Fishery Data Series No. 99-43

Production of Coho Salmon from the Unuk River, 1997–1998

by

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and

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December 1999

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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December 1999

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Projects F-10-12 and F-10-14, Job No. S-1-8.

The Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Fishery Data Series reports are intended for fishery and other technical professionals. Distribution is to state and local publication distribution centers, libraries and individuals and, on request, to other libraries, agencies, and individuals. This publication has undergone editorial and peer review.

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This document should be cited as:
Jones, E. L III, S. A. McPherson and A. B. Holm. 1999. Production of coho salmon from the Unuk River, 1997–1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-43 , Anchorage.

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ABSTRACT

Recovery of coded wire tags from adult coho salmon *Oncorhynchus kisutch* in 1998, tagged as smolt in 1997, was used to estimate smolt abundance, harvest, exploitation rate, and production from the Unuk River, near Ketchikan, Alaska. Baited G-40 minnow traps were fished daily on the Unuk River from 28 March through 18 April 1997. During this period 11,357 coho salmon smolt ≥70 mm fork length (FL) were tagged and released alive with valid tags having codes 04-43-35 and 04-43-36. Sampled smolt averaged 84 mm FL and 5.5 g in weight. In 1998, 149 adult coho salmon were recovered bearing coded wire tags, 139 of which were random fishery recoveries. These random recoveries represent an estimated harvest of 45,388 (SE = 7,461) coho salmon in U.S. marine waters. Of this harvest, the troll fishery took an estimated 57%, seine fisheries took 10%, drift gillnet fisheries took 20%, and recreational fisheries took 13%. An estimated 12,422 (SE = 3,298) adults escaped into the Unuk River, as determined by a mark-recapture study coupled with a radiotelemetry study. Estimated total run (i.e., escapement plus harvest) in 1998 for all coho salmon bound for the Unuk River was 57,811 (SE = 8,158); marine exploitation rate on this run was an estimated 79% (SE = 5.3%). Contribution of Unuk River coho salmon to the Ketchikan marine sport fishery was about 20% of the estimated harvest in that fishery. Smolt abundance in 1997 was 809,677 (SE = 189,345), as determined using Chapman's modification of the Peterson estimator, and the estimated marine survival rate was 7.1% (SE = 2.0%).

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 is unknown. However, it is believed that most of the production occurs in lower river tributaries of the United States; i.e., Cripple, Genes Lake, Kerr, Clear, and Lake Creeks and the Eulachon River (Figure 2; Pahlke, personal communication). 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, ADF&G, personal communication). Typically, only the Eulachon River is annually surveyed by helicopter for peak coho salmon spawning abundance with peak counts in the 1990s ranging from 235 to 860 and averaging 480 fish.

It is believed that the Unuk River produces a total run of between 20,000 and 50,000 adult coho salmon *Oncorhynchus kisutch* annually. The first recorded CWT-tagging of coho salmon on the Unuk River occurred in 1983 and continued through 1986 (Hubartt and Kissner 1987). These efforts coupled with recent CWT-tagging efforts, 1996–1999, suggest that Unuk River coho salmon contribute significantly to commercial and recreational fisheries in Southeast Alaska (ADF&G CWT Lab database). Annual run sizes vary depending on escapements and on freshwater and marine survival rates. Coho salmon returning to the Unuk River generally 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 of Sitka and Ketchikan before ascending the Unuk River (Figure 2). The majority of CWT recoveries occur in the Northwest (41%) and Southeast (39%) quadrants of Southeast Alaska (Figure 3). Unuk River coho salmon are also caught in the commercial marine troll and net fisheries of Northern British Columbia accounting for 4% (25) of the total Unuk River CWT recoveries since 1985 (Pacific States Marine Fisheries Commission Database, PSMFC). Coho salmon originating from the Unuk River are important contributors to the sport harvests in the nearby Ketchikan area and have been documented in marine sport fisheries as far north as Sitka

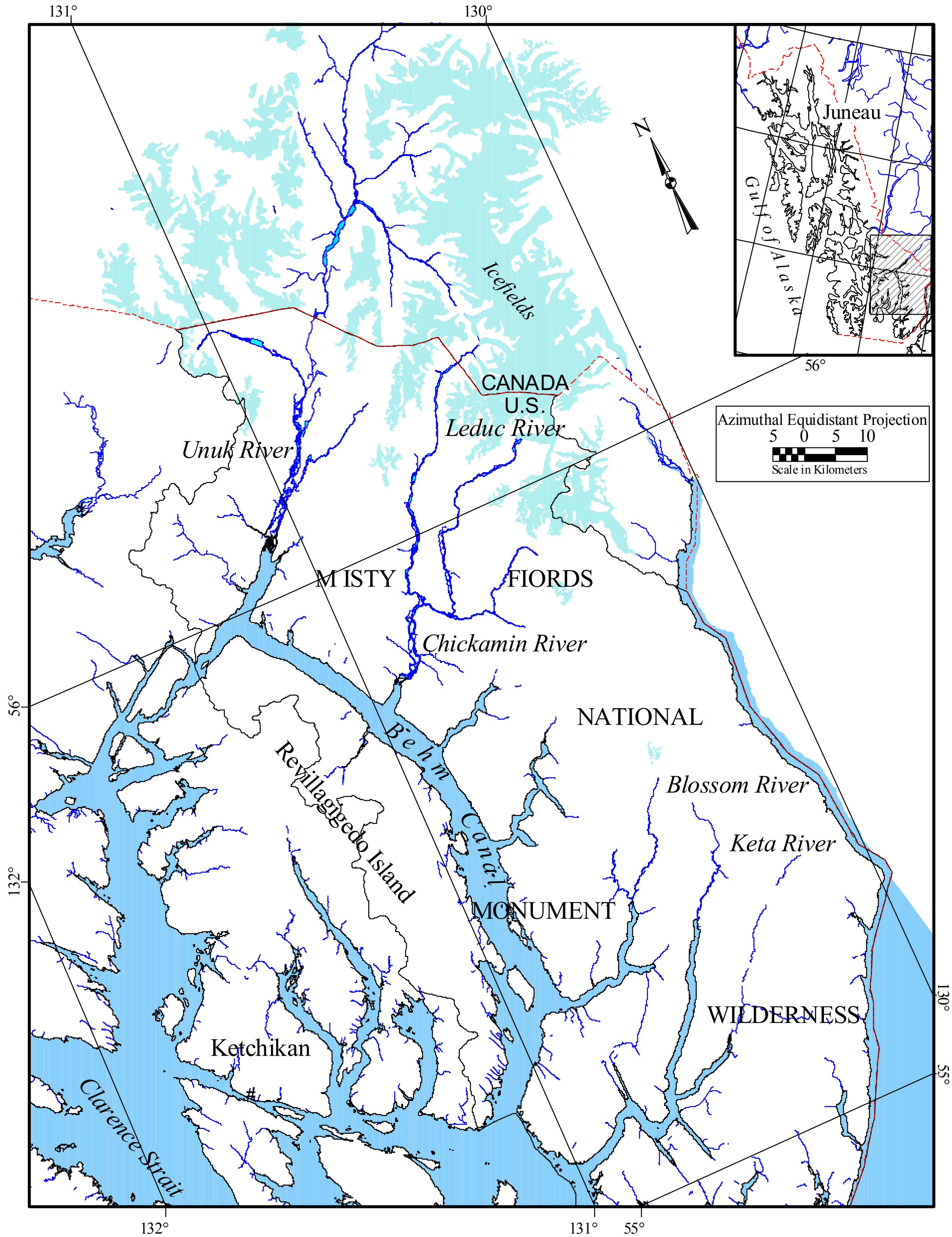

Figure 1.–Behm Canal area in Southeast Alaska and location of major coho salmon systems.

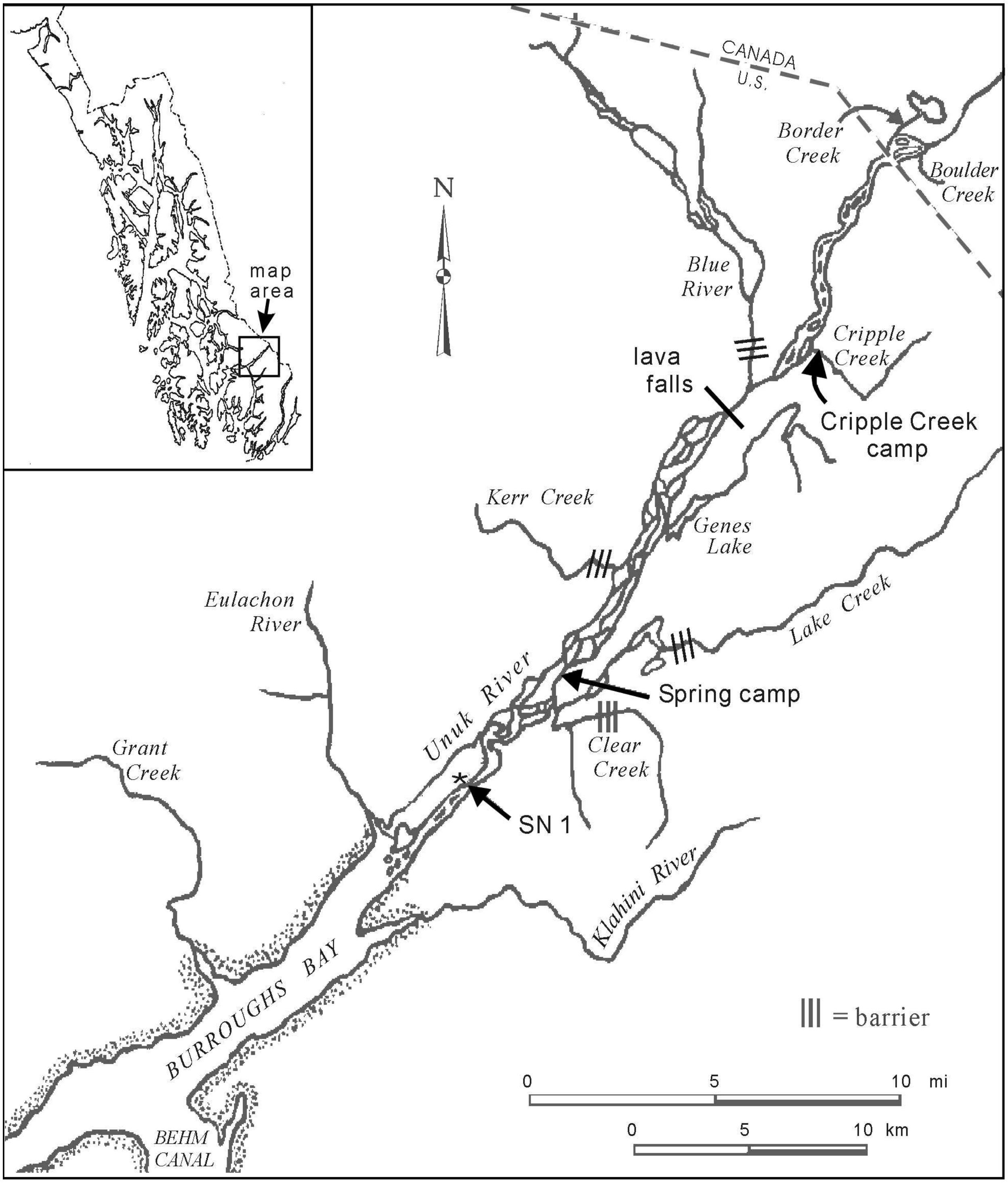

Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to salmon migration, and location of ADF&G research sites.

(ADF&G CWT Lab database). There is also a small freshwater sport fishery in the Unuk River in which up to 100 coho salmon are harvested annually.

Objectives of this year's study were to estimate: (1) abundance, mean length, and age composition of coho smolt leaving the Unuk River in 1997; (2) harvest of adult coho salmon returning to the Unuk River in 1998; and (3) escapement and age composition of returning adult coho salmon in 1998. These objectives were accomplished by tagging and sampling smolt in 1997 in the lower Unuk River and through the operation of an adult coho salmon mark-recapture study in 1998.

METHODS

SMOLT CAPTURE, CODED-WIRE-TAGGING, AND SAMPLING

Between 65 and 138 G-40 minnow traps, baited with salmon roe, were fished daily for 24 hours from 28 March to 18 April 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 of two personnel were used to set and fish traps on a regular basis. Generally, one crew was responsible for traps set upstream and downstream of Spring Camp located at approximately river km 14. Early in the season, water levels were low and ice and snow restricted fishing to the mainstem banks. These conditions slowly changed over the first few weeks and, after that time, all available habitat was accessible.

Salmonid smolt and fry were removed from minnow traps during each visit, transported to holding boxes at camp, and processed each morning. Coho salmon and chinook salmon *O. tshawytscha* smolt were separated by inspection from other species of salmon and Dolly Varden *Salvelinus malma*. Coho salmon and chinook salmon smolt were carefully examined, and species were separated 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) indicated a chinook salmon smolt whereas coho salmon smolt has a mottled or speckled adipose fin. In addition, chinook salmon smolt generally appear silvery when viewed from the side and coho salmon smolt are often darker and purplish with 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 solution of tricain methane-sulfonate (MS 222) buffered with sodium bicarbonate. Effort was made to keep the MS 222 solution at a constant river temperature by frequent water changes and sample sizes of tranquilized fish were kept at levels such that fish could be worked up quickly. All fish were tagged with a CWT and marked by excision of the adipose fin as described in Koerner (1977) and released. All chinook salmon smolt ≥50 mm FL were also tagged but with separate tag codes.

All coho salmon smolt with CWTs were held overnight and allowed to recover, then examined for survival and tag retention. The number of fish tagged, number of tagging-related mortalities, and the number of fish that had shed their tags were compiled and recorded on *ADF&G CWT Tagging Summary and Release Information Forms* which were submitted to the Commercial Fisheries Division (CFMD) Tag Lab in Juneau when field work ended. Length and weight composition of emigrating coho salmon smolt in 1997 was estimated by systematically sampling every 25th smolt captured. Each sampled smolt was measured to the nearest mm FL.

ESTIMATE OF SMOLT ABUNDANCE

Abundance of Unuk River coho salmon smolt in 1997 was estimated with a two-event mark-recapture study using Chapman's modification of the Petersen estimate (Chapman 1951):

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

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

where N_s is number of smolt emigrating in 1997, n_c is the number of smolt tagged in 1997, n_e the number of adults sampled in 1998, and m_a the number of adults in that sample with missing adipose fins. General assumptions (Seber 1982) that must hold for $\hat{N}$ to be a suitable estimate of abundance may be cast as follows:

(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.

RADIOTELEMETRY

The rate of mortality associated with capturing and marking mature coho salmon in 1998 using set gillnets in the lower river was estimated using a radiotelemetry study. Forty-one 150-151 MHz Advanced Telemetry Systems (ATS) radio transmitters were inserted esophageally into stomachs (Eiler 1990) of healthy fish between 13 August and 11 October. Tags were placed in one out of approximately every 20 coho salmon captured in the lower river in an effort to distribute them in proportion to the immigration. Every fish into which a radio transmitter was inserted was also tagged with a spaghetti tag and given secondary marks and sampled for ASL.

Aerial surveys were made 11 and 28 September and 3 and 6 November to locate each radio transmitter. The pilot and an experienced member of the crew covered the entire U.S. portion of the Unuk River and as far up as river km 56 within Canada searching for transmitters. The transmitters used in this study were equipped with motion or "mortality" sensors that doubled their pulse rate to 2 pulses per second after 3 to 4 hours of inactivity. Subsequent movement reset the transmitter to the normal active mode. Signals from radiotagged fish were recorded as either normal or "mortality" mode (Eiler 1990, Bendock and Alexandersdottir 1992, Johnson et al. 1993). Once a transmitter was located, it was deleted from future searches if it was transmitting in the mortality mode. Fates of the radiotagged fish were determined by whether they were successfully located upstream of tagging site above river km 6 or at the Eulachon River.

ESTIMATE OF ESCAPEMENT

A two-event mark-recapture study was used to estimate the escapement of coho salmon to the Unuk River in 1998. Fish were captured in the lower Unuk River between 1 August and 11 October using set gillnets for the first event. During a similar study designed to estimate the escapement of chinook salmon to the Unuk River in 1997 and 1998, the highest catches of fish occurred at one site and this same site was used exclusively in this study as well (Jones et al. 1998; Jones and McPherson 1999). This site (SN1) is located on the south channel or mainstem 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 4). Later fish were sampled for marks using a variety of gear types on the spawning grounds and with gillnets at another set gillnet site near the confluence of Lake and Clear creeks. This site (SN2) is located on the mainstem of the Unuk River at approximately river km 14. The set gillnets were 37 m (120 ft) long by 4 m (14 ft) deep with 14 cm (5 3/8″) stretch mesh.

Using a two member crew, set gillnets were fished at SN1 (Figure 5) six hours per day, six days per week. One net (essentially a cross net) was attached to the 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 (essentially a lead net) was then attached to the same buoy and fished downstream along the eddy line created between the mainstem flow and the side slough.

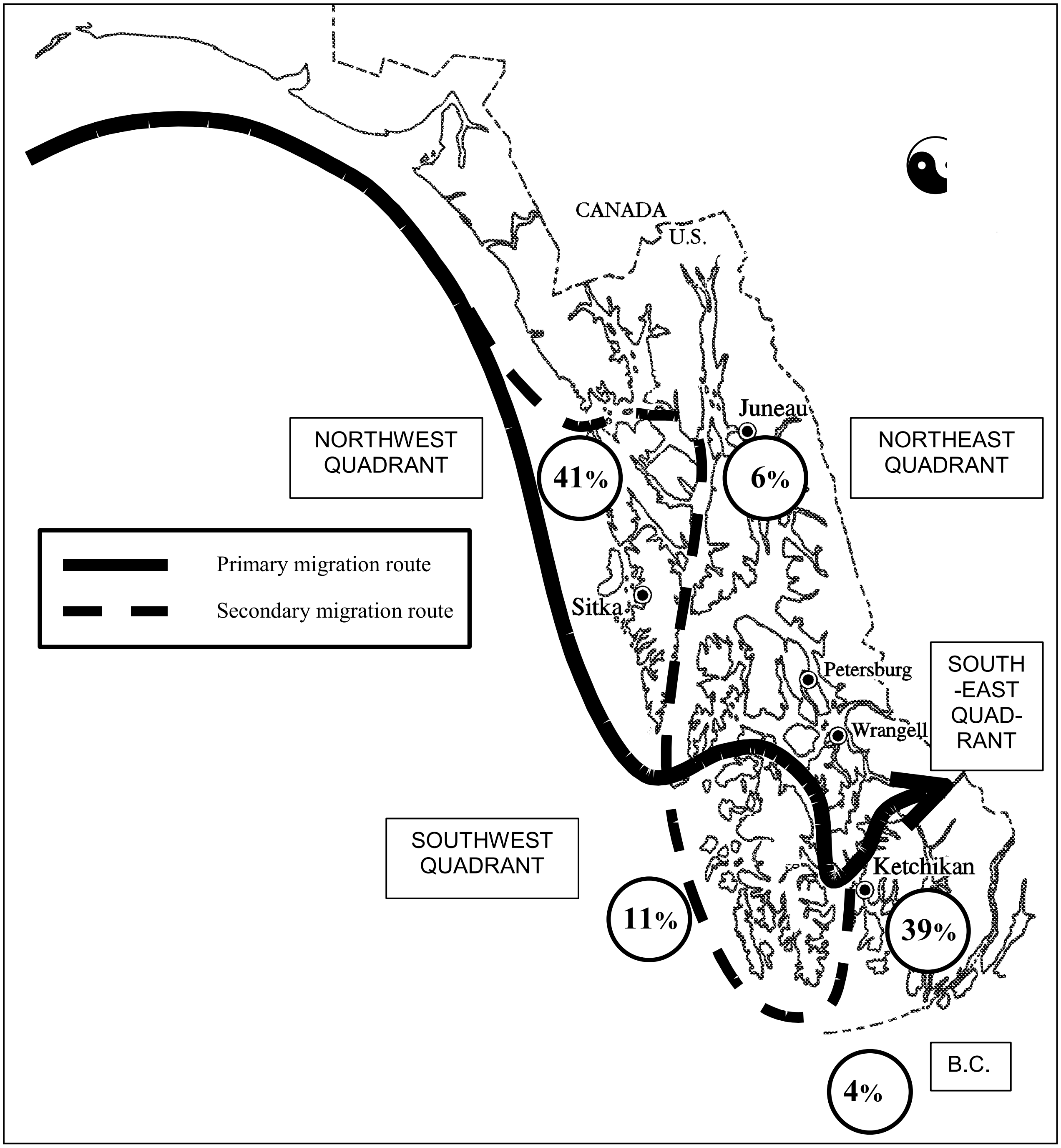

Figure 3.–Assumed, typical migration routes through Southeast Alaska of coho salmon bound for the Unuk River, based on recoveries of coded wire tags in marine sport and commercial fisheries since 1985. Also shown is the average percentage of coded wire tags from the Unuk River recovered in the Northwest, Northeast, Southwest, and Southeast quadrants of Southeast Alaska, as well as Canadian waters, since 1985(ADF&G Tag Lab and PSMFC databases).

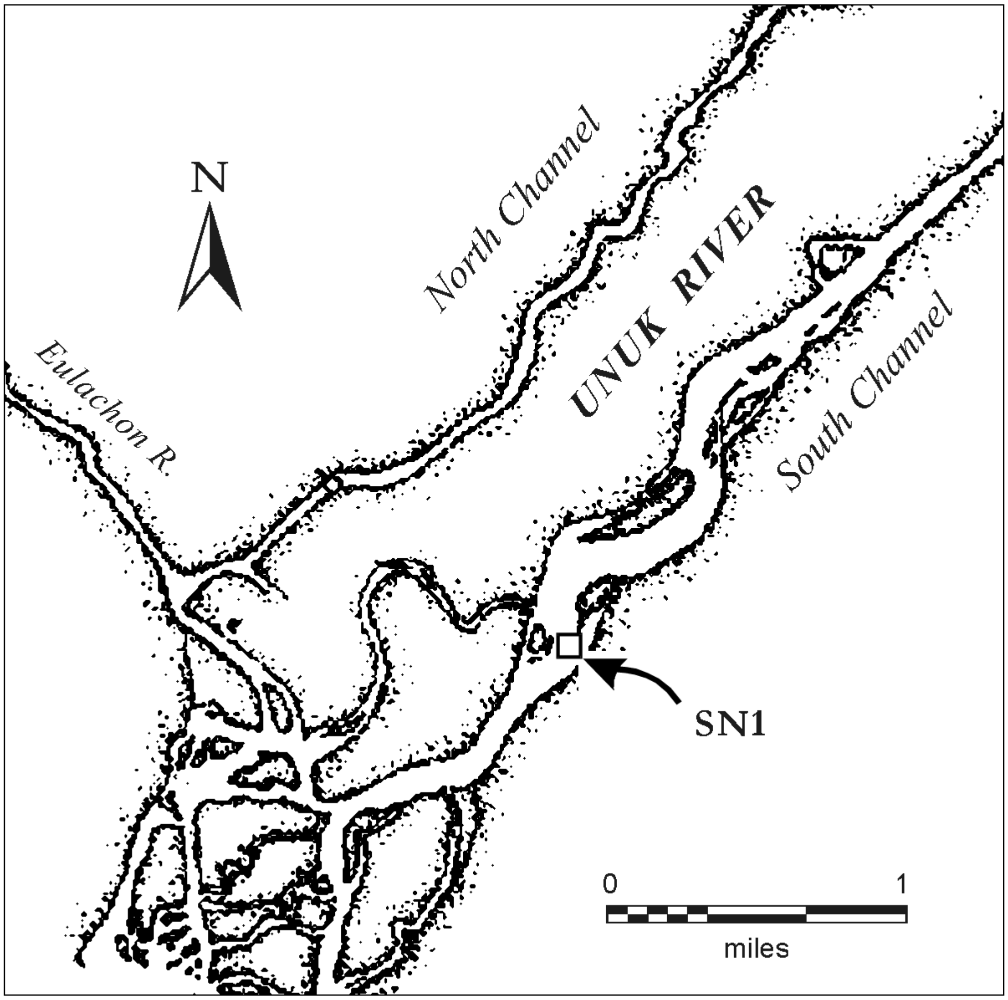

Figure 4.–Location of the set gillnet site (SN1) on the lower Unuk River in 1998.

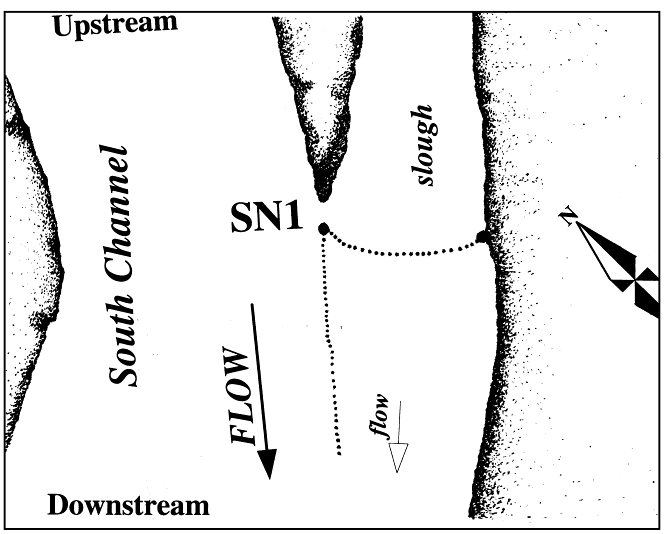

Figure 5.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River in 1998.

All fish captured, regardless of condition, 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 2½ mm 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× magnification. The presence of an adipose fin was also noted for each sampled fish, and those with missing adipose fins were sacrificed by having their heads removed and sent to the Tag Lab in Juneau for detection and decoding of CWTs.

Each captured fish that possessed an adipose fin and was previously unsampled was given three different marks: a uniquely numbered solid-core spaghetti tag, a clip of the left axillary appendage (LAA), and an operculum punch ¼″ in diameter that varied by date (Table 1).

Table 1.—Operculum punches, varying by date, used as secondary marks during the marking event of the two-event mark-recapture study.

Date	Operculum punch areas and abbreviations used
August 1–31	Left upper (LUOP)
September 1–15	Right upper (RUOP)
September 16–31	Right lower (RLOP)
October 1–31	Right middle (RMOP)

The two finclips enable detection of primary tag loss by temporal stratification. 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 a line crimp. Excess monofilament was then trimmed off. Each spaghetti tag was individually numbered and stamped with an ADF&G phone number.

Adult coho salmon were sampled for the presence of spaghetti tags and secondary marks on the spawning grounds, specifically at Gene's Lake, Clear, Lake, and Kerr creeks, the Eulachon River and in the mainstem of the Unuk River (Figure 2). Rod and reel snagging, bait, and lures as well as set gillnets were used to sample these fish, because varying the gear types used has been shown to produce unbiased estimates of age, sex, and length composition when sampling chinook salmon (McPherson et al. 1997; Jones et al. 1998; Jones and McPherson 1999). Also, set gillnets identical to those used at SN1 were used to sample fish at SN2. Sampling at SN2 was conducted between 22 August and 2 October to increase sample sizes. All inspected fish 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, secondary operculum punches, LLOPs, and LAAs and all were sampled for ASL data using the same techniques deployed in the lower river.

Chapman's modification of the Petersen estimate was used to estimate the abundance of adult coho salmon immigrating into the Unuk River in 1998 (Chapman 1951):

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

where $\hat{n}_1$ is the estimated number of fish marked during event 1 that immigrated to the river, n_2 is the number inspected for marks during event 2, and m_2 is the number of n_2 that possessed unique marks applied during event 1. To compensate for loss of tags from the study area caused by mortality associated with capture and tagging during event 1 (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 Estimate of Smolt Abundance. To provide evidence that assumption *a* was met, two χ^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 indicated to model the mark-recapture data; otherwise a temporally or spatially stratified estimator would be employed. Tests were made separately using the SPAS software program (Arnason et al. 1996). We also tested the hypothesis that the marked fraction sampled in event 2 did not vary over time. If it did, stratification of the experiment by time might be appropriate if the first χ^2 test above was rejected.

The possibility of size and sex selective sampling was also investigated, because assumption *a* can also be violated in this manner. The hypothesis that fish of different sizes were captured with equal probability was tested by using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.05$) (Appendix A1). Because sampling in the lower river spanned the entire known immigration of fish into the Unuk River and continued without interruption, the study is, due to the life history of the fish, closed to recruitment (assumption *b*). Assumption *c* was tested by a radiotelemetry study described earlier. 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 marks (assumption *e*). Double-sampling (assumption *f*) of fish was avoided by marking all sampled fish during 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 $\hat{\theta} = (1 - \hat{y})$ using the distribution binomial (t; n, $\hat{\theta}$) where t is the number of radios associated with successful spawning and n is the sample size (41) to compute $\hat{\theta} = t/n$. Then Table 2 was constructed and a bootstrap sample was built, by drawing with replacement a sample of size $\hat{N}_e^+$ from the empirical distribution defined by the capture histories (Table 2).

Table 2.–Capture histories for coho salmon in the population spawning in the Unuk River in 1998 (notation explained in text)**.**

Capture history	Sample size	Source of statistics
Number that died due to capture and tagging	181	$n_1\hat{y}$
Marked and not sampled in tributaries	543	$\hat{n}_1 - m_2$
Marked and recaptured in tributaries	18	m_2
Not marked, but captured in tributaries	401	$n_2 - m_2$
Not marked and not sampled in tributaries	11,460	$\hat{N}_e - \hat{n}_1 - n_2 + m_2$
Effective population for simulations	12,603	$\hat{N}_e^+$

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

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

where B is the number of bootstrap samples.

AGE, SEX, AND LENGTH COMPOSITION

The proportion of the spawning population composed of a given age was estimated as a binomial variable from fish sampled on the spawning grounds:

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

$$\operatorname{var}(\hat{p}_j) = \left(1 - \frac{n}{\hat{N}_e}\right)\left(\frac{\hat{p}_j(1-\hat{p}_j)}{n-1}\right) \quad (7)$$

where $\hat{p}_j$ is the estimated proportion of the population of age *j*, $\hat{n}_j$ is the number of coho salmon of age *j*, and *n* is the number of coho salmon sampled on the spawning grounds that were successfully aged, and $\hat{N}_e$ is the estimated total escapement.

Sex composition and age-sex composition for the entire spawning population 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

Harvest in 1998 of coho salmon originating from the Unuk River was estimated from fish sampled in commercial and recreational fisheries catches and from the escapement. Because several fisheries exploited Unuk River coho salmon over several months in 1998, 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 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, then summed across strata and across fisheries to obtain an estimate of the total $\hat{T}$:

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

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

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 in each stratum was counted and inspected to find recaptured fish. 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_{ci} had come from the Taku 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 $\theta_h = m_e / n_e$ where m_e is the number of adults sampled in 1998 that possessed valid detectable CWTs and n_e is the number of adults sampled in 1998. 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)

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

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

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

ESTIMATES OF RUN SIZE, EXPLOITATION, AND MARINE SURVIVAL

Estimates of total run (i.e., harvest and escapement) for coho salmon returning to the Unuk River in 1998 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

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

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

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 using the delta method (Seber 1982).

RESULTS

SMOLT CAPTURE, CODED-WIRE-TAGGING, AND SAMPLING

From 28 March to 18 May 1997, 11,502 coho salmon smolt ≥ 70 mm FL were captured in the Unuk River all of which were marked and tagged (Table 3). From 28 March to 8 May, 6,104 were tagged with CWT code 04-43-35, 23 of which were estimated to have died after tagging and 27 to have shed their tags resulting in 6,054 valid tags released. Another 5,398 smolt were tagged with CWT code 04-43-36 all of which were estimated to have survived tagging and 95 shed their tags resulting in 5,303 valid tags released. In total, 11,502 smolt were tagged of which 11,479 (=n_C) had their adipose fins clipped and 11,357 were released with valid tags.

Seventy-two percent (72%) of captured coho salmon smolt were taken between 31 March and 14 April (Figure 6; Table 3). Peak catches occurred from 5 April to 14 April (54%) with 50% of the catch occurring prior to 7 April; however, catches were protracted through most of the run. Coho salmon smolt averaged an estimated 84 mm FL in 1997 (Table 3; Figure 7). In addition to coho smolt tagging operations, 12,521 chinook salmon smolt were also captured and tagged of which 4 were estimated to have died after tagging and 0 to have shed their tags resulting in a valid release of 12,517 smolt bearing code 04-38-29 (Table 3).

ESTIMATE OF SMOLT ABUNDANCE

In 1998, 139 CWTs with codes released in the Unuk River were recovered from coho salmon in various fisheries as random recoveries in port, creel, or escapement sampling programs (Appendix A2). Recoveries in 1998 from smolt tagged in the spring of 1997 were primarily from troll gear (61%) and to a lesser extent from drift gillnet (19%) and purse seine (6%) gear. These recoveries were mostly from the Southeast (46%) and Northwest (40%) quadrants with the remainder being from the Southwest (9%) and Northeast (5%) quadrants. Of the 85 tags recovered in the commercial troll fishery, 54%, 28%, 12%, and 6% were from the Northwest, Southeast, Southwest, and Northeast quadrants. In the marine gillnet fisheries, 26 tags were recovered, all from the Southeast Quadrant and mainly off-loaded in Ketchikan (12) and Petersburg (9) and harvested in districts 106 (15) and 101 (10). Nine tags were recovered in the marine recreational fishery, six from the Ketchikan area and three from the Sitka area. Eight CWTs were recovered in seine fisheries

Table 3.–Number of salmon smolt caught and coded-wire-tagged using baited minnow traps on the Unuk River in 1997. Coho ≥70 mm FL total includes 23 overnight tagging mortalities and 122 shed tags. Chinook total includes 4 overnight tagging mortalities and 0 shed tags.

		Coho salmon			Chinook salmon			Water conditions	
Date	Traps checked	Number	Avg. length (mm)	Weight (g)	Number	Avg. length (mm)	Weight (g)	Temp. (°C)	Depth (in.)
28 Mar	77	448			359			2.0	4.0
29 Mar	100	578			413			1.0	4.3
30 Mar	105	664			420			1.5	3.3
31 Mar	106	686	82.2	5.8	518	71.4	3.5	2.0	2.8
1 Apr	114	620			527			2.0	0.5
2 Apr	117	270			443			0.5	7.5
3 Apr	108	285			248			2.0	5.5
4 Apr	81	220	81.6	5.6	574	71.8	3.8	1.0	3.5
5 Apr	135	734			673			1.5	1.5
6 Apr	133	900			712			1.0	1.0
7 Apr	105	428			550			2.0	1.3
8 Apr	128	526	84.2		741			2.0	2.0
9 Apr	138	541			908	70.6	3.5	2.0	3.0
10 Apr	126	664	85.8		897			2.0	3.8
11 Apr	119	506			1,073			2.0	5.5
12 Apr	112	582			710			2.5	5.8
13 Apr	118	592			823			3.0	7.0
14 Apr	98	730			591			3.0	8.0
15 Apr	106	528	86.4		477	71.3	3.7	3.0	8.3
16 Apr	94	392			313			2.0	14.0
17 Apr	101	608			379			2.0	14.8
18 Apr	65				173			1.7	14.5
Total	2,386	11,502			12,521				
Average	108	548	84.0	5.8	569	71.2	3.6	1.9	5.5
SD			9.68	1.81		6.03	0.96		
SE			0.03	0.01		0.02	0.00		

throughout the Northeast, Southeast, and Southwest quadrants and eleven CWTs were recovered during escapement sampling in the Unuk River.

The marked fraction with adipose finclips that returned to the Unuk River was estimated as $\theta_s = m_a / n_e$ where m_a is the number of adults sampled in 1998 that possessed adipose fin clips. The estimate of θ_s was 0.013 (SE = 0.003) and the estimate of smolt abundance $\hat{N}_s$ for 1997 is 809,677 (SE = 189,345). Both estimates were based on the 1,198 unique adult coho salmon handled in 1998 on the Unuk River while sampling for the two-event mark-recapture study (Appendix A3). Sixteen (16) of the fish inspected were missing adipose fins, and all were sacrificed to determine the tag codes present; 11 contained valid Unuk River tags and five heads had lost their tags after release. We assumed these five heads bore valid Unuk River tags as 100% of the valid tags were of Unuk River origin and previous studies (McPherson et al. 1997) have shown the incidence of naturally missing adipose fins in coho salmon to be low (i.e., less than 1 in 1,000), much below the rate here (i.e., 5 in 1,198).

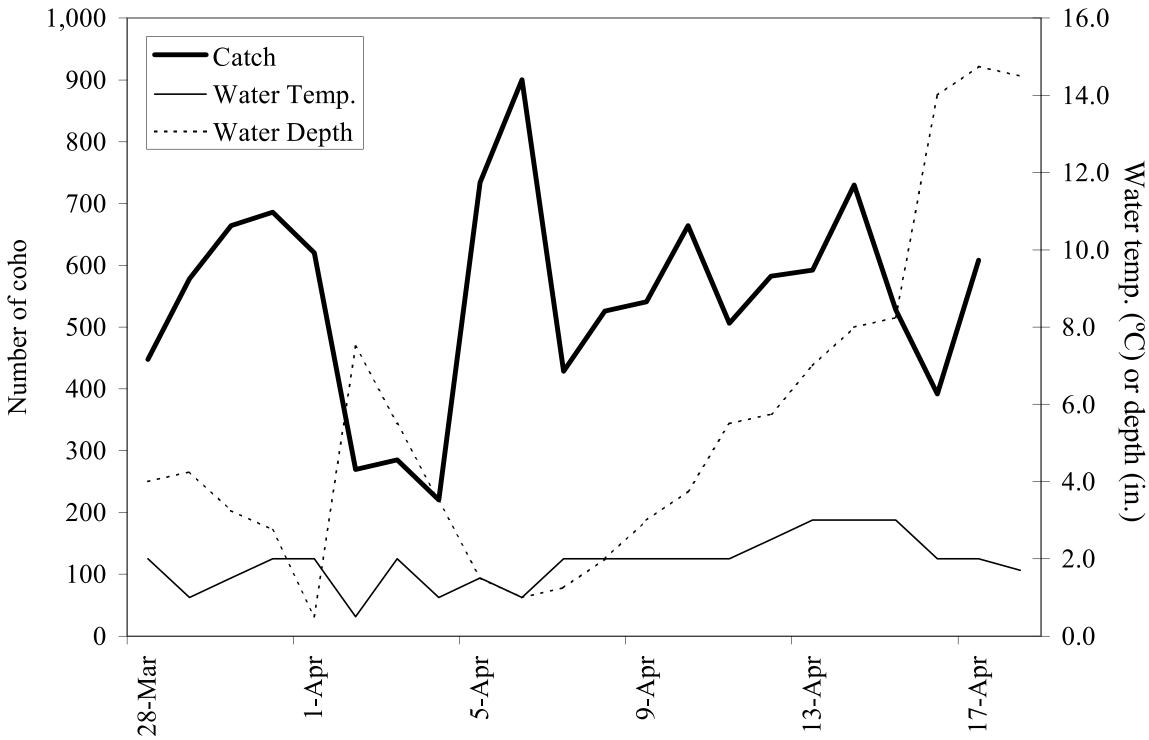

Figure 6.–Catch of coho salmon smolt ≥70 mm FL, daily water temperature, and water depth in the Unuk River in 1997.

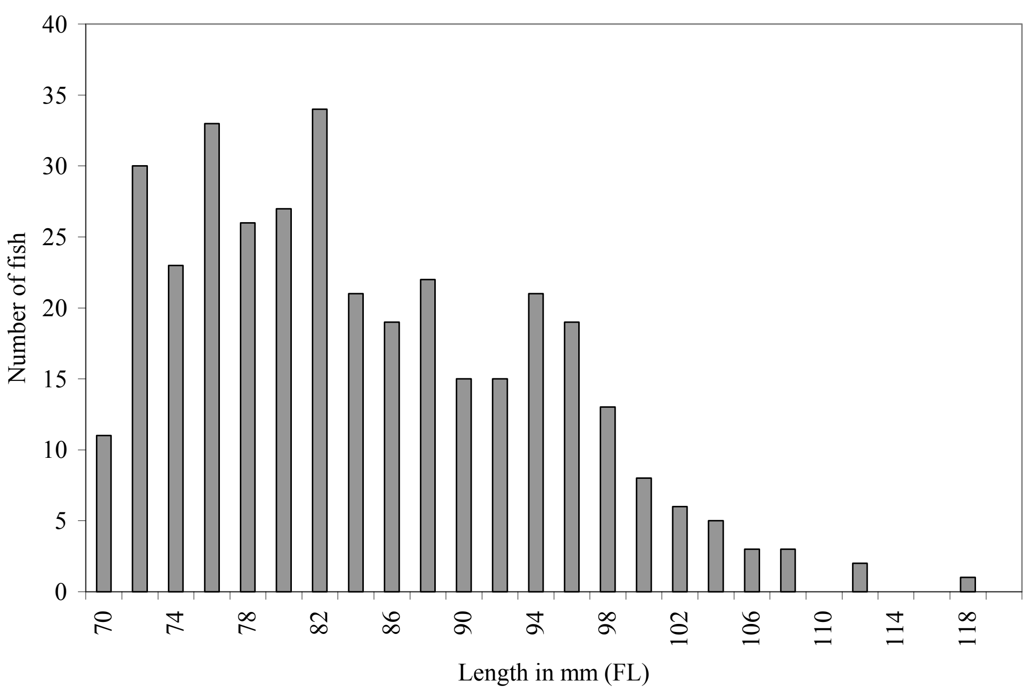

Figure 7.–Length frequency of coho salmon smolt ≥70 mm FL captured and measured in the Unuk River in 1997.

RADIOTELEMETRY

Telemetry flights were flown on 11 and 28 September and 3 and 6 November. Radiotagged fish were found in the Eulachon River and as far up as river mile 56 on the Unuk River in Canada (Figure 8; Appendix A4). On average, 45% of fish were found in the main channel of the Unuk River, 10% in the Eulachon River, and 4%, 1%, and 1% in Lake, Clear, and Cripple creeks. The remaining 40% were fish not found on an individual survey and only seven of these fish were not found in any survey. Three fish were seen at or near SN1 shortly after marking but never seen again. These fish likely backed back down into the salt water and were considered mortalities. These fish along with the seven not found constituted 24% of the total fish tagged with radio transmitters (Appendix A4). Thus, we estimate $\hat{y} = 0.24$ to adjust for the rate of mortality described in equation 4.

ESTIMATE OF ESCAPEMENT

We sampled a total of 797 coho salmon during event 1 in the lower Unuk River, and 742 of these were tagged and released (n_1). Ninety-five percent (95%) of the catch occurred between 5 August and 6 October (Table 4, Figure 9). Forty-three (43) fish were in poor condition upon capture and not tagged and 12 fish were missing adipose fins and sacrificed. Of the 12 sacrificed fish in event 1, 8 carried CWTs from smolt tagging on the Unuk River in 1997 and the other 4 had lost their tags.

We sampled a total of 419 coho salmon during event 2. Of these, 138 were sampled using set gillnets operated at SN2 and 281 were sampled by various methods at Genes, Clear, Lake, and Kerr creeks, the Eulachon River, and on the mainstem Unuk River (Table 4). Eighteen (18) of these fish were previously marked during event 1 and all of them possessed the primary tag with easily identifiable secondary marks. The largest samples were obtained by fishing set gillnets at SN2 (138 fish and 7 recoveries) and from the use of various gear types at the Eulachon River (111 fish and 4 recoveries). The event 2 samples were caught primarily after the second week of September because environmental conditions (i.e., flood events) precluded spending any significant effort during the first month of sampling.

The distribution of fish lengths marked in event 1 was significantly different (P = 0.01, Figure 10) from the distribution of lengths recaptured in event 2. Since the length distributions of fish captured during events 1 and 2 were also significantly different (P < 0.001, Figure 10), the selectivity of sampling during event 1 is not determined by the K-S tests (Appendix A1). However, the fractions of small ($\leq$600 mm MEF) and large (>600 mm MEF) coho salmon captured in event 2 that had been marked during event 1 ($\theta_{\leq 600} = 0.031$, $\theta_{>600} = 0.047$) were not significantly different ($\chi^2 = 0.42$, P = 0.52). Thus, sampling in event 1 (e.g., Figure 10) did not appear to be size-selective (else θ would vary by fish size), and the selectivity during sampling event 2 was not of consequence to estimating escapement.

Coho salmon marked early in the experiment (August 1 to September 5) were much less likely to be recaptured than fish marked later ($\chi^2 = 9.4$, df = 1, P = 0.002). In contrast, the fraction of fish inspected during event 2 which were previously marked in event 1 did not vary by sampling date (before or after 9/22; $\chi^2 = 1.76$, df = 1, P = 0.185), sampling location (downstream or upstream—i.e., Eulachon River vs. Clear, Genes, Lake, and Kerr Creeks; $\chi^2 = 0.061$, df = 1, P = 0.81), or sampling method (sampling with various gear types on the spawning grounds vs. the set gillnets used at SN2; $\chi^2 = 0.30$, df = 1, P = 0.58). Thus, all samples from event 2 were pooled and escapement was estimated using the Petersen model. The number of marked coho salmon ($n_1 = 742$) was discounted by the rate of mortality ($y = 0.24$) as determined by the radiotelemetry study to get the actual number of marked fish escaping ($\hat{n}_1 = 561$). Fish were divided into four capture histories (Table 2) and bootstrap procedures were performed to estimate variance, bias, and confidence intervals for $\hat{N}$.

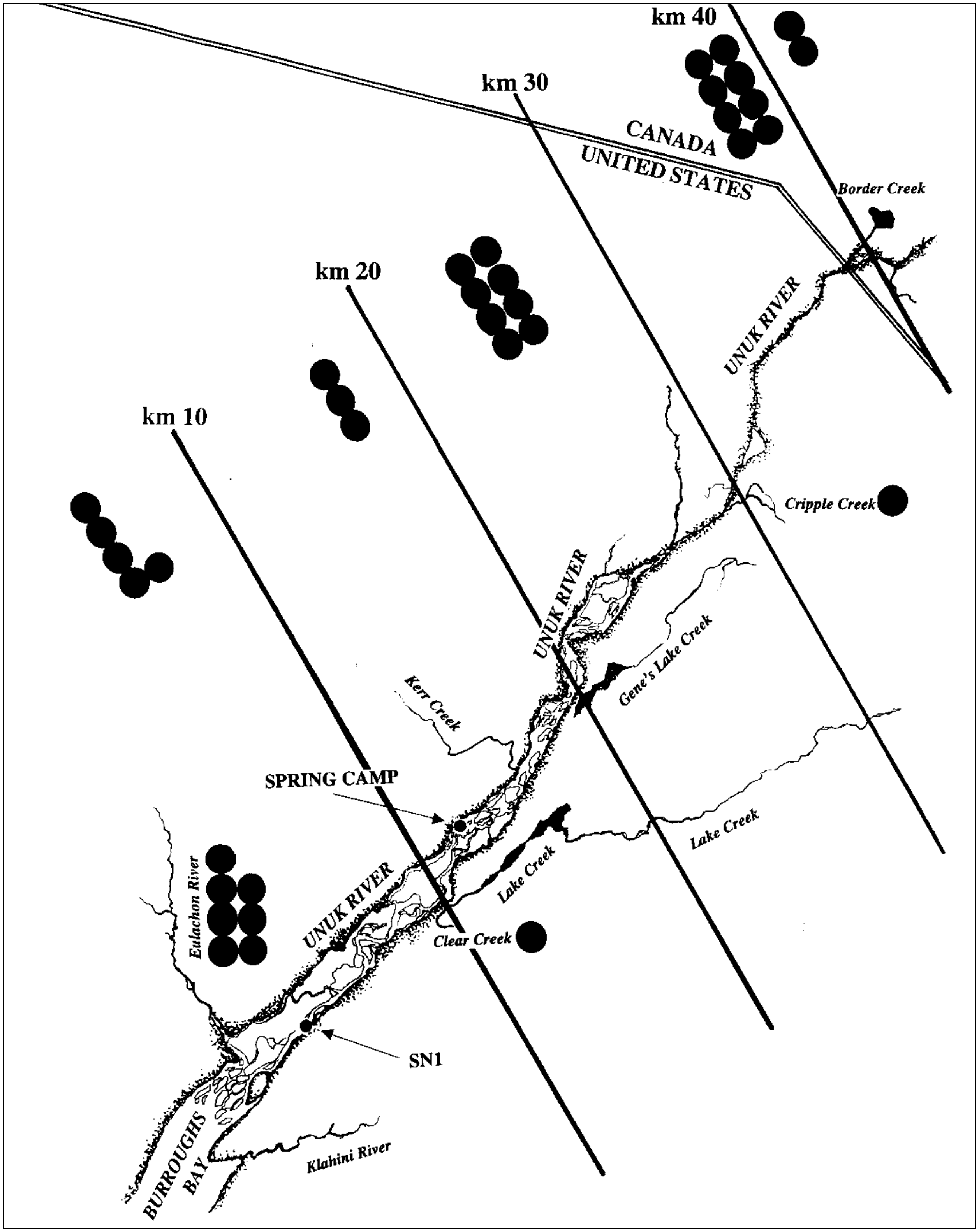

Figure 8.–Radiotracking index map showing the Unuk River (measured per 10 river km) and the main coho salmon spawning tributaries. Each circle refers to the farthest upstream location identified for a radiotagged fish.

Table 4.–Number of marked coho salmon released in the lower Unuk River and recaptured, by marking period and recovery location, and the number examined for marks at each recovery location, 1998.

			RECOVERY LOCATION							
Marking dates	No. marked	Fraction recovered	Eulachon River	Mainstem Unuk	SN2	Clear Creek	Lake Creek	Kerr Creek	Genes L. Creek	Total
8/1–8/22	200	0.0050					1			1
8/23–9/5	188	0.0106					1	1		2
9/6–9/19	239	0.0418			6	1	1	2		10
9/20–10/11	115	0.0435	4		1					5
Total/Average	742	0.0243	4		7	1	3	3		18
No. inspected			111	3	138	35	41	26	65	419
Fraction marked			0.036	0.000	0.051	0.029	0.073	0.115	0.000	0.043

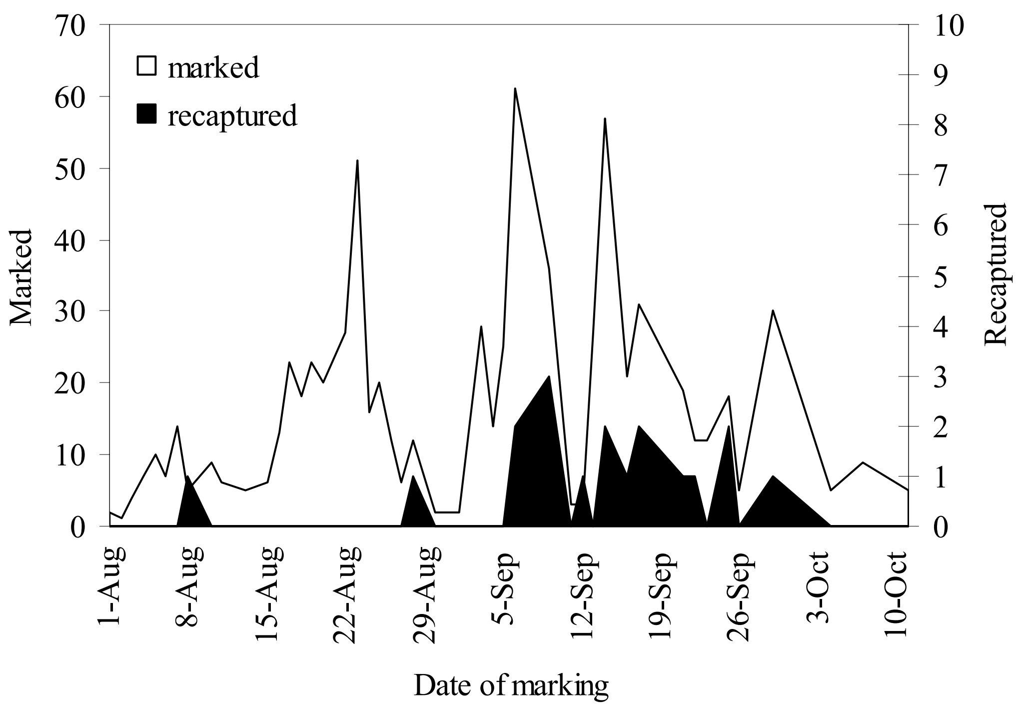

Figure 9.–Numbers of coho salmon marked in event 1 (open line) **by date and the subset recaptured in event 2** (filled line).

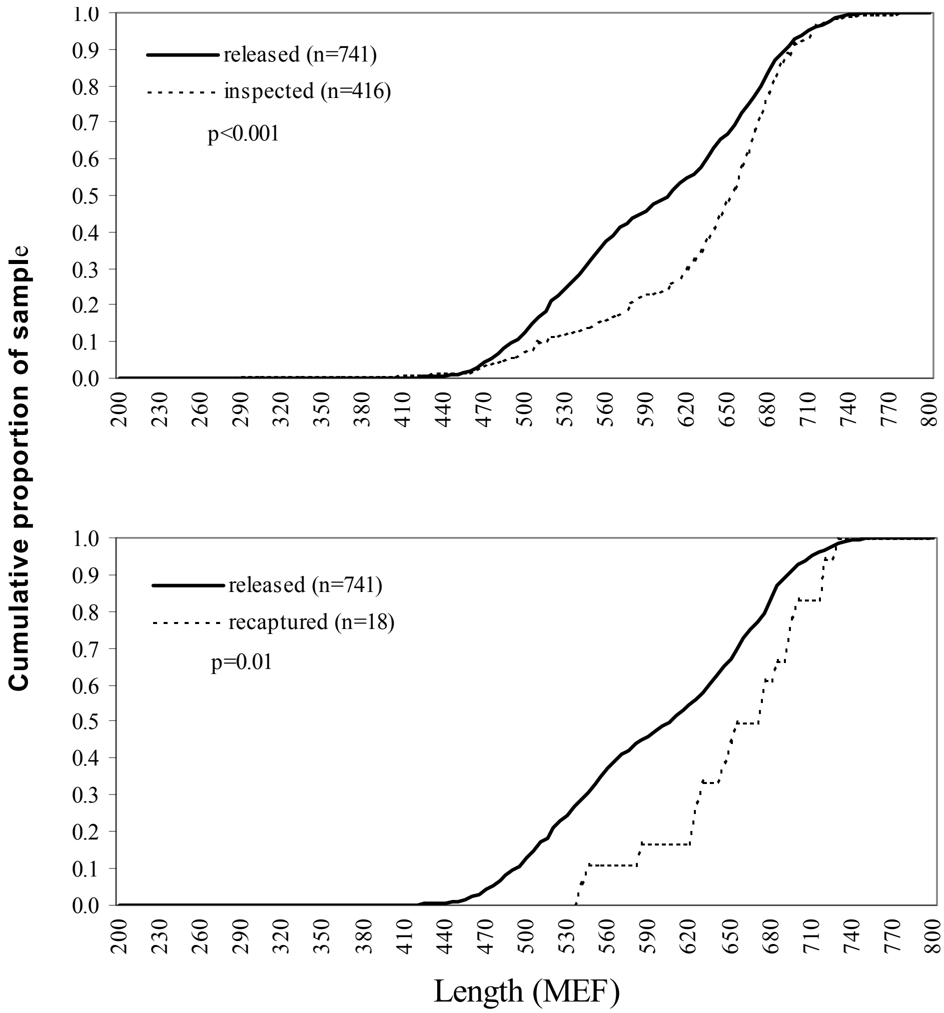

Figure 10.–Cumulative relative frequencies of adult coho salmon marked in the lower Unuk River in 1998 versus those inspected and recaptured on the spawning grounds.

The estimated escapement of coho salmon in the Unuk River in 1998 was 12,422 (SE = 3,298). Statistical bias in $\hat{N}$ was estimated at 2.5% and the 95% confidence interval for the estimate were 7,973 to 21,174 with a RP of ± 52%.

ESTIMATES OF AGE, SEX, AND LENGTH COMPOSITION

Estimates of age, sex, and length composition were based on samples collected in event 1 because event 1 sampling was shown to not be size-selective. Age-1.1 coho salmon dominated the age compositions of fish during sampling (Figure 11). Of the 742 fish tagged and released during event 1, 681 were successfully aged; 75% (SE = 1.7%) were age-1.1, and 25% (SE = 1.7%) were age-2.1. Males composed 55% (SE = 1.9%) of the aged sample in event 1 (Table 5; Appendix A5). For comparison purposes, 350 of the 419 fish sampled in event 2 were successfully aged, and 70% (SE = 2.4%) were age-1.1, and 29% (SE = 2.4%) age-2.1; age-1.0 and age-2.0 were each less than 1% (SE = 0.3%). From the total run of 57,811 coho salmon bound for the Unuk

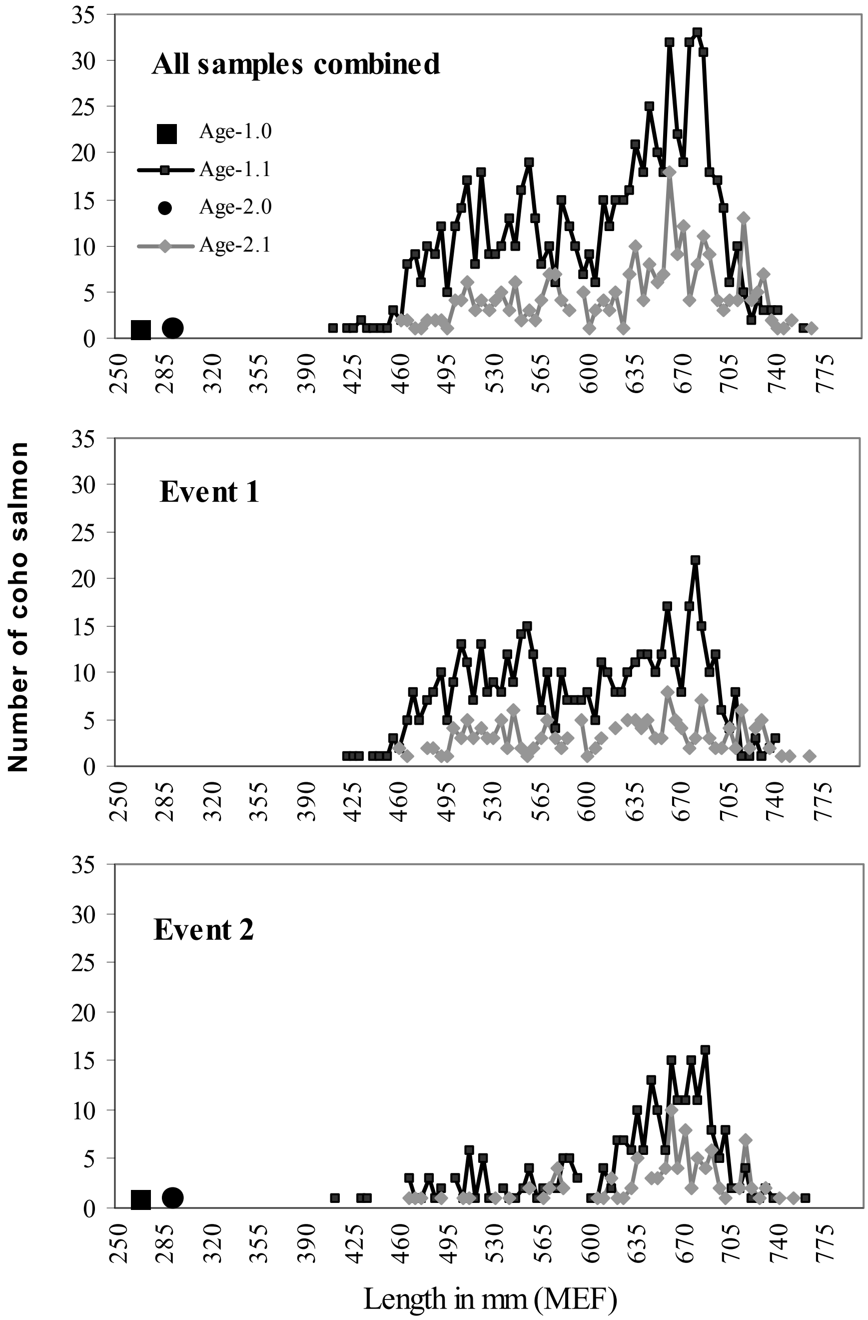

Figure 11.–Numbers of coho salmon sampled by length and age in the Unuk River in 1998.

River, an estimated 43,209 (SE = 6,172) were age-1.1 and 14,601 (SE = 2,270) were age-2.1 and 31,579 (SE = 6,030) were males (Table 5). For events 1 and 2 combined, age-1.1 fish accounted for 73% (SE = 1.4%), age-2.1 fish for 27% (SE = 1.4%) and 56% (SE = 0.2) of the escapement were males (Appendix A5). The age composition for fish sampled during event 1 was not significantly different than those sampled in event 2 (P = 0.16), and this was the case for the sex composition as well (P = 0.14).

In general, smaller fish were captured during event 1 than in event 2 (Appendix A5; Figure 11). During event 1, the smallest fish sampled was 420 mm, the largest was 765 mm, and the mean was 600 mm (SE = 3 mm) MEF in length. In event 2, the smallest fish sampled was 265 mm, the largest was 780 mm, and the mean was 634 mm (SE = 4 mm) MEF in length.

Estimates of Harvest, Mean Date of Harvest, Total Run, Exploitation Rate, and Marine Survival

An estimated 45,388 (SE = 7,461) coho salmon originating from the Unuk River were harvested in marine commercial and sport fisheries in 1998 throughout Southeast Alaska (Tables 6, 7). The troll fishery in the Northwest Quadrant took 38.0% of the estimated marine harvest and the drift gillnet fishery in District 101 near Ketchikan took 9.8% (Table 7). The troll harvest was spread over a long period (i.e., July through September) and most gillnet harvest occurred during a three week period (i.e., 16 August through 4 September) (Figure 12). Estimated mean date of harvest in the troll fishery was 8 August, compared to 30 August for the gillnet fishery (Appendix A6). Coho salmon originating from the Unuk River contributed an estimated 7.3% (4,445 fish; SE = 1,698) of the District 101 gillnet catch (60,265 fish). Eighty-four (84%) percent of the estimated harvest occurred by 5 September. The estimated harvest of coho salmon bound for the Unuk River in the Ketchikan marine recreational fishery was 4,691 (SE = 2,334) or 19.5% of the Ketchikan marine recreational fishery (24,059 fish), based on harvest and sampling data from Hubartt et al. (1999). An estimated 57,811 (SE = 8,158) coho salmon bound for the Unuk River returned in 1998. The estimated marine survival rate was 7.1% (SE = 2.0%), which is substantially lower than the average seen in recent years (1984–1997) from nearby Hugh Smith Lake (13.4%) located approximately 100 km south (Shaul 1998). The estimated exploitation rate in marine commercial and sport fisheries was 78.5% (SE = 5.3%)(Table 7), which is slightly higher than the average from Hugh Smith Lake (70%) in recent years (1982–1997) but similar to that seen in 1998 (77%).

Table 5.–Age and sex composition of Unuk River coho salmon escapement, harvest, and run in 1998 based on samples gathered during event 1 sampling in the lower river.

		Age		
		1.1	2.1	**Total**
Females	N	236	73	309
	%	34.7	10.7	45.4
	SE	1.8	1.2	1.9
	Escapement	4,305	1,332	5,636
	SE	1,164	381	2,222
	Harvest	15,729	4,865	20,595
	SE	2,712	960	5,026
	Total run	20,034	6,197	26,231
	SE	3,014	1,107	5,495
Males	N	273	99	372
	%	40.1	14.5	54.6
	SE	1.9	1.4	1.9
	Escapement	4,980	1,806	6,786
	SE	1,341	506	2,438
	Harvest	853	614	24,794
	SE	3,107	1,242	5,515
	Total run	23,175	8,404	31,579
	SE	3,443	1,416	6,029
Total	N	509	172	681
	%	74.7	25.3	100.0
	SE	1.7	1.7	
	Escapement	9,285	3,137	12,422
	SE	2,473	857	3,298
	Harvest	33,925	11,464	45,388
	SE	5,626	2,027	7,461
	Total run	43,209	14,601	57,811
	SE	6,172	2,270	8,158

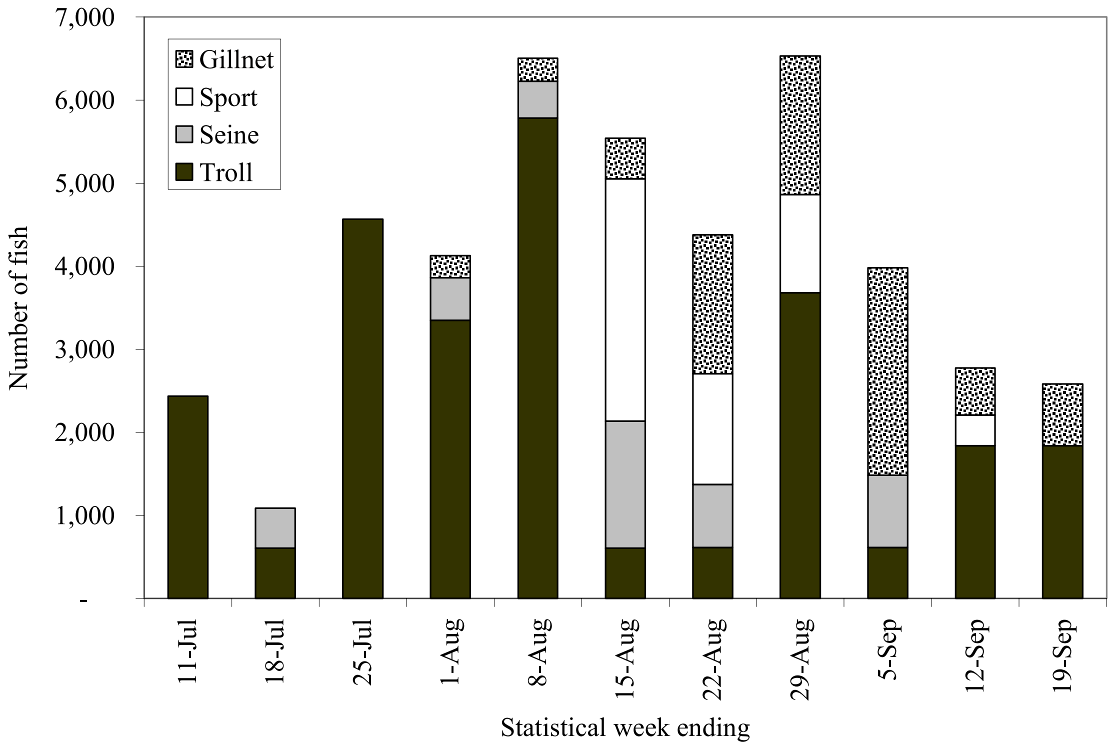

Figure 12.–Estimated harvest of coho salmon bound for the Unuk River, by statistical week, in marine commercial and recreational fisheries in 1998. Weekly estimates of harvest in the troll fishery are approximated.

DISCUSSION

Varying the types of gear used for sampling chinook salmon in spawning areas has been shown to reduce bias in age, sex, and length composition summaries (McPherson et al. 1997; Jones et al. 1998; Jones and McPherson 1999). However, it became evident that this strategy did not yield representative samples of the coho salmon escapement on the Unuk River in 1998, because frequent flooding early in the study (late August and early September) precluded effective sampling of the early-run component of the immigration (Figure 9). The early-run fish are typically smaller fish, having spent less time feeding in the salt water, and this is apparent from the average lengths gathered from stratum 1 (566 mm MEF) versus stratum 2 (664 mm MEF). These fish may have spawned in areas not sampled during this study (such as Boundary Creek and the upper Eulachon River), but it is also likely they simply avoided capture by immigrating on flood events and spawned before sampling could be effectively resumed in mid September. The resulting sampling bias made the data collected during the second sampling event unsuitable for use in the age, sex, and length composition summaries. However, the samples collected by gillnet during the first sampling event were suitable for constructing unbiased composition summaries (Table 5; Appendix A5).

Experiences from sampling chinook salmon on the Unuk River suggested that fish bound for the various spawning tributaries could be proportionately sampled with set gillnets at SN1 (Pahlke et al. 1996, Jones et al. 1998). Thus, SN1 was the most logical site to use for marking coho salmon in 1998. In this study the marked fraction in each tributary ranged between 0% and 12% and averaged 4% for all tributaries combined. Kerr Creek produced the highest marked fraction, although it was not significantly different from the other sampling sites combined (χ^2 = 3.05, df = 1, P = 0.08). Loss of primary tags in this study was not a problem, as none of the recoveries were missing their primary tags. In all cases, secondary marks were clearly visible on recaptured fish.

Data gathered in the radiotelemetry study (Appendix A4) showed fish scattered throughout the drainage. Not all radiotagged fish behaved in a similar fashion. Some fish (e.g., frequencies 151.913 and 151.872) moved quickly to their spawning areas and remained there until dying, while other fish (e.g., frequencies 151.793 and 151.174) 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 to spawn and die (Appendix A4). Such milling behavior has been noted not only in coho salmon (Jones and McPherson 1997) but also in chinook salmon (Jones et al. 1998; Jones and McPherson 1999). Milling fish may gain an advantage by ripening in deep glacial waters, pools, or in lake areas for extended periods of time, 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*). Other fish (i.e., those that move quickly to their spawning areas) may gain an advantage by reaching an otherwise unattainable spawning location during high water, or a distant spawning location that requires a great deal of time to reach. Some fish were not found for weeks after being tagged but were successfully located during one of the later radiotelemetry flights. These fish probably backed down into the salt water, exhibiting a "sulking" behavior as a result of capture and marking. This behavior has been noted in one study of coho salmon on the Taku River (Eiler et al. *In prep*) and repeatedly in studies of chinook salmon (Johnson et al. 1992; Pahlke et al. 1996). Other fish were simply not found at all or were found emitting a mortality signal at or near SN1, and considered to have died as result of the handling and tagging procedures.

Although the population of spawning adults in this study was not strictly closed to losses from mortality, it was closed to recruitment, as tagging appeared to span the immigration. Similarly, the population estimate for maturing smolts 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 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 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 6). Also, the fraction of adults escaping to the Unuk River over time (before and after September 10) contained similar fractions of CWTs (χ^2 < 0.001, df = 1, P = 0.98): 1.52% (8/520) for the first period and 1.49% (4/265) for the later period. In contrast, the estimate of adult abundance relies largely on the first 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 finding similar marked fractions by area and size of fish sampled on the spawning grounds, as previously noted.

The relative precision (RP) of our chinook and coho salmon mark-recapture experiments has been shown to improve in consecutive years of study, owing to knowledge gained over time. Our goal for this first-year study was to achieve a RP of ± 50% for a 95% confidence interval; in fact, a RP of ± 53% (CV = 27%) was obtained. Marking of fish probably began early enough to avoid missing any immigrating fish; however, the inherent tendency of most coho salmon stocks is toward very prolonged immigrations, and marking ceased in 1998 on 11 October—probably before the last immigrants entered the river (Figure 9). 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 to be insignificant at the achieved level of precision (50%) for our experiment.

Table 6.–Estimated marine harvest of adult coho salmon bound for the Unuk River in 1998, where $\hat{\theta}_h = 0.0092$ and $G(\hat{\theta}_h^{-1}) = 0.191$. In fishing periods and fishing quadrants for which no CWT was recovered with the appropriate code, harvest was assumed to be zero. H = number of adult coho salmon caught in a stratum in 1998, a = number of adult coho salmon missing adipose fins in a sample of H in a stratum, a' = number of heads that arrive at the ADF&G Tag Lab for dissection (subset of a) in a stratum, t = number of heads containing tags, t' = number of valid tags (subset of t) in a stratum, m_c = number of tags with code(s) originating from the Unuk River (subset of t') in a stratum, and $\hat{r}$ = harvest of coho salmon originating from the Unuk River in a stratum.

TROLL FISHERY

Stat.wk	Dates (period)	Quad	H	var(H)	n_i	a	a'	t	t'	m_c	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
19–33	5/3–8/15 (3)	NE	135,976	0	36,893	699	688	575	573	3	1,228	833	133%
34–41	8/16–10/10 (4)	NE	31,778	0	11,904	295	293	237	236	2	588	453	151%
19–33	5/3–8/15 (3)	NW	761,928	0	232,803	4,712	4,645	3,917	3,913	32	11,583	5,392	91%
34–41	8/16–10/10 (4)	NW	314,915	0	85,395	2,246	2,230	1,952	1,950	14	5,669	2,829	98%
19–33	5/3–8/15 (3)	SE	122,693	0	76,236	892	878	665	664	13	2,318	1,167	99%
34–41	8/16–10/10 (4)	SE	59,399	0	36,447	711	702	558	556	11	1,985	1,021	101%
19–33	5/3–8/15 (3)	SW	184,373	0	82,554	804	793	549	548	9	2,224	1,179	104%
34–41	8/16–10/10 (4)	SW	24,157	0	7,961	109	104	76	76	1	346	346	196%
Subtotal troll fishery			1,635,219	0	570,193	10,468	10,333	8,529	8,516	85	25,940	6,472	49%

SEINE FISHERY

Stat.wk	Date	District	H	var(H)	n_i	a	a'	t	t'	m_c	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
29	7/12–7/18	104	9,221	0	4,165	44	44	28	28	2	482	372	151%
31	7/26–8/1	104	11,519	0	2,442	24	24	18	18	1	514	513	196%
33	8/9–8/15	104	26,990	0	3,162	44	42	29	29	1	974	973	196%
32	8/2–8/8	106	4,646	0	1,140	11	11	6	6	1	444	443	196%
36	8/30–9/5	106	7,348	0	918	11	11	6	6	1	872	871	196%
33	8/9–8/15	109	12,884	0	2,578	65	65	61	60	1	553	553	196%
34	8/16–8/22	109	23,922	0	3,509	81	79	68	68	1	761	761	196%
Subtotal seine fishery			96,530	0	17,914	280	276	216	215	8	4,600	1,786	76%

SPORT FISHERY

Biweek	Date	Area	H	var(H)	n_i	a	a'	t	t'	m_c	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
16	8/3–8/16	Sitka	14,903	6,385,157	4,435	162	160	145	145	3	1,112	767	135%
16	7/6–7/19	Ketchikan	1,332	98,394	132	23	14	12	12	1	1,805	1,805	196%
17	7/2– 8/2	Ketchikan	1,348	80,733	259	20	17	15	15	2	1,334	1,044	196%
18	8/3–8/16	Ketchikan	2,401	1,340,873	442	8	8	6	6	2	1,183	982	196%
19	8/17–8/30	Ketchikan	4,007	945,056	1,218	36	35	31	31	1	369	368	196%
Subtotal sport fishery			23,991	8,850,213	6,486	249	234	209	209	9	5,803	2,457	83%

GILLNET FISHERY

Stat.wk	Date	District	H	var(H)	n_i	a	a'	t	t'	m_c	$\hat{r}$	$SE(\hat{r})$	$RP(\hat{r})$
31	7/26–8/1	106	11,803	0	4,938	136	134	110	110	1	264	264	196%
32	8/2–8/8	106	17,796	0	7,052	91	90	73	73	1	278	277	196%
33	8/9–8/15	106	16,156	0	7,221	69	69	49	49	2	487	376	151%
34	8/16–8/22	106	19,661	0	7,033	86	83	65	65	4	1,262	791	123%
35	8/23–8/29	106	22,830	0	9,059	92	92	75	75	2	549	423	151%
36	8/30–9/5	106	21,852	0	8,189	140	140	119	119	1	291	290	196%
37	9/6–9/12	106	26,473	0	10,313	230	228	200	199	2	567	437	151%
38	9/13–9/19	106	37,559	0	12,509	264	263	233	233	1	328	328	196%
39	9/20–9/26	106	20,482	0	7,834	199	197	174	174	2	575	443	151%
34	8/16–8/22	101	3,482	0	934	20	20	16	16	1	406	406	196%
35	8/23–8/29	101	6,326	0	1,300	39	37	32	32	2	1,117	862	151%
36	8/30–9/5	101	6,512	0	1,608	37	37	28	28	5	2,205	1,310	116%
38	9/13–9/19	101	12,766	0	4,325	191	149	127	127	1	412	412	196%
39	9/20–9/26	101	5,381	0	1,959	63	62	54	54	1	304	304	196%
Subtotal gillnet fishery			229,079	0	84,274	1,657	1,601	1,355	1,354	26	9,046	2,135	46%
TOTAL ALL FISHERIES			2,017,779	8,850,213	690,092	12,984	12,757	10,598	10,583	128	45,388	7,461	32%

Table 7.–Estimated harvest, exploitation, and total run of Unuk River coho salmon in 1998.

Fishery	Area	Estimated harvest	SE	Percent of marine harvest	Percent of total run
U. S. TROLL FISHERY	NE Quadrant	1,816	948	4.0	3.1
	NW Quadrant	17,251	6,089	38.0	29.8
	SE Quadrant	4,303	1,550	9.5	7.4
	SW Quadrant	2,570	1,228	5.7	4.4
	Subtotal	25,940	6,472	57.2	44.9
SEINE	District 104	1,970	1,162	4.3	3.4
	District 106	2,630	1,357	5.8	4.5
	Subtotal	4,600	1,786	10.1	8.0
SPORT	Sitka	1,112	767	2.4	1.9
	Ketchikan	4,691	2,334	10.3	8.1
	Subtotal	5,803	2,457	12.8	10.0
GILLNET	District 106	4,601	1,293	10.1	8.0
	District 101	4,445	1,698	9.8	7.7
	Subtotal	9,046	2,135	19.9	15.6
Total marine harvest		45,388	7,461	100.0	78.5
Total escapement		12,422	3,298		21.5
Total run		57,811	8,158		100.0
Estimated marine survival		7.1%	2.0%		
Estimated exploitation rate		78.5%	5.3%		

This is an ongoing study designed to estimate total escapement, harvest, run, marine survival, and exploitation rate of Unuk River coho salmon. Recent changes in run strength in nearby Ketchikan stocks have prompted concern over the status of coho salmon in southern Southeast Alaska. It has been thought that the Unuk River produced total runs between 20,000 and 50,000 adult coho salmon. Results from our study have shown this range to be low, considering this year's total run estimate of 58,540. The study has further shown that coho salmon from the Unuk River contribute significantly to the marine and recreational fisheries of Southeast Alaska.

Unlike the long-term study conducted at Hugh Smith Lake (a small producer averaging about 4,339 coho salmon during 1982–1997; Shaul 1998), the Unuk River study is the only one to be conducted on such a large producer of coho salmon in southern Southeast Alaska. Results of these studies and future year's 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.

By tagging more smolt each spring with CWTs, we can improve the precision of smolt abundance and harvest estimates, especially those from the sport fishery. Thus, we recommend that 21K smolt be tagged to meet a target RP of 25%. This can be accomplished by starting earlier and ending later in order to cover a greater proportion of the smolt emigration. In addition, concentrating effort on coho versus chinook salmon smolt trapping during periods of poor chinook salmon trapping conditions should further boost the numbers of coho salmon tagged each spring and ultimately lead to a greater number of tags recovered from the fisheries in the following year.

In an effort to gain a larger representative sample of the adult population, escapement sampling should start immediately after event 1 marking begins. Further, more emphasis should be placed on sampling the early-run tributaries, including those accessible in Canada. Because adverse environmental conditions like those encountered in 1998 can defeat these efforts, it is imperative that gillnet sampling during the marked event provide constant sampling effort over time, and span the vast (95%) portion of the immigration.

Finally, the rate of naturally missing adipose fins should be scrutinized during smolt tagging; our results suggest either a high CWT loss rate between 1998 and 1999 (5 of 16 fish with missing adipose fins) or a high rate of missing adipose fins (5 of 1,198 fish sampled on the spawning grounds). It has been shown in other coho salmon studies that the rate of missing adipose fins is typically less than 1 in every 1,000 fish (McPherson and Bernard 1996); we therefore assume that all fish sampled in the Unuk River with missing adipose fins were previously marked 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 1 in 100, then difficulties may arise in distinguishing between the two rates.

ACKNOWLEDGMENTS

We thank Dave Magnus, Dave Dreyer, Red Weller, and Cliff Kemmerling of ADF&G for coho salmon smolt tagging operations in 1997. We thank Tim Schantz, Brett Hiatt, Steve McCurdy, Zelda Swain, and Alicia Bachensky of ADF&G for adult coho salmon mark-recapture sampling in 1998. We thank Keith Pahlke for his help with the logistical setup and implementation of the radiotagging study and Bob Marshall for his expertise with biometric support. We thank all of the personnel involved with the recovery of CWT-tagged coho salmon in 1998 and Karen Crandall, Detlef Buettner, Anna Sharp and the rest of the CFMD Tag Lab in Juneau for dissecting and decoding heads and providing sampling supplies and data on CWT recoveries. We thank Sue Millard for aging adult scales and Alma Seward for help with the final preparation of this manuscript.

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APPENDIX A

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

RESULTS OF HYPOTHESIS TESTS, K-S AND χ^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 the second sampling event but there is during the first.	
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 the second sampling event; the status of size-selectivity during the first event 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 the second sampling event 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 the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

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 the second event (Cases I or II).

Appendix A2.–Random and select recoveries of coded-wire-tagged coho salmon bound for the Unuk River in 1998.

Head number	Tag code	Gear	Recovery date	Stat. week	Quad	Dist.	Sub-dist.	Length	Port survey site	Sample number
					RANDOM RECOVERIES					
29717	44335	TROLL	21-Jul	30	NE	109	10	703	PORT ALEXANDER	98080097
29958	44335	TROLL	3-Aug	32	NE	109	10	664	PORT ALEXANDER	98080156
84003	44335	TROLL	7-Aug	32	NE	109	10	663	PORT ALEXANDER	98080166
69006	44336	TROLL	23-Aug	35	NE	109	10	750	SITKA	98031154
18151	44335	TROLL	24-Aug	35	NE	109	61	684	PETERSBURG	98050944
50530	44336	TROLL	6-Jul	28	NW	113	91	635	ELFIN COVE	98020101
40148	44335	TROLL	7-Jul	28	NW	113	94	630	HOONAH	98110052
65569	44335	TROLL	7-Jul	28	NW	113		633	SITKA	98030609
40127	44336	TROLL	8-Jul	28	NW	113	91	565	HOONAH	98110051
55579	44335	TROLL	9-Jul	28	NW	113	41	588	SITKA	98030634
40192	44336	TROLL	12-Jul	29	NW	113	91	645	HOONAH	98119997
66142	44336	TROLL	21-Jul	30	NW	113	21	628	SITKA	98030802
57079	44336	TROLL	24-Jul	30	NW	113	21	635	SITKA	98030844
37318	44336	TROLL	25-Jul	30	NW	113	91	684	PELICAN	98010054
57833	44335	TROLL	27-Jul	31	NW	113		668	SITKA	98030900
57281	44336	TROLL	27-Jul	31	NW	113	21	670	SITKA	98030869
37380	44335	TROLL	28-Jul	31	NW	113	91	668	PELICAN	98010059
57802	44335	TROLL	29-Jul	31	NW	113	31	542	SITKA	98030899
57384	44335	TROLL	2-Aug	32	NW	113	41	664	SITKA	98030935
67441	44335	TROLL	4-Aug	32	NW	113	41	650	SITKA	98030957
67237	44336	TROLL	5-Aug	32	NW	113	45	640	SITKA	98030973
37602	44336	TROLL	11-Aug	33	NW	113	91	640	PELICAN	98010088
68416	44336	TROLL	23-Aug	35	NW	113	91	688	SITKA	98031136
68677	44336	TROLL	26-Aug	35	NW	113		720	SITKA	98031151
37797	44335	TROLL	27-Aug	35	NW	113	91	732	PELICAN	98010117
37801	44336	TROLL	27-Aug	35	NW	113	91	771	PELICAN	98010117
37823	44336	TROLL	31-Aug	36	NW	113	91	701	PELICAN	98010120
123596	44336	TROLL	2-Sep	36	NW	113	41	648	SITKA	98031216
37960	44336	TROLL	9-Sep	37	NW	113	91	678	PELICAN	98010139
125127	44336	TROLL	10-Sep	37	NW	113	41	711	SITKA	98031274
125150	44335	TROLL	11-Sep	37	NW	113	91	690	SITKA	98031294
112977	44336	TROLL	17-Sep	38	NW	113	41	714	SITKA	98031359
125881	44336	TROLL	18-Sep	38	NW	113	41	703	SITKA	98031387
37413	44336	TROLL	29-Jul	31	NW	116		528	PELICAN	98010062
55300	44335	TROLL	10-Jul	28	NW	154		667	SITKA	98030649
66391	44335	TROLL	21-Jul	30	NW	154		669	SITKA	98030805
57974	44335	TROLL	30-Jul	31	NW	154		700	SITKA	98030914
67585	44336	TROLL	5-Aug	32	NW	154		638	SITKA	98030978
67737	44335	TROLL	7-Aug	32	NW	154		660	SITKA	98031002
68323	44335	TROLL	24-Aug	35	NW	154		707	SITKA	98031117
69242	44335	TROLL	6-Sep	37	NW	154		695	SITKA	98031256
45363	44335	TROLL	25-Jul	30	NW	181	60	675	YAKUTAT	98140027
45409	44336	TROLL	29-Jul	31	NW	181	60	710	YAKUTAT	98140040
56543	44336	TROLL	9-Jul	28	NW			648	SITKA	98030673
37374	44335	TROLL	25-Jul	30	NW			561	PELICAN	98010056
37325	44335	TROLL	25-Jul	30	NW			678	PELICAN	98010056
56983	44336	TROLL	27-Jul	31	NW			696	SITKA	98030868
57183	44335	TROLL	27-Jul	31	NW			665	SITKA	98030881
67198	44335	TROLL	2-Aug	32	NW			653	SITKA	98030953
67861	44336	TROLL	6-Aug	32	NW			628	SITKA	98031017

-continued-

Head number	Tag code	Gear	Recovery date	Stat. week	Quad	Dist.	Sub-dist.	Length	Port survey site	Sample number
85326	44336	TROLL	26-Aug	35	NW			700	HOONAH	98110195
5981	44335	TROLL	19-Jul	30	SE	105	50	667	KETCHIKAN	98060203
16005	44336	TROLL	21-Jul	30	SE	105	50	621	CRAIG	98070199
28174	44336	TROLL	22-Jul	30	SE			657	PETERSBURG	98050436
43848	44335	TROLL	24-Jul	30	SE	105	50	640	CRAIG	98070238
43996	44336	TROLL	30-Jul	31	SE			681	CRAIG	98070305
43897	44336	TROLL	3-Aug	32	SE	105	10	683	CRAIG	98070339
16233	44336	TROLL	3-Aug	32	SE	105		695	CRAIG	98070333
16415	44335	TROLL	4-Aug	32	SE	105	10	548	CRAIG	98070346
28352	44336	TROLL	4-Aug	32	SE			687	PETERSBURG	98050648
16371	44336	TROLL	5-Aug	32	SE	105	50	683	CRAIG	98070372
25665	44335	TROLL	5-Aug	32	SE			626	PETERSBURG	98050680
25664	44335	TROLL	5-Aug	32	SE			669	PETERSBURG	98050680
16469	44335	TROLL	7-Aug	32	SE			721	CRAIG	98070393
27846	44214	TROLL	22-Aug	34	SE	105	50	710	KETCHIKAN	98060438
27869	44335	TROLL	22-Aug	34	SE	105	50	681	KETCHIKAN	98060438
16530	44336	TROLL	24-Aug	35	SE	105	10	700	CRAIG	98070428
16337	44335	TROLL	25-Aug	35	SE	105	50	678	CRAIG	98070448
20123	44336	TROLL	25-Aug	35	SE			670	KETCHIKAN	98060465
20562	44335	TROLL	8-Sep	37	SE	101		718	KETCHIKAN	98060516
23615	44336	TROLL	8-Sep	37	SE			686	KETCHIKAN	98060519
23578	44335	TROLL	14-Sep	38	SE	101		788	KETCHIKAN	98060545
79117	44335	TROLL	18-Sep	38	SE	102	80	692	KETCHIKAN	98060571
79118	44335	TROLL	18-Sep	38	SE	102	80	746	KETCHIKAN	98060571
79137	44336	TROLL	19-Sep	38	SE	101	29	773	KETCHIKAN	98060572
43614	44335	TROLL	9-Jul	28	SW	103	70	630	CRAIG	98070079
43708	44336	TROLL	17-Jul	29	SW	104	40	562	CRAIG	98070154
27309	44336	TROLL	24-Jul	30	SW			654	KETCHIKAN	98060254
27239	44336	TROLL	24-Jul	30	SW			676	KETCHIKAN	98060252
27308	44336	TROLL	24-Jul	30	SW			746	KETCHIKAN	98060254
27610	44336	TROLL	28-Jul	31	SW			674	KETCHIKAN	98060270
16276	44336	TROLL	5-Aug	32	SW	104	40	695	CRAIG	98070357
27826	44335	TROLL	6-Aug	32	SW			721	KETCHIKAN	98060330
16482	44336	TROLL	11-Aug	33	SW	104	40	665	CRAIG	98070403
27271	44335	TROLL	26-Aug	35	SW			722	KETCHIKAN	98060467
4856	44335	SEINE	13-Jul	29	SW	104	20	450	KETCHIKAN	98060159
4716	44335	SEINE	13-Jul	29	SW	104		655	KETCHIKAN	98060168
27389	44336	SEINE	31-Jul	31	SW	104		710	KETCHIKAN	98060294
23703	44335	SEINE	10-Aug	33	SW	104	10	563	KETCHIKAN	98060365
27730	44336	SEINE	5-Aug	32	SE	106		550	KETCHIKAN	98060323
20646	44335	SEINE	30-Aug	36	SE			688	KETCHIKAN	98060490
28577	44335	SEINE	11-Aug	33	NE	109	61	703	PETERSBURG	98050751
70820	44335	SEINE	19-Aug	34	NE	109	10	680	PETERSBURG	98050868
39005	44335	SPORT	7-Aug	32	NW	113	61		SITKA	98035327
39751	44335	SPORT	13-Aug	33	NW	113	45	680	SITKA	98035439
39761	44335	SPORT	14-Aug	33	NW	113	45	710	SITKA	98035444
9097	44336	SPORT	5-Aug	32	SE	101	90	660	KETCHIKAN	98065112
9128	44336	SPORT	18-Aug	34	SE	101	90	705	KETCHIKAN	98065140
9130	44336	SPORT	20-Aug	34	SE	101	90	485	KETCHIKAN	98065134
9458	44335	SPORT	6-Sep	37	SE	101	90	740	KETCHIKAN	98065177
9464	44335	SPORT	7-Sep	37	SE	101	90	675	KETCHIKAN	98065170
9310	44336	SPORT	19-Sep	38	SE	101	90	720	KETCHIKAN	98065256

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Head number	Tag code	Gear	Recovery date	Stat. week	Quad	Dist.	Sub-dist.	Length	Port survey site	Sample number
23312	44336	GILLNET	19-Aug	34	SE	101	11	686	KETCHIKAN	98060430
40994	44335	GILLNET	26-Aug	35	SE	101	28	692	METLAKATLA	98090112
41019	44335	GILLNET	27-Aug	35	SE	101	28	730	METLAKATLA	98090119
20941	44335	GILLNET	31-Aug	36	SE	101	11	751	KETCHIKAN	98060496
23491	44336	GILLNET	31-Aug	36	SE	101	11	647	KETCHIKAN	98060497
23346	44336	GILLNET	1-Sep	36	SE	101	11	677	KETCHIKAN	98060498
27775	44335	GILLNET	2-Sep	36	SE	101	11	651	KETCHIKAN	98060504
27785	44336	GILLNET	2-Sep	36	SE	101	11	659	KETCHIKAN	98060504
20760	44335	GILLNET	14-Sep	38	SE	101	11	718	KETCHIKAN	98060541
79222	44335	GILLNET	23-Sep	39	SE	101	11	731	KETCHIKAN	98060582
15808	44336	GILLNET	29-Jul	31	SE	106		559	WRANGELL	98120070
26935	44335	GILLNET	4-Aug	32	SE	106	30	560	KETCHIKAN	98060314
28752	44335	GILLNET	12-Aug	33	SE	106	41	680	PETERSBURG	98050768
28714	44335	GILLNET	12-Aug	33	SE	106	41	707	PETERSBURG	98050782
28865	44336	GILLNET	18-Aug	34	SE	106		624	PETERSBURG	98050849
25686	44335	GILLNET	19-Aug	34	SE	106		707	PETERSBURG	98050850
25695	44335	GILLNET	20-Aug	34	SE	106	41	685	PETERSBURG	98050911
25697	44335	GILLNET	20-Aug	34	SE	106	41	721	PETERSBURG	98050911
20862	44214	GILLNET	25-Aug	35	SE	106	30	712	KETCHIKAN	98060462
28829	44336	GILLNET	26-Aug	35	SE	106		729	PETERSBURG	98050957
27771	44335	GILLNET	2-Sep	36	SE	106	30	764	KETCHIKAN	98060505
23965	44336	GILLNET	7-Sep	37	SE	106	30	707	KETCHIKAN	98060512
46622	44335	GILLNET	7-Sep	37	SE	106		742	PETERSBURG	98051066
47007	44336	GILLNET	17-Sep	38	SE	106		745	KAKE	98270024
73358	44335	GILLNET	22-Sep	39	SE	106	41	780	PETERSBURG	98051164
15659	44336	GILLNET	23-Sep	39	SE	106	30	730	WRANGELL	98120141
61113	44336	ESCAPE	5-Aug	32	SE	101	75	570	UNUK &	98930054
61120	44335	ESCAPE	13-Aug	33	SE	101	75	475	UNUK &	98930061
61121	44335	ESCAPE	16-Aug	34	SE	101	75	525	UNUK &	98930063
61124	44336	ESCAPE	25-Aug	35	SE	101	75	650	UNUK &	98930071
61126	44336	ESCAPE	5-Sep	36	SE	101	75	515	UNUK &	98930079
61129	44336	ESCAPE	14-Sep	38	SE	101	75	680	UNUK &	98930087
61128	44336	ESCAPE	14-Sep	38	SE	101	75	705	UNUK &	98930087
61132	44336	ESCAPE	19-Sep	38	SE	101	75	690	UNUK &	98930092
61130	44336	ESCAPE	19-Sep	38	SE	101	75	715	UNUK &	98930092
61133	44336	ESCAPE	26-Sep	39	SE	101	75	695	UNUK &	98930099
61135	44335	ESCAPE	16-Oct	42	SE	101	75	555	UNUK &	98933008
SELECT RECOVERIES										
55262	44335	TROLL	6-Jul	28	NW	113			SITKA	98030587
57021	44336	TROLL	17-Jul	29	NW	156			SITKA	98030833
56935	44336	TROLL	21-Jul	30	NW				SITKA	98030821
67301	44335	TROLL	4-Aug	32	NW				SITKA	98030984
68773	44336	TROLL	7-Aug	32	NW				SITKA	98031096
67946	44335	TROLL	8-Aug	32	NW				SITKA	98031020
68268	44335	TROLL	11-Aug	33	NW				SITKA	98031045
68884	44336	TROLL	27-Aug	35	NW	154			SITKA	98031173
123584	44335	TROLL	1-Sep	36	NW	113	91		SITKA	98031209
125802	44335	TROLL	12-Sep	37	NW				SITKA	98031328

Appendix A3.–Numbers of coded-wire-tagged and untagged adult coho salmon sampled in the Unuk River in 1998.

Date	Number examined	Number of clips	Valid tags	Head number	Tag code	Recovery location
1-Aug-98	2					
2-Aug-98	1					
3-Aug-98	4					
4-Aug-98	7					
5-Aug-98	12	1	1	61113	44336	Event 1-Set Gillnet
6-Aug-98	7					
7-Aug-98	14					
8-Aug-98	5					
10-Aug-98	9					
11-Aug-98	7					
13-Aug-98	6	1	1	61120	44335	Event 1-Set Gillnet
15-Aug-98	6					
16-Aug-98	15	1	1	61121	44335	Event 1-Set Gillnet
17-Aug-98	23					
18-Aug-98	23	1		61122	LOST	Event 1-Set Gillnet
19-Aug-98	24					
20-Aug-98	24					
22-Aug-98	32					
23-Aug-98	56	1		61123	LOST	Event 1-Set Gillnet
24-Aug-98	16					
25-Aug-98	21	1	1	61124	44336	Event 1-Set Gillnet
26-Aug-98	14					
27-Aug-98	7					
28-Aug-98	13	1		61125	LOST	Event 1-Set Gillnet
30-Aug-98	2					
1-Sep-98	2					
3-Sep-98	29					
4-Sep-98	14					
5-Sep-98	26	1	1	61126	44336	Event 1-Set Gillnet
6-Sep-98	71					
9-Sep-98	43					
10-Sep-98	4					
11-Sep-98	7					
12-Sep-98	7					
13-Sep-98	58					
14-Sep-98	65	1	1	61128	44336	Event 1-Set Gillnet
		1	1	61129	44336	Event 1-Set Gillnet
15-Sep-98	9					
16-Sep-98	39					
17-Sep-98	37					
18-Sep-98	6	1	1	61130	44336	Event 2-Set Gillnets
19-Sep-98	14	1		61131	LOST	Event 2-Set Gillnets
		1	1	61132	44336	Event 2-Set Gillnets
20-Sep-98	12					
21-Sep-98	22					
22-Sep-98	14					

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Date	Number examined	Number of clips	Valid tags	Head number	Tag code	Recovery location
23-Sep-98	14					
24-Sep-98	14					
25-Sep-98	28					
26-Sep-98	9	1	1	61133	44336	Event 1-Set Gillnet
27-Sep-98	19					
28-Sep-98	4					
29-Sep-98	32					
2-Oct-98	1					
3-Oct-98	29					
4-Oct-98	5					
5-Oct-98	23					
6-Oct-98	7					
7-Oct-98	10	1		61134	LOST	Event 1-Set Gillnet
8-Oct-98	36					
9-Oct-98	23					
11-Oct-98	5					
16-Oct-98	17	1	1	61135	44335	Event 2-Clear Creek
17-Oct-98	22					
20-Oct-98	6					
21-Oct-98	19					
22-Oct-98	18					
23-Oct-98	25					
2-Oct-99	2					
20-Oct-99	1					
Grand	1,198	16				
	1,198	16	11			
Marked Fraction (θ)		0.0134	0.0092			
SE (θ)		0.0033	0.0028			

Appendix A4.–Assigned fate and observed location of fish possessing radio transmitters during four surveys flown by fixed-wing aircraft on the Unuk River in 1998. [a]Frequencies are code 195 except for frequency 151.592 tagged on 24 August with code 165.

		Location (RM or stream) by tracking flight				
Date	Frequency[a]	11-Sep-98	28-Sep-98	3-Nov-98	6-Nov-98	Fate
8/13/98	151.712	18	20	21*		Spawned
8/15/98	151.833	16	16	15*		Spawned
8/19/98	151.753	5	4	5*		Spawned
8/19/98	151.793	Lake Creek	Lake Creek	Clear Creek*		Spawned
8/19/98	151.954	10	19	12*		Spawned
8/20/98	151.653	Not found	Not found	35*		Spawned
8/20/98	151.733	22	23	Not found		Spawned
8/20/98	151.892	24*	Not found	Not found		Spawned
8/22/98	151.592[a]	Not found	Not found	Not found	Not found	Died
8/22/98	151.913	Eulachon River	Eulachon River	Eulachon River*		Spawned
8/24/98	151.592	Not found	Not found	Not found	Not found	Died
8/24/98	151.872	Eulachon River	Eulachon River	Eulachon River*		Spawned
8/25/98	151.774	20	Lake Creek	25*		Spawned
8/28/98	151.853	10	13	2*		Spawned
9/3/98	151.812	Not found	Eulachon River	Not found	Not found	Spawned
9/3/98	151.935	Eulachon River	19	Eulachon River*		Spawned
9/5/98	150.013	Not found	Not found	Not found	Not found	Died
9/5/98	151.093	3	2	2*		Died
9/6/98	151.133	Not found	Not found	Not found	Not found	Died
9/6/98	151.153	5	15	Not found		Spawned
9/6/98	151.174	Lake Creek	Not found	Eulachon River*		Spawned
9/9/98	151.193	3	11	14*		Spawned
9/11/98	151.213	3.5	Clear Creek	Cripple Creek*		Spawned
9/13/98	151.234		21	24*		Spawned
9/14/98	151.273		Not found	Not found	Not found	Died
9/14/98	151.253		1	Not found	Not found	Died
9/14/98	151.293		Eulachon River	Eulachon River*		Spawned
9/16/98	151.314		8	13*		Spawned
9/17/98	151.334		18	24*		Spawned
9/21/98	151.354		2	2*		Died
9/22/98	151.373		12	Not found		Spawned
9/25/98	151.392		4	Not found	4*	Spawned
9/29/98	151.412			Not found	Not found	Died
9/29/98	151.434			Not found	Not found	Died
10/7/98	151.453			Not found	24*	Spawned
10/7/98	151.472			18*		Spawned
10/7/98	151.493			Not found	12*	Spawned
10/7/98	151.514			Eulachon River*		Spawned
10/11/98	150.993			Not found	18	Spawned
10/11/98	151.533			13*		Spawned
10/11/98	151.553			Not found	7*	Spawned

*Mortality signal

Appendix A5.–Age and sex composition of adult coho salmon sampled during the two-event mark-recapture study performed on the Unuk River in 1998.

		AGE				
		1.0	1.1	2.0	2.1	Total
AGE COMPOSITION OF ADULT COHO SALMON						
PANEL A: ALL SAMPLES COMBINED						
Female	n		335		116	451
	%		74.3%		25.7%	43.7%
	SE of %		2.1%		2.1%	1.5%
	Escapement		4,036		1,398	5,434
	SE of Esc.		1,624		570	2,182
	Avg. Length		629		644	633
	SE Len.		3		6	3
Male	n	1	420	1	158	580
	%	0.2%	72.4%	0.2%	27.2%	56.3%
	SE of %	0.2%	1.9%	0.2%	1.9%	1.5%
	Escapement	12	5,060	12	1,904	6,988
	SE of Esc.	12	1,796	12	685	2,474
	Avg. Length	265	589	290	615	595
	SE Len.		4		6	3
Total	n	1	755	1	274	1031
	%	0.1%	73.2%	0.1%	26.6%	100.0%
	SE of %	0.1%	1.4%	0.1%	1.4%	
	Escapement	12	9,097	12	3,301	12,422
	SE of Esc.	12	2,421	12	892	3,298
	Avg. Length	265	607	290	627	612
	SE Len.		3		4	2
					Unique fish	1198
PANEL B: EVENT 1-MARKING IN THE LOWER RIVER						
SN1						
Female	n		236		73	309
	%		76.4%		23.6%	45.4%
	SE of %		2.4%		2.4%	1.9%
	Escapement		4,305		1,332	5,636
	SE of Esc.		1,702		540	2,222
	Avg. Length		618		631	621
	SE Len.		5		9	4
Male	n		273		99	372
	%		73.4%		26.6%	54.6%
	SE of %		2.3%		2.3%	1.9%
	Escapement		4,980		1,806	6,786
	SE of Esc.		1,795		665	2,438
	Avg. Length		575		604	583
	SE Len.		4		8	4
Total	n		509		172	681
	%		74.7%		25.3%	100.0%
	SE of %		1.7%		1.7%	
	Escapement		9,285		3,137	12,422

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		AGE				
		1.0	1.1	2.0	2.1	Total
	SE of Esc.		2,473		857	3,298
	Avg. Length		595		615	600
	SE Len.		3		6	3
					Total sampled	797
					Spaghetti tags	742
PANEL C: EVENT 2-SAMPLING FOR MARKS						
TOTAL						
Female	n		99		43	142
	%		69.7%		30.3%	40.6%
	SE of %		3.9%		3.9%	2.6%
	Escapement		3,514		1,526	5,040
	SE of Esc.		1,475		660	2,101
	Avg. Length		656		667	659
	SE Len.		3		5	2
Male	n	1	147	1	59	208
	%	0.5%	70.7%	0.5%	28.4%	59.4%
	SE of %	0.5%	3.2%	0.5%	3.1%	2.6%
	Escapement	35	5,217	35	2,094	7,382
	SE of Esc.	35	1,810	35	753	2,543
	Avg. Length	265	615	290	633	617
	SE Len.	0	7	0	10	6
Total	n	1	246	1	102	350
	%	0.3%	70%	0.3%	29.1%	100.0%
	SE of %	0.3%	2.4%	0.3%	2.4%	0.0%
	Escapement	35	8,731	35	3,620	12,422
	SE of Esc.	35	2,337	35	1,004	3,298
	Avg. Length	265	631	290	648	634
	SE Len.		4		6	4
					Total sampled	419
					Spaghetti tags	18
SN2						
Female	n		33		12	45
	%		73.3%		26.7%	39.1%
	SE of %		6.7%		6.7%	4.6%
	Escapement		620		225	845
	SE of Esc.		1,508		536	2,063
	Avg. Length		670		647	664
	SE Len.		3		9	4
Male	n		47		23	70
	%		67.1%		32.9%	60.9%
	SE of %		5.7%		5.7%	4.6%
	Escapement		883		432	1,315
	SE of Esc.		1,723		836	2,573
	Avg. Length		671		662	668
	SE Len.		5		15	6
Total	n		80		35	115
	%		69.6%		30.4%	100.0%
	SE of %		4.3%		4.3%	0.0%

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		AGE				
		1.0	1.1	2.0	2.1	Total
	Escapement		8,642		3,781	12,422
	SE of Esc.		2,352		1,129	3,298
	Avg. Length		671		657	667
	SE Len.		3		10	4
					Total sampled	138
					Spaghetti tags	7
		GENE'S LAKE CREEK				
Female	N		10		11	21
	%		47.6%		52.4%	37.5%
	SE of %		11.2%		11.2%	6.5%
	Escapement		2,218		2,440	4,658
	SE of Esc.		1,070		1,157	2,020
	Avg. Length		662		685	674
	SE Len.		6		7	5
Male	n		23		12	35
	%		65.7%		34.3%	62.5%
	SE of %		8.1%		8.1%	6.5%
	Escapement		5,102		2,662	7,764
	SE of Esc.		1,814		1,074	2,608
	Avg. Length		577		647	601
	SE Len.		18		23	15
Total	n		33		23	56
	%		58.9%		41.1%	100.0%
	SE of %		6.6%		6.6%	0.0%
	Escapement		7,320		5,102	12,422
	SE of Esc.		2,100		1,570	3,298
	Avg. Length		602		665	628
	SE Len.		15		13	11
					Total sampled	65
					Spaghetti tags	0
		CLEAR CREEK				
Female	n		4		6	10
	%		40.0%		60.0%	34.5%
	SE of %		16.3%		16.3%	9.0%
	Escapement		1,713		2,570	4,284
	SE of Esc.		995		1,319	1,937
	Avg. Length		628		673	655
	SE Len.		17		16	14
Male	n		12		7	19
	%		63.2%		36.8%	65.5%
	SE of %		11.4%		11.4%	9.0%
	Escapement		5,140		2,998	8,139
	SE of Esc.		1,899		1,316	2,670
	Avg. Length		532		576	548
	SE Len.		19		33	17
Total	n		16		13	29
	%		55.2%		44.8%	100.0%
	SE of %		9.4%		9.4%	0.0%
	Escapement		6,854		5,569	12,422

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		AGE				
		1.0	1.1	2.0	2.1	Total
	SE of Esc.		2,140		1,858	3,298
	Avg. Length		556		620	585
	SE Len.		18		23	15
					Total sampled	35
					Spaghetti tags	1
			LAKE CREEK			
Female	N		7		4	11
	%		63.6%		36.4%	32.4%
	SE of %		15.2%		15.2%	8.1%
	Escapement		2,558		1,461	4,019
	SE of Esc.		1,311		870	1,876
	Avg. Length		636		673	650
	SE Len.		11		10	9
Male	N	1	12	1	9	23
	%	4.3%	52.2%	4.3%	39.1%	67.6%
	SE of %	4.3%	10.6%	4.3%	10.4%	8.1%
	Escapement	365	4,384	365	3,288	8,403
	SE of Esc.	365	1,650	365	1,346	2,713
	Avg. Length	265	618	290	606	584
	SE Len.		23		19	25
Total	N	1	19	1	13	34
	%	2.9%	55.9%	2.9%	38.2%	100.0%
	SE of %	2.9%	8.6%	2.9%	8.5%	0.0%
	Escapement	365	6,942	365	4,750	12,422
	SE of Esc.	365	2,114	365	1,618	3,298
	Avg. Length	265	625	290	627	605
	SE Len.		15		16	18
					Total sampled	41
					Spaghetti tags	3
			KERR CREEK			
Female	n		9			9
	%		100.0%			37.5%
	SE of %		0.0%			10.1%
	Escapement		4,658			4,658
	SE of Esc.		2,020			2,020
	Avg. Length		661			661
	SE Len.		9			9
Male	n		11		4	15
	%		73.3%		26.7%	62.5%
	SE of %		11.8%		11.8%	10.1%
	Escapement		5,693		2,070	7,764
	SE of Esc.		2,099		1,109	2,608
	Avg. Length		553		586	562
	SE Len.		23		25	18
Total	N		20		4	24
	%		83.3%		16.7%	100.0%
	SE of %		7.8%		7.8%	0.0%
	Escapement		10,352		2,070	12,422
	SE of Esc.		2,902		1,081	3,298

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		AGE				
		1.0	1.1	2.0	2.1	Total
	Avg. Length		602		586	599
	SE Len.		18		25	15
					Total sampled	26
					Spaghetti tags	3
		EULACHON RIVER				
Female	n		34		9	43
	%		79.1%		20.9%	48.3%
	SE of %		6.3%		6.3%	5.3%
	Escapement		4,746		1,256	6,002
	SE of Esc.		1,846		593	2,293
	Avg. Length		646		663	650
	SE Len.		6		6	5
Male	n		42		4	46
	%		91.3%		8.7%	51.7%
	SE of %		4.2%		4.2%	5.3%
	Escapement		5,862		558	6,420
	SE of Esc.		2,180		325	2,371
	Avg. Length		612		636	614
	SE Len.		11		22	10
Total	n		76		13	89
	%		85.4%		14.6%	100.0%
	SE of %		3.8%		3.8%	0.0%
	Escapement		10,608		1,814	12,422
	SE of Esc.		2,853		660	3,298
	Avg. Length		627		655	631
	SE Len.		7		8	6
					Total sampled	111
					Spaghetti tags	4
		UNUK RIVER MAINSTEM				
Female	n		2		1	3
	%		66.7%		33.3%	100.0%
	SE of %		33.3%		33.3%	0.0%
	Escapement		8,281		4,141	12,422
	SE of Esc.		4,558		4,141	3,298
	Avg. Length		665		690	673
	SE Len.		5		0	9
					Total sampled	3
					Spaghetti tags	0

Appendix A6.–Estimated harvests of coho salmon bound for the Unuk River in 1998 in marine commercial and sport fisheries by statistical week. Harvest in the troll fishery was approximated by weighting the catches for each troll period by the number of tags recovered in a statistical week.

Stat.	Ending	Troll		Seine		Sport		Gillnet		Total		Estimated Weekly prop.	Estimated cumulative	Estimated cum. prop.
week	date	tags	harvest	tags	harvest	tags	harvest	tags	harvest	tags	harvest	harvest	harvest	harvest
28	11-Jul-98	8	2,435							8	2,435	0.054	2,435	0.054
29	18-Jul-98	2	609	2	482					4	1,091	0.024	3,526	0.078
30	25-Jul-98	15	4,566							15	4,566	0.101	8,093	0.178
31	1-Aug-98	11	3,349	1	514			1	264	13	4,127	0.091	12,219	0.269
32	8-Aug-98	19	5,784	1	444			1	278	21	6,506	0.143	18,725	0.413
33	15-Aug-98	2	609	2	1,527	4	2,917	2	487	10	5,541	0.122	24,266	0.535
34	22-Aug-98	2	613	1	761	2	1,334	5	1,668	10	4,376	0.096	28,642	0.631
35	29-Aug-98	12	3,680			2	1,183	4	1,666	18	6,530	0.144	35,172	0.775
36	5-Sep-98	2	613	1	872			6	2,496	9	3,981	0.088	39,153	0.863
37	12-Sep-98	6	1,840			1	369	2	567	9	2,776	0.061	41,929	0.924
38	19-Sep-98	6	1,840					2	740	8	2,581	0.057	44,509	0.981
39	26-Sep-98							3	879	3	879	0.019	45,388	1.000
	Total	85	25,940	8	4,600	9	5,803	26	9,046	128	45,388	1.000		
Est. mean date of harvest			8-Aug		12-Aug		25-Aug		30-Aug		14-Aug			

Appendix A7.–Computer data files on 1997 Unuk River coho salmon smolt and subsequent estimates of 1998 Unuk River adult coho salmon run parameters.

File name	Description
98UNK43.XLS	Spreadsheet containing all the mark-recapture data with various pivot table results, Tables 2, 5, and 6, Figures 9, 10, and 11, Appendices A2, A3, A5, and A6, abundance estimates, SPAS.EXE results, 98UNK43BOOT.EXE results, and various χ^2 hypothesis test results.
98UNK43KS.XLS	Spreadsheet containing the Kolmogorov-Smirnov (K-S) 2-sample test results, Figure 8, and various data sets used in these calculations.
97UNKSM.XLS	Spreadsheet containing the smolt tagging numbers, length and weight data, Table 4, and Figures 6 and 7.
98UNK43BOOT.BAS	BASIC compiled program for bootstrapping abundance estimates for estimation of variance and bias.
98UNK43BOOT.DAT	Data file with 1998 Unuk River coho salmon data for use in 98unk43boot.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.
98UNK43SPAS.DAT	Data file containing the 1998 Unuk River coho salmon data for use in SPAS.exe.
98UNK43SPAS.OUT	Output from SPAS.EXE for the 1998 Unuk River coho salmon data.