures on the central portion of the run or evidence of a bimodal distribution. Such bimodal distributions in coho salmon populations have been seen at Steep Creek near Juneau (Jones and McPherson 1997) and at Hugh Smith Lake near Ketchikan (Leon Shaul, Alaska Department of Fish and Game, Douglas, personal communication). Weather and water conditions did not prevent sampling with the exception of a short period in early September. In general, sampling conditions improved throughout the project.

In 2000, some fish moved quickly to their spawning areas and remained there until dying, while others seemed to spend prolonged periods of time milling in areas that likely afforded some kind of ripening habitat such as deep pools or eddys before moving to their spawning areas (Appendix A4). On average, it took fish just over one week from the time of release until they were recorded at the radio towers located at river km 15. One fish took as little as 2 days to travel this distance and another took as long as 30 days. Fish that move quickly to their spawning areas may gain an advantage by reaching an otherwise unattainable spawning location during high water (which is common early in the run), or a distant spawning location that requires a great deal of time to reach. Fish that spend prolonged periods of time milling may gain an advantage by ripening in deep glacial waters, pools, or in lake areas, thus minimizing contact with predators such as brown bears (*Ursus arctos*), black bears (*U. americana*), river otters (*Lutra canadensis*), and even bald eagles (*Haleaetus leucocephalus*). A run timing strategy that occurs after bears go into hybernation would be particularly beneficial to fish especially when spawning in small, shallow water streams. It is fairly common to see coho salmon spawning in the small tributaries of Mendenhall Lake in early November and not prior.

Stream life between sampling events for recaptures varied greatly, and in general, fish marked early were recaptured early, and vice versa. On average, the time between marking and recovery was 24 days; however, one fish showed excessive stream life at 43 days and the shortest stream life seen was 11 days (Appendix A4).

A "sulking" behavior, as a result of capture and marking, was seen in coho salmon in the 1998 and 1999 studies on the Unuk River (Jones et. al. 1999, 2000) and has been noted in another study of coho salmon performed on the Taku River (Eiler et al. *In prep*) and repeatedly in studies of chinook salmon (Bernard et al. 1999). Some "sulking" was noticeable this year. For the fish that were released in Event 1, that were later captured again in Event 1, an average of 4 days elapsed with a peak of 13 days for one fish.

In the radiotelemetry study, some fish were not found at all or were found emitting a mortality signal at or near SN1. It is important to understand that although some of these fish did indeed die as a result of tagging, some probably went to other systems to spawn. One radio tagged coho salmon from the 1999 study was never seen again in the Unuk River after release but it was located again 76 days later in Grant Creek which flows into Burroughs Bay approximately 7 km west of the mouth of the Unuk River. A small number of radio tagged fish may have entered the Unuk River but might have not been detected by either survey method (i.e., radio tower or aerial survey). In 2000, 25 radio tagged fish were successfully tracked upstream of the radio towers by either a positive hit at one of the radio towers or during one of the four aerial surveys. However, 20% of these fish were never recorded at the radio towers and 16% were never recorded by one of the aerial surveys indicating the importance of using both survey methods. These results also suggest that a small percentage, around 3% (0.20 * 0.16), of the radio tags not found actually entered the Unuk River to spawn. If this were the case, then $\hat{n}_1$ would be increased by 2 fish thus increasing the estimate of escapement by 85 fish ($\hat{N}$ = 15,761), a relatively small effect, given the magnitude of the parameters obtained in this particular year. These results do suggest that similar analyses be performed in subsequent years as the effect may be larger under different circumstances.

Although the population of spawning adults in this study was not strictly closed to losses from mortality, it was considered closed to recruitment, as tagging appeared to span the immigration. Similarly, the smolt population estimate was closed to recruitment, because Pacific salmon typically return to their natal streams to spawn. The models used to estimate adult and smolt population sizes rely on the complex assumption that every fish has an equal probability of being marked, or that every fish has an equal chance of being sampled as an adult, or that marked and unmarked fish mix completely between sampling events. The estimate of smolt abundance relies largely on the latter portion of the assumption, as effort to capture smolt cannot be proportionally allocated to rearing areas. Thus, we note that distribution of CWT recoveries obtained during marine harvest sampling illustrates considerable mixing of marked and unmarked fish during their 14 to 16 months at sea (Table 5). Fractions of adults escaping to the Unuk River over time (before September 5 and after September 4) marginally contained similar fractions of CWTs (?^{2}<2.18, df = 1, P = 0.14): 0.61% (2/328) for the early period and 1.80% (12/668) for the late period. In contrast, the estimate of adult abundance relies largely on the first part of the assumption, because adults could not be captured in proportion to their abundance on the spawning grounds over time or by area. Evidence supporting this assumption comes from the radiotelemetry study.

The knowledge gained over successive years of study often leads to increases in precision over time. During the first two years of study we achieved RPs of ±44% (CV = 27%) in 1998 and ±82% (CV = 50%) in 1999. In 2000, our goal was to achieve a RP similar to that which we saw in the first year of study; however, because of the low number of recoveries obtained during Event 2 sampling, we achieved a RP of ±54% (CV = 33%) for a 90% confidence interval.

Event 1 sampling probably began early enough to avoid missing any significant numbers of immigrating fish. Prior to the coho salmon study, a chinook salmon study takes place. This study can be used as a good indicator as to when coho salmon initially start to show up in the lower Unuk River. After three years of study, the earliest coho salmon encountered at the marking site was on July 26, 1999 and this fish was captured during chinook salmon work. Typically, coho salmon marking begins around the first week of August.

Event 2 sampling inherently ended early due to the nature of prolonged immigrations of coho salmon. In Yakutat, Alaska, coho salmon have been seen spawning in early iced-out streams as late as March of the following year (Bob Johnson, Alaska Department of Fish and Game, Yakutat, personal communication). In our study, marking ceased on 7 October, probably well before the last immigrants entered the river, yet likely late enough to cover the vast majority of the immigration (Figure 8). Thus, estimates of escapement, catch, and total run are most likely biased low by a small percent. From a practical perspective, this small bias is likely insignificant.

This is an ongoing study designed to estimate total escapement, harvest, run, marine survival, and exploitation rate of Unuk River coho salmon. Concern over the status of coho salmon in southern Southeast Alaska has been prompted by recent changes in run strength in stocks near Ketchikan. Results from the last three years of study have shown that the Unuk River produces total runs ranging between 30,000 and 60,000 adult coho salmon. This year the total run was only half that seen in 1998 and 1999. The smolt production of 803,762 in the spring of 1999 was one of the highest seen in three years of study. However, marine survival was very low at 3.8% when compared to 7.1% and 9.8% in 1998 and 1999, respectively. Data gathered in three years of study on Unuk River coho salmon suggest that marine survival is probably the most important factor in determining adult production.

Coho salmon in southern Southeast Alaska undergo the highest exploitation rates seen in the region, and this project is one of only two full stock assessment projects conducted annually in southern Southeast Alaska. The other, Hugh Smith Lake, is much smaller, producing runs of 2,000 to 5,000 fish annually (Shaul 1998). This study has further shown that coho salmon from the Unuk River contribute significantly to the marine and recreational fisheries of Southeast Alaska. Results of these studies and future years' studies are the crucial components for better managing coho salmon, not only in the Ketchikan Management Area, but in Southeast Alaska as a whole.

CONCLUSION AND RECOMMENDATIONS

We recommend the following strategies for continued success of this project on the Unuk River in upcoming years.

The use of aerial telemetry surveys as well as remote radio towers as neither method has been shown to be failsafe for tracking fish. The fraction of radio tags not accounted for is a crucial component necessary in order to estimate escapement accurately and precisely.

By tagging more smolt each spring with CWTs, we can improve the precision of smolt abundance and harvest estimates, especially those in the sport fishery. Therefore, we recommend that at least 21,000 smolt be tagged annually to meet a target RP of 25%. In most years, this can be accomplished by running the smolt tagging project longer, thus covering a greater proportion of the smolt emigration. Typically, chinook salmon smolt catches decline dramatically by the end of April, whereas coho salmon catches remain consistent. Thus, concentrating efforts to capture coho salmon after this time should boost the numbers such that more tags are recovered from fisheries in the following year.

In an effort to improve the relative precision of the adult escapement estimate, effort should be increased during both sampling events. Event 1 gillnetting should be increased from 6 h per day to at least 10 h per day. This should in effect double the number of tags available for recapture in Event 2. Combined with increases in Event 2 effort, this should at least double the number of recoveries seen annually.

Finally, the rate of naturally missing adipose fins should continue to be scrutinized during smolt tagging. Fortunately all CWTs recovered in 2000 tested positive for valid CWTs. However, our results from the first two years of study suggest either high rates CWT loss (31% in 1998; 10% in 1999) or high rates of naturally missing adipose fins (0.42% in 1998; 0.23% in 1999). It has been shown in other coho salmon studies that the rate of missing adipose fins is typically less than 0.10% (McPherson and Bernard 1996). Therefore, we assume that all fish sampled in the Unuk River with missing adipose fins were previously marked as smolt with CWTs. However, if the rate of missing adipose fins is found to be much higher than 1 in 1,000, or if the CWT marked fraction becomes much lower than it is at present (about 3 per 100), then difficulties may arise in distinguishing between the two rates.

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APPENDIX A

Appendix A1.–Detection of size-selectivity in sampling and its effects on estimation of abundance and age and size composition.

RESULTS OF HYPOTHESIS TESTS, **K-S AND** c^2 on lengths of fish

MARKED during Event 1 and **RECAPTURED** during Event 2	**MARKED** during Event 1 and **INSPECTED** during Event 2
Case I:	
Accept H_o	Accept H_o
There is no size-selectivity during either sampling event.	
Case II:	
Accept H_o	Reject H_o
There is no size-selectivity during Event 2 but there is during the Event 1.	
Case III:	
Reject H_o	Accept H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during Event 2; the status of size-selectivity during Event 1 is unknown.	

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

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from Event 2 to estimate proportions in compositions.

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

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only Event 2 to estimate proportions in compositions, and apply formulae to correct for size bias to the data from Event 2.

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

Appendix A2.–Numbers of coded wire tagged and untagged adult coho salmon sampled in the Unuk River during Event 1 of the mark-recapture study using set gillnets in 2000.

Date	Number examined	Number of clips	Valid tags	Head number	Tag code
8/1-8/28	67	0	0		
8/29	45	1	1	182086	040143
8/30	24	0	0		
8/31	59	1	1	182041	040143
9/1-9/7	111	0	0		
9/8	12	1	1	182042	040143
9/9	13	1	1	182043	040143
9/10	40	0	0		
9/11	10	1	1	182044	040143
9/12-9/20	26	0	0		
9/21	30	2	2	182047, 182048	040143, 040143
9/22-10/22	188	0	0		
10/23	38	1	1	182049	040143
Total	663	8	8		
	Marked Fraction (θ)	0.0121	0.0121		
	SE (θ)	0.0413	0.0413		

Appendix A3.–Random and select recoveries of coded wire tagged coho salmon bound for the Unuk River in 2000.

Head number	Tag code	Gear	Recovery date	Stat. week	Quad.	Dist.	Length	Port survey site	Sample number
				RANDOM RECOVERIES					
502376	40143	TROLL	6-Jul-00	28	NE	109	570	PETERSBURG	50332
159152	40143	TROLL	21-Jul-00	30	NE	109	614	CRAIG	70242
83774	40143	TROLL	12-Aug-00	33	NE	109	516	PORT ALEXANDER	80146
157422	40143	TROLL	4-Jul-00	28	NW	113	591	SITKA	30481
134937	40143	TROLL	4-Jul-00	28	NW	113	556	SITKA	30463
135448	40143	TROLL	19-Jul-00	30	NW	113	618	SITKA	30664
135573	40143	TROLL	20-Jul-00	30	NW	113	625	SITKA	30685
135927	40143	TROLL	22-Jul-00	30	NW	113	627	SITKA	30705
158293	40143	TROLL	23-Jul-00	31	NW	113	660	HOONAH	110180
135800	40143	TROLL	26-Jul-00	31	NW	113	738	SITKA	30737
158731	40143	TROLL	30-Jul-00	32	NW	113	715	HOONAH	110190
154596	40143	TROLL	4-Aug-00	32	NW	154	611	SITKA	30832
154464	40143	TROLL	5-Aug-00	32	NW	113	622	SITKA	30844
158893	40143	TROLL	7-Aug-00	33	NW	113	730	HOONAH	110203
164805	40143	TROLL	8-Aug-00	33	NW	113	656	PELICAN	10113
501055	40143	TROLL	9-Aug-00	33	NW			EXCURSION INLET	100090
163585	40143	TROLL	10-Aug-00	33	NW	114	620	ELFIN COVE	20120
155271	40143	TROLL	12-Aug-00	33	NW		671	SITKA	30946
501786	40143	TROLL	26-Aug-00	35	NW		669	EXCURSION INLET	100130
500136	40143	TROLL	28-Aug-00	36	NW	113	590	JUNEAU	40114
165775	40143	TROLL	21-Sep-00	39	NW	113	705	PELICAN	10240
66565	40143	TROLL	6-Jul-00	28	SE	101	625	KETCHIKAN	60157
67823	40143	TROLL	6-Jul-00	28	SE	102	633	KETCHIKAN	60162
507380	40143	TROLL	24-Jul-00	31	SE	105	674	KETCHIKAN	60313
159022	40143	TROLL	25-Jul-00	31	SE	105	594	CRAIG	70274
502776	40143	TROLL	25-Jul-00	31	SE	105	652	PETERSBURG	50581
159069	40143	TROLL	29-Jul-00	31	SE	105	539	CRAIG	70305
508332	40143	TROLL	8-Aug-00	33	SE	105	563	KETCHIKAN	60417
508322	40143	TROLL	8-Aug-00	33	SE	105	663	KETCHIKAN	60417
502990	40143	TROLL	13-Aug-00	34	SE	105	660	PETERSBURG	50801
179941	40143	TROLL	28-Aug-00	36	SE	105	701	CRAIG	70517
510667	40143	TROLL	29-Aug-00	36	SE	102	724	KETCHIKAN	60532
510712	40143	TROLL	29-Aug-00	36	SE		739	KETCHIKAN	60536
510352	40143	TROLL	5-Sep-00	37	SE	105	686	KETCHIKAN	60564
508401	40143	TROLL	6-Sep-00	37	SE	101	687	KETCHIKAN	60565
159710	40143	TROLL	12-Jul-00	29	SW	104	609	CRAIG	70120
159775	40143	TROLL	14-Jul-00	29	SW	104	609	CRAIG	70159
150459	40143	TROLL	17-Jul-00	30	SW	103	642	CRAIG	70187
507701	40143	TROLL	20-Jul-00	30	SW	103	625	KETCHIKAN	60268
159240	40143	TROLL	2-Aug-00	32	SW	104	629	CRAIG	70344
509011	40143	TROLL	5-Aug-00	32	SW	103	604	CRAIG	70378
509020	40143	TROLL	5-Aug-00	32	SW	104	662	CRAIG	70373
509141	40143	TROLL	7-Aug-00	33	SW	104	697	CRAIG	70410
508901	40143	TROLL	12-Aug-00	33	SW		635	KETCHIKAN	60451
179469	40143	TROLL	13-Aug-00	34	SW	104	620	CRAIG	70470
150231	40143	TROLL	8-Jul-00	28			618	CRAIG	70095
157928	40143	TROLL	11-Jul-00	29			626	SITKA	30592
154409	40143	TROLL	31-Jul-00	32			646	SITKA	30807
502971	40143	TROLL	10-Aug-00	33			675	PETERSBURG	50765
508585	40143	TROLL	12-Aug-00	33			654	KETCHIKAN	60455
508342	40143	TROLL	13-Aug-00	34			695	KETCHIKAN	60463

-continued-

Appendix A3.–Page 2 of 2

Head number	Tag code	Gear	Recovery date	Stat. week	Quad.	Dist.	Length	Port survey site	Sample number
503068	40143	PURSE	12-Aug-00	33	NE	109	660	PETERSBURG	50780
507530	40143	PURSE	19-Jul-00	30	SE	101	579	KETCHIKAN	60258
503023	40143	PURSE	20-Aug-00	35	SE	106	604	PETERSBURG	50877
510747	40143	PURSE	11-Sep-00	38	SE	102	667	KETCHIKAN	60567
507054	40143	PURSE	16-Jul-00	30	SW	104	647	KETCHIKAN	60219
508182	40143	PURSE	7-Aug-00	33	SW	104	706	KETCHIKAN	60407
150191	40143	SPORT	14-Aug-00	34	NW	113	660	SITKA	35474
169409	40143	SPORT	20-Aug-00	35	NW	113	690	SITKA	35485
82814	40143	SPORT	1-Aug-00	32	SW	104	722	CRAIG	75106
507112	40143	DRIFT	25-Jul-00	31	SE	106	687	KETCHIKAN	60323
502144	40143	DRIFT	9-Aug-00	33	SE	106	603	PETERSBURG	50763
502148	40143	DRIFT	9-Aug-00	33	SE	106	660	PETERSBURG	50764
508233	40143	DRIFT	14-Aug-00	34	SE	106	670	KETCHIKAN	60472
503216	40143	DRIFT	23-Aug-00	35	SE	106	625	PETERSBURG	50905
508042	40143	DRIFT	29-Aug-00	36	SE	106	619	KETCHIKAN	60535
508034	40143	DRIFT	29-Aug-00	36	SE	106	642	KETCHIKAN	60535
508037	40143	DRIFT	29-Aug-00	36	SE	106	685	KETCHIKAN	60535
508022	40143	DRIFT	29-Aug-00	36	SE	106	793	KETCHIKAN	60535
503386	40143	DRIFT	30-Aug-00	36	SE	106	749	PETERSBURG	50972
173350	40143	DRIFT	21-Sep-00	39	SE	101	698	METLAKATLA	90337
82086	40143	ESCAPE	29-Aug-00	36		101	625	UNUK & TRIBUTARIES	930055
182041	40143	ESCAPE	31-Aug-00	36		101	605	UNUK & TRIBUTARIES	930057
182042	40143	ESCAPE	8-Sep-00	37		101	570	UNUK & TRIBUTARIES	930063
182043	40143	ESCAPE	9-Sep-00	37		101	660	UNUK & TRIBUTARIES	930064
82095	40143	ESCAPE	9-Sep-00	37		101	595	UNUK & TRIBUTARIES	937011
82096	40143	ESCAPE	10-Sep-00	38		101	745	UNUK & TRIBUTARIES	934007
182044	40143	ESCAPE	11-Sep-00	38		101	605	UNUK & TRIBUTARIES	930066
182047	40143	ESCAPE	21-Sep-00	39		101	525	UNUK & TRIBUTARIES	939501
182048	40143	ESCAPE	21-Sep-00	39		101	580	UNUK & TRIBUTARIES	939501
182045	40143	ESCAPE	23-Sep-00	39		101	660	UNUK & TRIBUTARIES	934015
82097	40143	ESCAPE	27-Sep-00	40		101	680	UNUK & TRIBUTARIES	932009
82098	40143	ESCAPE	6-Oct-00	41		101	610	UNUK & TRIBUTARIES	934021
82099	40143	ESCAPE	17-Oct-00	43		101		UNUK & TRIBUTARIES	934024
182049	40143	ESCAPE	23-Oct-00	44		101	690	UNUK & TRIBUTARIES	939002
				SELECT RECOVERIES					
156704	40143	TROLL	31-Aug-00	36	NW	113		SITKA	31063

Appendix A4.–Fates and locations of fish possessing radio transmitters as recorded at two remote radio towers and seen during five fixed-wing aircraft surveys flown on the Unuk River in 2000.

			Radio tower		Location by tracking flight				Assumed
Date	Code	Frequency	North Bank	South Bank	5-Sep-00	19-Sep-00	3-Oct-00	24-Oct-00	fate
8/28/00	185	151.123			Eulachon R.	Eulachon R.	Eulachon R.	Eulachon R.	Spawned
8/28/00	195	151.123			Eulachon R.	Eulachon R.	Eulachon R.	Eulachon R.*	Spawned
8/29/00	195	151.085			Eulachon R.	Eulachon R.	head N.Fork	37	Spawned
8/29/00	195	151.103	9/1/00		31	31	34	32	Spawned
8/29/00	195	151.164	9/1/00	9/1/00	21	27	35	37	Spawned
8/29/00	195	151.183			2*	2*	2*	*Recovered* [1]	Lost
8/29/00	195	151.604			23	23	5*	5*	Spawned
8/30/00	195	151.064	9/10/00	9/10/00	8	23	Boundary Lk.	43	Spawned
8/30/00	195	151.144			2*	2*	2*	2*	Lost
8/30/00	195	151.244	9/1/00		24	31	not found	Twin John Pond	Spawned
8/30/00	195	151.345		9/11/00	2	not found	not found	21	Spawned
8/30/00	195	151.624			21	16	16	16	Spawned
8/31/00	195	151.464			Boundary Lk.	37	37	37	Spawned
8/31/00	195	151.645			29	32	31	31	Spawned
9/1/00	195	151.284			Kerr Ck.	Kerr Ck.	14	14	Spawned
9/2/00	185	151.645		9/18/00	X	X	X	X	Spawned
9/7/00	185	151.064		9/13/00	X	14	35	Twin John Pond	Spawned
9/8/00	185	151.284	9/15/00	9/15/00	X	Kerr Ck.	34	not found	Spawned
9/8/00	185	151.464	9/15/00	9/15/00	X	Kerr Ck.	18	37	Spawned
9/9/00	185	151.604	10/9/00	10/9/00	X	2	not found	16	Spawned
9/10/00	185	151.103		9/18/00	X	13	31	South Fk. Unuk	Spawned
9/10/00	185	151.183		9/13/00	X	23	not found	23*	Spawned
9/15/00	185	151.144	10/12/00	9/30/00	X	not found	29	not found	Spawned
9/20/00	145	151.103	9/24/00		not found	not found	not found	not found	Spawned
9/21/00	185	151.164	9/26/00	9/26/00	X	X	29	29	Spawned
9/22/00	175	151.103			X	X	6*	5*	Lost
9/22/00	175	151.164			X	X	not found	not found	Lost
9/23/00	175	151.064		10/1/00	X	X	13	not found	Spawned
9/24/00	145	151.064	9/26/00	9/26/00	X	X	11*	11*	Spawned
9/25/00	175	151.085		10/1/00	X	X	23	not found	Spawned
9/26/00	185	151.085	10/8/00	10/8/00	X	X	10	Boundary Lake	Spawned
9/28/00	145	151.085			X	X	X	Eulachon R.*	Lost
10/2/00	145	151.144	10/5/00	10/5/00	X	X	3	Boundary Lk.	Spawned

***** Indicates that a mortality signal was recorded and **X** indicates the frequency was not tracked.

[1] Radio tag was found on October 6 just downstream of the tagging site on the shoreline and the fish was assumed to have died.

Appendix A5.–Age and sex composition of adult coho salmon sampled during the two-event mark-recapture study performed on the Unuk River in 2000.

		AGE		
		1.1	2.1	Total
AGE COMPOSITION OF ADULT COHO SALMON				
PANEL A: ALL SAMPLES COMBINED				
{Biased with respect to escapement}				
Female	n	283	57	435
	%	34.1	6.9	52.5
	SE of %	1.6	0.9	1.7
	Avg. length	604	643	610
	SE length.	3.30	8.84	2.84
Male	n	412	77	489
	%	49.7	9.3	59.0
	SE of %	1.7	1.0	1.7
	Avg. length	567	609	573
	SE length.	3.70	9.20	3.51
Total	n	695	134	829
	%	83.8	16.2	100.0
	SE of %	1.3	1.3	
	Avg. length	581	623	588
	SE length.	2.67	6.64	2.54
			Unique fish	950
PANEL B: EVENT 1-MARKING IN THE LOWER RIVER				
{Unbiased with respect to escapement}				
SN1				
Female	n	143	25	168
	%	35.1	6.1	41.3
	SE of %	2.4	1.2	2.4
	Escapement	5,508	963	6,471
	SE of esc.	1,849	363	3,319
	Avg. length	596	633	602
	SE length.	4.28	14.89	4.36
Male	n	207	32	239
	%	50.9	7.9	58.7
	SE of %	2.5	1.3	2.4
	Escapement	7,973	1,233	9,206
	SE of esc.	2,653	452	3,959
	Avg. length	572	636	580
	SE length.	4.41	10.59	4.31
Total	n	350	57	407
	%	86.0	14.0	100.0
	SE of %	1.7	1.7	
	Escapement	13,481	2,196	15,677
	SE of esc.	4,450	767	5,167
	Avg. length	582	635	589
	SE length.	3.20	8.75	3.14
			Total sampled	477
			Spaghetti tags Released	387

-continued-

PANEL C: EVENT 2-SAMPLING FOR MARKS
{Biased with respect to escapement}

TOTAL				
Female	n	140	32	172
	%	33.2	7.6	40.8
	SE of %	2.3	1.3	2.4
	Avg. length	614	651	621
	SE length.	4.51	10.63	4.30
Male	n	205	45	250
	%	48.6	10.7	59.2
	SE of %	2.4	1.5	2.4
	Avg. length	579	606	584
	SE length.	5.07	11.00	4.65
Total	n	345	77	422
	%	81.8	18.2	100.0
	SE of %	1.9	1.9	
	Avg. length	593	625	599
	SE length.	3.64	8.16	3.38
			Total sampled	484
			Spaghetti tags recovered	11
EULACHON RIVER				
Female	n	56	3	59
	%	43.4	2.3	45.7
	SE of %	4.4	1.3	4.4
	Avg. length	615	558	612
	SE length.	6.14	27.74	6.16
Male	n	64	6	70
	%	49.6	4.7	54.3
	SE of %	4.4	1.9	4.4
	Avg. length	562	534	560
	SE length.	7.52	13.32	7.01
Total	n	120	9	129
	%	93.0	7.0	100.0
	SE of %	2.3	2.3	
	Avg. length	587	542	584
	SE length.	5.47	12.42	5.25
			Total sampled	148
			Spaghetti tags recovered	1
LAKE CREEK				
Female	N	24	13	37
	%	23.5	12.7	36.3
	SE of %	4.2	3.3	4.8
	Avg. length	626	662	639
	SE length.	12.09	14.10	9.58
Male	n	48	17	65
	%	47.1	16.7	63.7
	SE of %	5.0	3.7	4.8
	Avg. length	571	593	577
	SE length.	10.25	16.43	8.72
Total	n	72	30	102
	%	70.6	29.4	100.0
	SE of %	4.5	4.5	
	Avg. length	590	623	599
	SE length.	8.46	12.64	7.16
			Total sampled	119
			Spaghetti tags recovered	5

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BOUNDARY CREEK				
Female	n	22	4	26
	%	27.8	5.1	32.9
	SE of %	5.1	2.5	5.3
	Avg. length	611	713	627
	SE length.	10.05	10.51	11.28
Male	n	42	11	53
	%	53.2	13.9	67.1
	SE of %	5.7	3.9	5.3
	Avg. length	624	665	633
	SE length.	12.24	17.16	10.51
Total	n	64	15	79
	%	81.0	19.0	100.0
	SE of %	4.4	4.4	
	Avg. length	620	677	631
	SE length.	8.72	13.88	7.93
			Total sampled	94
			Spaghetti tags recovered	3

HELL ROARING CREEK				
Female	N	24	8	32
	%	32.9	11.0	43.8
	SE of %	5.5	3.7	5.8
	Avg. length	619	645	626
	SE length.	11.93	22.14	10.53
Male	N	34	7	41
	%	46.6	9.6	56.2
	SE of %	5.9	3.5	5.8
	Avg. length	578	621	585
	SE length.	11.61	35.57	11.46
Total	N	58	15	73
	%	79.5	20.5	100.0
	SE of %	4.8	4.8	
	Avg. length	595	634	603
	SE length.	8.76	19.84	8.22
			Total sampled	81
			Spaghetti tags recovered	2

GENE'S LAKE CREEK				
Female	n	11	2	13
	%	44.0	8.0	52.0
	SE of %	10.1	5.5	10.2
	Avg. length	584	663	596
	SE length.	19.80	27.50	18.80
Male	n	8	4	12
	%	32.0	16.0	48.0
	SE of %	9.5	7.5	10.2
	Avg. length	557	585	566
	SE length.	28.98	6.12	19.39
Total	N	19	6	25
	%	76.0	24.0	100.0
	SE of %	8.7	8.7	
	Avg. length	572	611	582
	SE length.	16.53	18.23	13.55
			Total sampled	27
			Spaghetti tags recovered	0

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CUTTHROAT SLOUGH			
Female	n	1	1
	%	20.0	20.0
	SE of %	20.0	20.0
	Avg. length	545	545
	SE length.	0.00	0.00
Male	n	4	4
	%	80.0	80.0
	SE of %	20.0	20.0
	Avg. length	570	570
	SE length.	36.91	36.91
Total	n	5	5
	%	100.0	100.0
	SE of %		
	Avg. length	565	565
	SE length.	29.03	29.03
		Total sampled	5
		Spaghetti tags recovered	0
GRIZZLY SLOUGH			
Female	N	1	1
	%	25.0	25.0
	SE of %	25.0	25.0
	Avg. length	520	520
	SE length.	1.00	1.00
Male	N	3	3
	%	75.0	75.0
	SE of %	25.0	25.0
	Avg. length	520	520
	SE length.	52.99	52.99
Total	N	4	4
	%	100.0	100.0
	SE of %		
	Avg. length	520	520
	SE length.	37.47	37.47
		Total sampled	5
		Spaghetti tags recovered	0
KERR CREEK			
Female	n	1	1
	%	50.0	50.0
	SE of %	50.0	50.0
	Avg. length	670	670
	SE length.	1.00	1.00
Male	n	1	1
	%	50.0	50.0
	SE of %	50.0	50.0
	Avg. length	615	615
	SE length.	1.00	1.00
Total	N	2	2
	%	100.0	100.0
	SE of %		
	Avg. length	643	643
	SE length.	27.50	27.50
		Total sampled	2
		Spaghetti tags recovered	0

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ROCK FACE SLOUGH				
Female	n		1	1
	%		50.0	50.0
	SE of %		50.0	50.0
	Avg. length		625	625
	SE length.		1.00	1.00
Male	n	1		1
	%	50.0		50.0
	SE of %	50.0		50.0
	Avg. length	545		545
	SE length.	1.00		1.00
Total	n	1	1	2
	%	50.0	50.0	100.0
	SE of %	50.0	50.0	
	Avg. length	545	625	585
	SE length.	1.00	1.00	40.00
			Total sampled	2
			Spaghetti tags recovered	0
CLEAR CREEK				
Female	N		1	1
	%		100.0	100.0
	SE of %			
	Avg. length		600	600
	SE length.		1.00	1.00
Male	N			
	%			
	SE of %			
	Avg. length			
	SE length.			
Total	N		1	1
	%		100.0	100.0
	SE of %			
	Avg. length		600	600
	SE length.		1.00	1.00
			Total sampled	1
			Spaghetti tags recovered	0

Appendix A6.–Estimated harvests of coho salmon bound for the Unuk River in 2000 in marine commercial and sport fisheries by statistical week. Harvest in the troll fishery was approximated by weighting catches for each period by the number of tags recovered in a statistical week.

Stat. week	Ending date	Troll		Seine		Sport		Gillnet		Total		Estimated weekly prop. harvest	Estimated cumulative harvest	Estimated cum. prop. harvest
		tags	harvest	tags	harvest	tags	harvest	tags	harvest	tags	harvest			
27	1-Jul-00													
28	8-Jul-00	6	1,106							6	1,106	0.076	1,106	0.08
29	15-Jul-00	3	553							3	553	0.038	1,658	0.11
30	22-Jul-00	6	1,106	2	647					8	1,753	0.121	3,411	0.23
31	29-Jul-00	6	1,106					1	210	7	1,315	0.091	4,727	0.33
32	5-Aug-00	7	1,290			1	290			8	1,580	0.109	6,307	0.43
33	12-Aug-00	12	2,211	2	647			2	420	16	3,278	0.226	9,585	0.66
34	19-Aug-00	3	553	1	324	1	290	1	210	6	1,377	0.095	10,962	0.76
35	26-Aug-00	1	184			1	290	1	210	3	684	0.047	11,646	0.80
36	2-Sep-00	4	737					5	1,049	9	1,786	0.123	13,433	0.93
37	9-Sep-00	2	369							2	369	0.025	13,801	0.95
38	16-Sep-00			1	324					1	324	0.022	14,125	0.97
39	23-Sep-00	1	184					1	210	2	394	0.027	14,519	1.00
40	30-Sep-00												14,519	1.00
41	7-Oct-00												14,519	1.00
	Total	51	9,397	6	1,942	3	871	11	2,308	71	14,519	1.000		
Est. mean date of harvest			30-Jul		6-Aug		10-Aug		20-Aug		3-Aug			

Appendix A7.–Computer data files on 1999 Unuk River coho salmon smolt and subsequent estimates of 2000 Unuk River adult coho salmon run parameters.

File name	Description
00UNK43.XLS	Spreadsheet containing all the mark-recapture data, various pivot table results, Tables 1-6, Figures 5, 6, and 8-11, Appendices A2-A6, harvest estimation calculations, abundance estimates, smolt tagging numbers and length and weight data, bootstrap results, Kolmogorov-Smirnov (K-S) 2-sample tests, various c^2 hypothesis test results.
43qbas00. BAS	BASIC compiled program for bootstrapping abundance estimates for estimation of variance and bias.
43qbas00.DAT	Data file with 2000 Unuk River coho salmon data for use in 43Unuk00.exe.
SPAS.EXE	Stratified Population Analysis (SPAS) program used to perform computer analysis of 2-sample mark-recovery data where each sample is from a geographically or temporally stratified population.
43Spas00.DAT	Data file containing the 2000 Unuk River coho salmon data for use in SPAS.exe.
43Spas00.OUT	Output from SPAS.EXE for the 2000 Unuk River coho salmon data.