Fishery Data Series No. 98-23

A Mark-Recapture Experiment to Estimate the Escapement of Chinook Salmon in the Unuk River, 1997

by

Edgar L. Jones III,

Scott A. McPherson,

and

David L. Magnus

September 1998

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

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

FISHERY DATA SERIES NO. 98-23

A MARK-RECAPTURE EXPERIMENT TO ESTIMATE THE ESCAPEMENT OF CHINOOK SALMON IN THE UNUK RIVER, 1997

by

Edgar L. Jones III
Division of Sport Fish, Douglas

Scott A. McPherson
Division of Sport Fish, Douglas

and

David L. Magnus
Division of Sport Fish, Douglas

Alaska Department of Fish and Game
Division of Sport Fish
333 Raspberry Road
Anchorage, AK 99518-1599

September 1998

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-10-13, Job No. S-1-8.

Edgar L. Jones III [1]
Alaska Department of Fish and Game, Division of Sport Fish, Region I
P. O. Box 240020, Douglas, AK 99824-0020, USA

Scott A. McPherson
Alaska Department of Fish and Game, Division of Sport Fish, Region I
P. O. Box 240020, Douglas, AK 99824-0020, USA

David L. Magnus
Alaska Department of Fish and Game, Division of Sport Fish, Region I
P. O. Box 240020, Douglas, AK 99824-0020, USA

[1]Author to whom all correspondence should be addressed: e-mail: edj@fishgame.state.ak.us

This document should be cited as:
Jones III, Edgar L., Scott A. McPherson, and David L. Magnus. 1998. A mark-recapture experiment to estimate the escapement of chinook salmon in the Unuk River, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-23 , Anchorage.

TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The abundance of medium and large chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Unuk River in 1997 was estimated using a mark-recapture experiment. Fish were captured in the lower Unuk River using set gillnets from June through July, and each healthy fish was individually marked with a solid-core spaghetti tag sewn through its back and was given two secondary marks in the form of an upper-left operculum punch and removal of the left axillary appendage. Spawning grounds sampling took place from July through August to estimate the fraction of the escapement that had been marked.

During this study, 404 chinook salmon were captured in the lower Unuk River, and 382 of these were marked and released alive. Three hundred seven (307) fish were considered large (≥660 mm mid-eye to fork [MEF]) and 75 were considered medium (401–659 mm MEF) in size. At the spawning grounds, 965 fish were sampled; 761 were considered large fish, and of these, 78 were recaptures which had been previously marked in the lower river with spaghetti tags. One hundred fifty-six (156) medium fish were sampled, and 16 of these were recaptures.

A modified Petersen model was used to estimate that 2,970 (SE = 277, M = 307, C = 761, R = 78) large, 701 (SE = 158, M = 75, C = 156, R = 16) medium, and 3,671 (SE = 320) fish >400 mm MEF in length immigrated into the Unuk River in 1997. An estimated 32% of this immigration was sampled during the project. Peak survey counts in August totaled 636 large chinook salmon, about 21% of the mark-recapture estimate of large fish, a trend seen in similar studies. Of the spawning population >400 mm MEF, 38% were estimated to be age-1.4 fish from the 1991 brood year, 34% were estimated to be age-1.3 fish, and 25% were estimated to be age-1.2 fish.

Key words: abundance, large and medium chinook salmon, Unuk River, mark-recapture, set gillnets, spaghetti tags, operculum punch, axillary appendage, Petersen model, peak survey counts.

INTRODUCTION

The Unuk, Chickamin, Blossom, and Keta rivers traverse the Misty Fjords National Monument and are index streams for the chinook salmon *Oncorhynchus tshawytscha* escapement estimation program in Southeast Alaska (Pahlke 1997a). These systems flow into Behm Canal, a narrow saltwater passage east of Ketchikan (Figure 1). Indices of escapement—peak single-day survey counts of "large" chinook salmon ≥660 mm mideye to fork of tail (MEF)—in each of these systems are roughly dome-shaped when plotted against time (since 1975), with peak values occurring between 1987 and 1990 (Pahlke 1997a). Peak 1987–1990 values of escapement are two to five times greater than the "baseline" (1975–1980) or current values of the index.

Concern for escapements in Behm Canal systems reached high levels in 1992, and historical data on the two major Behm Canal systems, the Unuk and Chickamin rivers, were reviewed to evaluate the status of stocks in these systems. During this review, the Division of Sport Fish agreed to begin a research program on the Unuk River, the largest chinook salmon producer in Behm Canal. Goals of the program are to estimate escapement, total run size, harvest rates, and harvest distribution for chinook salmon older than 3-ocean age from the two most important Behm Canal systems, the Unuk and Chickamin rivers.

The current escapement goal for the Unuk River is 650–1,400 large fish counted in surveys, or about 3,000–7,000 total escapement of large fish (McPherson and Carlile 1997). Only large fish are counted in aerial surveys, because they can be distinguished with more confidence from other species that may be present and their size increases their visibility from the air. For our purposes, chinook salmon ≥660 mm MEF are considered large fish and generally consist of fish 3-ocean age or older, chinook salmon 401 mm–659 mm MEF are considered medium fish, and chinook salmon ≤400 mm MEF are considered

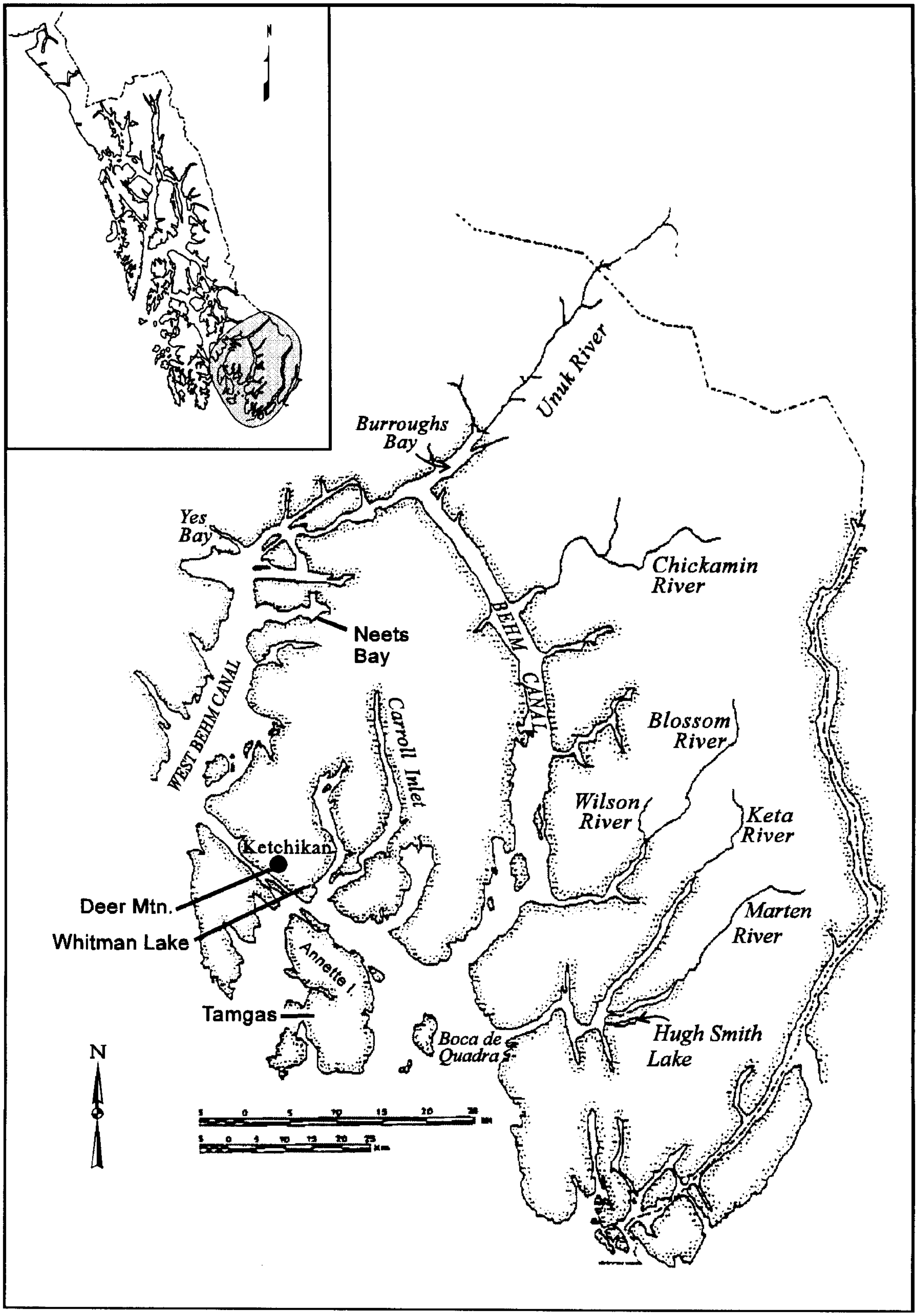

Figure 1.–Behm Canal area in Southeast Alaska and location of major chinook salmon systems and hatcheries.

small fish. Escapement in the Unuk River is determined each year by summing the peak observer aerial and foot survey counts of large spawners observed in six index tributaries (i.e., Cripple, Gene's Lake, Kerr, Clear, and Lake creeks plus the Eulachon River).

In an attempt to validate these survey areas and to estimate the fraction counted in the surveys, a mark-recapture experiment and radio telemetry study were conducted in 1994 (Pahlke et al. 1996). The radio telemetry study indicated that 83% (SE = 9%) of all spawning occurred in the six tributaries surveyed. The mark-recapture experiment estimated 4,623 large chinook salmon entered the river: the survey count of 711 fish represented 15% of this estimate. The highest survey count on record was 2,126 large fish and occurred in 1986 (Pahlke 1997a). Average peak survey counts in six Unuk River tributaries for 1977–1996 were distributed as follows: Cripple Creek (454 fish, 40%), Gene's Lake Creek (334 fish, 29%), Eulachon River (209 fish, 18%), Clear Creek (93 fish, 8%), Lake Creek (26 fish, 2%), and Kerr Creek (29 fish, 2%). Cripple Creek and Gene's Lake Creek are not surveyed from the air because of heavy canopy cover; survey counts in these areas are made on foot. All other index areas are surveyed by helicopter or on foot (Pahlke et al. 1996).

Previous studies on the Unuk River were based on coded wire tags (CWTs) inserted in chinook salmon juveniles of the 1992–1996 broods (Pahlke 1995). Indications from this research are that commercial and sport harvest rates on the Unuk River chinook salmon stock (age-1.1-1.5) ranged between 14% and 24%; however, the precision of the harvest estimates was low, and escapement was inferred from the 1994 mark-recapture study expansion of 15% and an alternative expansion of 25% of spawners counted.

Beginning in 1993, chinook salmon fall fingerlings, or young-of-the-year (YOY), and spring smolt were tagged with CWTs on the Unuk River. Fall YOY tagging efforts were approximately 14,000 in 1993, 20,000 in 1994, 40,000 in 1995, 40,000 in 1996, and 62,000 in 1997. Spring (smolt) tagging efforts were 3,000 in 1994, 3,300 in 1995, 8,000 in 1996, 12,500 in 1997, and 17,000 in 1998 (Appendix A3). The first returns of large fish from this effort (age-1.3 fish from the 1992 brood year) returned in 1997.

The goals of the current sampling program for adult chinook salmon returning to the Unuk River are threefold: (1) to estimate escapement; (2) to estimate age distribution in the escapement; and (3) to sample escapement for the fraction of fish possessing CWTs by brood year. The results are essential to estimate the marked fraction of each brood for CWTd fish and to estimate harvest in current and future sport and commercial fisheries. These harvest and escapement data will enable us to estimate total run size, harvest rates, and distribution of harvests for this important chinook salmon indicator stock in southern Southeast Alaska.

The objectives of this study were to estimate abundance of medium and large chinook salmon spawning in the Unuk River in 1997 and to estimate the age and sex composition of these fish.

STUDY AREA

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 Alaska (Figure 2). The Unuk River is the fourth largest producer of king salmon in Southeast Alaska (Pahlke et al. 1996); its drainage encompasses an area of approximately 3,885 km^2. In 1994, 86% of all chinook salmon spawning occurred in the six index spawning tributaries, all of which are within the United States border (Pahlke et al. 1996). It is believed that the majority of chinook salmon rear in the lower 39 km of the river.

METHODS

A two-event mark-recapture experiment for a closed population was used to estimate the number of immigrant medium and large chinook salmon to the Unuk River in 1997. Fish were captured by set gillnet in the lower river for the

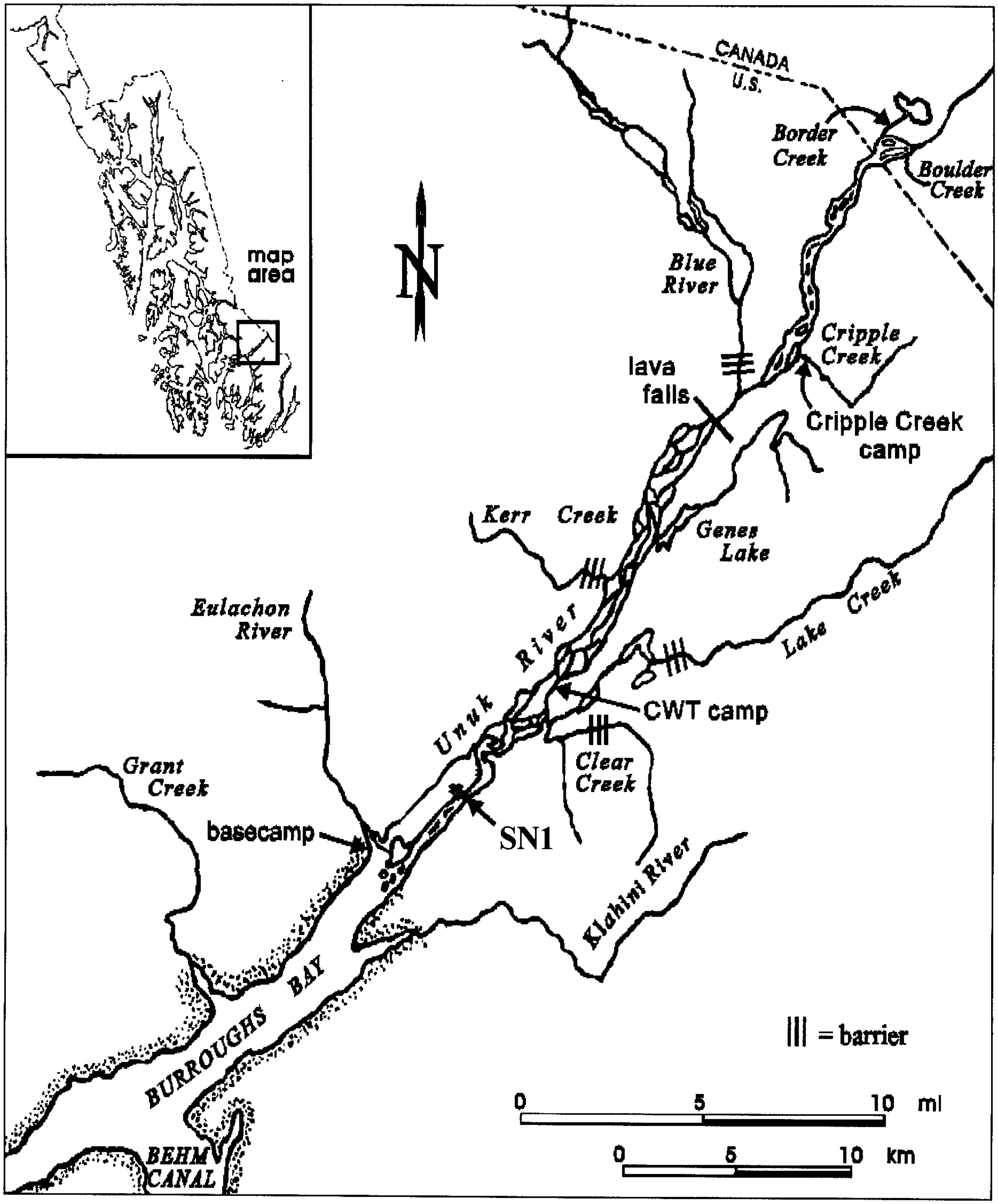

Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to chinook salmon migration, and location of ADF&G research sites. Dog Salmon Creek (not shown) flows into the Unuk River about 2 miles upstream of Gene's Lake on the opposite shore.

first event and were sampled for marks with a variety of gear types on the spawning grounds for the second event.

EVENT 1: SAMPLING IN THE LOWER RIVER

Adult chinook salmon were sampled by set gillnet as they immigrated into the lower Unuk River between 11 June and 24 July 1997. They were captured in set gillnets 120 ft long by 14 ft deep with 7.25″ stretch mesh. Set gillnets were fished initially at two locations for the first 13 days, but one site did not produce any catches of chinook salmon. The decision was therefore made to fish at one site exclusively, using two back-to-back shifts of personnel. This site (SN1) was located approximately 2 miles upstream on the south channel or mainstem of the lower Unuk River well below all known spawning areas, with the exception of the Eulachon River (Figure 3).

Two set gillnets were fished at SN1 (Figure 4). 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 fixed buoy and allowed to trail downstream along the eddy line formed between the Unuk mainstem and the side slough. This net configuration produced high catches of adult chinook salmon and was employed for the duration of the set gillnet sampling.

Regardless of health, each fish captured was sampled for age, sex, and length (ASL) prior to release. Length in MEF was measured to the nearest 5 mm and sex was estimated from secondary maturation characteristics. Four scales were taken about 1″ apart 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 (Welander 1940). Scales were mounted on gum cards which held scales from ten fish, as described in ADF&G (1993). The age of each fish was later determined from the pattern of circuli (Olsen 1992), seen on images of scales impressed into acetate cards magnified 70× (Clutter and Whitesel 1956). The presence or absence of an adipose fin was also noted for each sampled fish. Those fish missing adipose fins were sacrificed, and their heads were sent to the ADF&G Tag Lab for inspection for presence of CWTs.

All captured fish judged healthy and possessing adipose fins were marked and released. Each fish was given three different marks: a primary mark, being a uniquely numbered solid-core spaghetti tag, and two secondary marks, one being a clip of the left axillary appendage (LAA) and the other being a left upper operculum punch (LUOP) ¼″ in diameter. The spaghetti tag consisted of a 2¼″ section of laminated Floy tubing shrunk onto a 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. The excess monofilament was then trimmed off. Each spaghetti tag was individually numbered and stamped with an ADF&G phone number.

EVENT 2: SAMPLING ON THE SPAWNING GROUNDS

Fish were sampled on Cripple, Gene’s Lake, Clear, Kerr, Dog Salmon, Lake, and Boundary creeks and the Eulachon River in 1997 (Figure 2). Various methods were used to capture these fish, including rod and reel, spear, dip net, set gillnet, and random carcass pickups. Use of a variety of gear types has been shown to produce unbiased estimates of age, sex, and length composition (McPherson et al. 1997). All inspected fish were given a left lower operculum punch (LLOP) to prevent double sampling. These fish were closely examined for the presence of the primary tag, the LUOP, the LLOP, and the LAA, for the absence of their adipose fin, and sampled for AWL data using the same techniques employed during the lower river sampling. Foot survey counts were also performed on each of the sampled tributaries. These counts were spaced approximately one week apart and were adjusted to coincide with the historical peak observed abundance.

ABUNDANCE BY SIZE

Separate experiments and estimates were generated for both size groups, since sampling is/

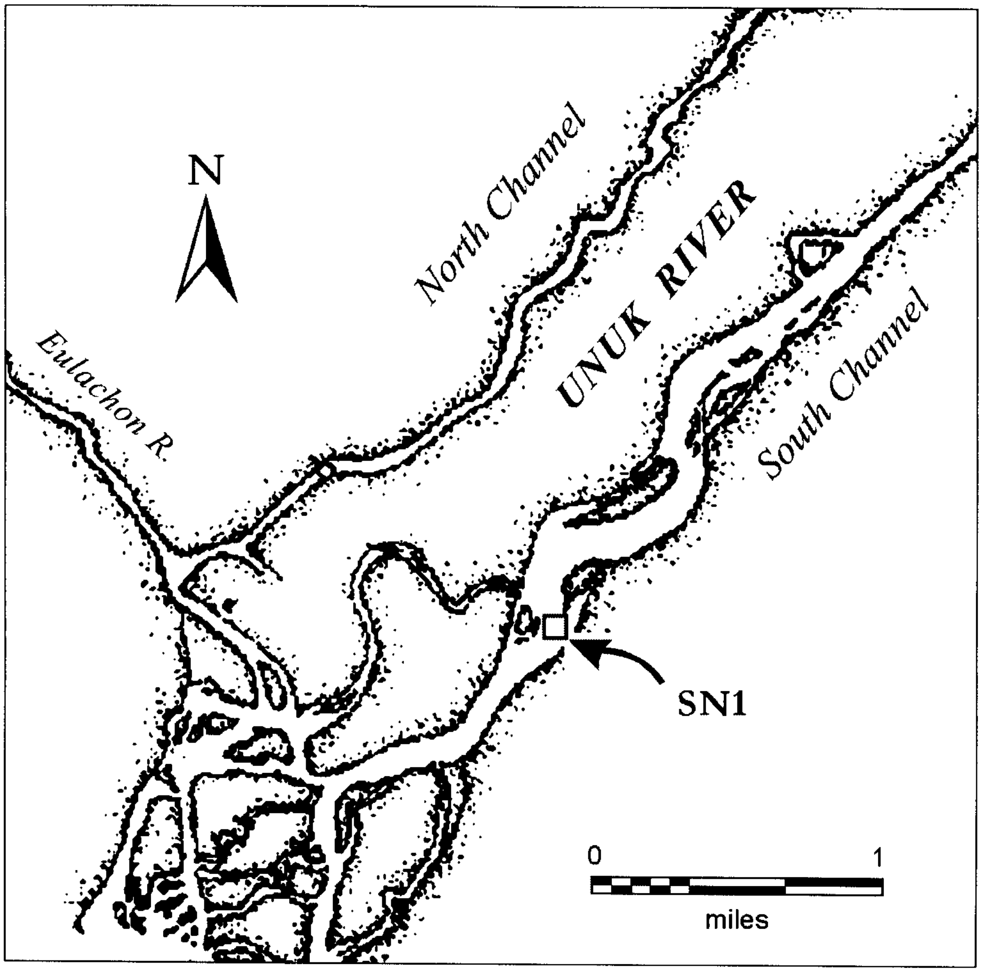

Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River in 1997.

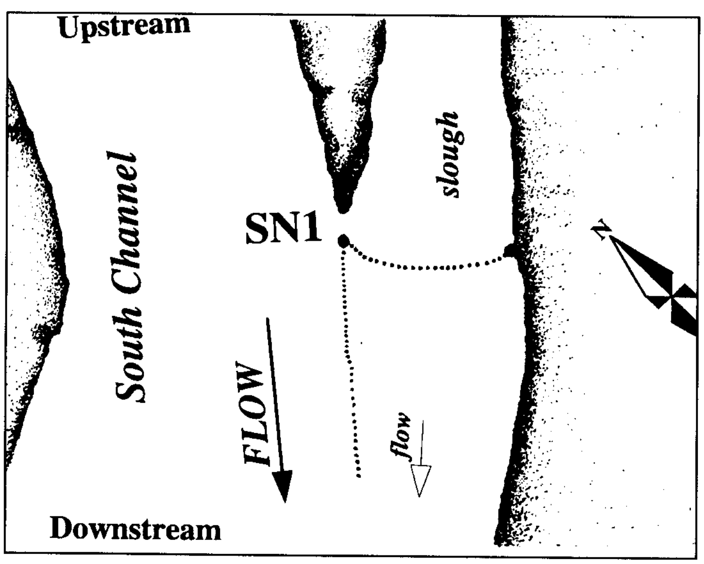

Figure 4.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River in 1997.

was size-selective for large fish. Abundance of medium (401–659 mm MEF) and large (≥660 mm MEF) fish was estimated separately, by using Chapman's modification of the Petersen estimate (Seber 1982, p. 60). Estimated abundance ($\hat{N}_i$) was calculated as

$$\hat{N}_i = \frac{(M_i + 1)(C_i + 1)}{(R_i + 1)} - 1 \qquad (1)$$

where M_i is the number of fish of size *i* sampled and marked during event 1, C_i is the number of fish of size *i* inspected for marks during event 2, and R_i is the number of C_i that possessed marks applied during event 1 as seen during event 2. The general assumptions that must hold for $\hat{N}_i$ to be a suitable estimate of abundance are in Seber (1982) and may be cast as follows:

- *(a)* every fish has an equal probability of being marked in event 1, or that every fish has an equal probability of being captured in event 2, or that 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.

To provide evidence that assumption *a* was met, two chi-square tests were performed: (1) for equal proportions of marks by recapture 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 is accepted, the pooled Petersen estimator (equation 1) is used to model the mark-recapture data; else a temporally or spatially stratified estimator is employed (Arnason et. al. 1996).

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 using two Kolmogorov-Smirnov (K-S) 2-sample tests (α = 0.05). These hypotheses tests are shown in Appendix A.4.

Size and sex selection was tested using chi-square tests comparing fish (by size, sex) marked in the lower river with fish recaptured and also inspected on the spawning grounds. Because sampling in the lower river spanned the entire known immigration of fish into the Unuk River and continued without interruption, the experiment is, due to the life history of the fish, closed to recruitment (assumption *b*).

Regarding assumption *c*, we were not able to test this assumption but we were careful to not harm or stress fish and we did not mark injured fish.

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 a LLOP.

Variance, bias, and confidence intervals for $\hat{N}_i$ were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991). Fish were divided into four capture histories (Table 1).

A bootstrap sample was built by drawing with replacement a sample of size $\hat{N}_i^*$ from the empirical distribution defined by the capture histories. A new set of statistics from each bootstrap sample $\left\{\hat{M}_i^*, \hat{C}_i^*, \hat{R}_i^*\right\}$ was generated, along with a new estimate for abundance $\hat{N}_i^*$, and 1,000 such bootstrap samples were drawn creating the empirical distribution $\hat{F}(\hat{N}_i^*)$, which is an estimate of F($\hat{N}_i$). The difference between the average $\hat{N}_i^*$ of bootstrap estimates and $\hat{N}_i$ is an estimate of statistical bias in the latter statistic (Efron and Tibshirani 1993, Section 10.2). Con-fidence intervals were estimated from $\hat{F}(\hat{N}_i^*)$ with the percentile method (Efron and Tibshirani 1993, Section 13.3).

Variance was estimated as

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

where B is the number of bootstrap samples.

AGE AND SEX COMPOSITION

All fish were sampled for scales and proportions by age and sex were estimated as binomial variables described by

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \qquad (3)$$

and sample variance was calculated by

$$\mathrm{var}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \qquad (4)$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age j of size group i, n_{ij} is the number of fish of age j of size group i, and n_i is the number of fish in the sample n of size group i taken on the spawning grounds (note: $\sum_j \hat{p}_j = 1$).

Age and sex composition for the entire spawning population and its associated variances were also estimated, 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 $\sum_{jk} \hat{p}_{jk} = 1$.

Estimated sex composition for samples gathered on the spawning grounds were again pooled together, and estimates from the lower river were excluded because of the difficulty in accurately sexing fish (many are ocean-bright and do not possess distinct secondary maturation characteristics). Numbers of spawning fish by age were estimated as the summation of products of estimated age composition and estimated abundance within a size category:

Table 1.–Capture histories for medium and large chinook salmon in the population spawning in the Unuk River in 1997 (notation explained in text).

Capture history	Medium	Large	Source of statistics
Marked and not sampled in tributaries	59	229	$\hat{M}_i - R_i$
Marked and recaptured in tributaries	16	78	R_i
Not marked, but captured in tributaries	140	683	$C_i - R_i$
Not marked and not sampled in tributaries	486	1,980	$\hat{N}_i - \hat{M}_i - C_i + R_i$
Effective population for simulations	701	2,970	$\hat{N}_i^+$

$$\hat{N}_j = \sum_i (\hat{p}_{ij}\hat{N}_i) \qquad (5)$$

and a sample variance calculated according to the procedures in Goodman (1960):

$$\mathrm{var}(N_j) = \sum \begin{array}{l}\mathrm{var}(p_{ij})N_i^2 + \mathrm{var}(N_i)p_{ij}^2 \\ - \mathrm{var}(p_{ij})\,\mathrm{var}(N_i)\end{array} \qquad (6)$$

The proportion of the spawning population >400 mm MEF composed of a given age was estimated as the summed totals across size categories:

$$p_j = \frac{N_j}{N} \qquad (7)$$

and a variance approximated according to the procedures in Seber (1982, p. 8-9):

$$\mathrm{var}(p_j) = \frac{\mathrm{var}(p_{ij})N_i^2 + \mathrm{var}(N_i)(p_{ij} - p_j)^2}{N^2} \qquad (8)$$

RESULTS

Tagging, Recovery and Abundance

Of 404 chinook salmon sampled in the lower river, 383 were tagged and released (Appendix A1; Table 2). Ninety-five percent of the catches occurred between 23 June and 22 July. Five fish were considered unhealthy upon capture and were not tagged (Appendix A1). Of the fish tagged, none were small, 76 were medium, and 307 were large. Sixteen fish sampled in the gill-nets were missing adipose fins and were sacrificed. In general, the numbers of recaptures sampled on the spawning grounds in each tributary and the dates when they were first marked occurred in rough proportion to numbers seen in the daily gillnet catches (Figure 5).

The length distributions of marked medium, large, and medium and large fish combined were not significantly different than length distributions for fish *recaptured* on the spawning grounds (P = 0.24, P = 0.22, and P = 0.17; Figure 6). Thus, the mark-recapture data does not need length stratification. Similarly, length distributions of marked chinook salmon were comparable to those fish *inspected* on the spawning grounds for large fish (P = 0.29) and medium and large fish (P = 0.10), but not for medium fish (P<0.001; Figure 7). Thus, only ages from event 2 were used to calculate age and length compositions.

A data matrix was created using the mark-recapture data in order to perform the chi-square tests suggested by Arnason et al. (1996):

Medium chinook salmon

Time	Marks	Cripple Creek	Gene's Lake Creek	All others
Stratum 1	22	3	1	0
Stratum 2	20	2	1	0
Stratum 3	33	3	4	2
	$U_{i.}$	60	68	28

Large chinook salmon

Time	Marks	Cripple Creek	Gene's Lake Creek	All others
Stratum 1	100	4	6	10
Stratum 2	105	11	4	12
Stratum 3	102	17	3	11
	$U_{i.}$	305	230	226

where $U_{i.}$ is the number not marked.

Test 1 for equal proportions of marks in event 2 suggests similarities exist in the fraction marked among medium fish inspected in the various tributaries (Cripple Creek: 0.133; Gene's Lake Creek: 0.088; Clear/Kerr/Boundary/Dog Salmon/ Lake creeks and Eulachon River pooled: 0.071). These results (χ^2 = 1.06, df = 2, P = 0.59), coupled with results of test 2 for complete mixing of fish between event 1 and event 2 (χ^2 = 1.30, df = 2, P = 0.52), suggest the use of the pooled Petersen estimate for medium fish. For large fish, test 1 indicated the fraction marked in the various tributaries (Cripple Creek: 0.105; Gene's Lake Creek: 0.057; Clear/Kerr/Boundary/Dog Salmon/ Lake creeks and Eulachon River pooled: 0.146) was not similar (χ^2 = 9.96, df = 2, P = 0.007). The result of test 2, however, was not significant (χ^2 = 2.89, df = 2, P = 0.24) and, according to Arnason et al. (1996), passing either of these tests (i.e., p >0.05) is sufficient evidence for the use of the pooled Petersen estimate.

Because observer survey counts of escapement are of large chinook salmon, estimates of abundance were stratified into medium and large fish for comparison purposes. Estimated abundance of medium fish $\hat{N}_{med}$ on the spawning grounds in 1997 was 701 (SE = 158), based on 75 fish marked in the lower river ($\hat{M}_{med}$) and 156 fish inspected for marks ($\hat{C}_{med}$) on the spawning grounds, 16 of which were recaptured fish ($\hat{R}_{med}$) (Table 2). With a bias of 2.26%, the 95% confidence interval for the estimated abundance of medium fish is 489 to 1,109.

Estimated abundance of large fish $\hat{N}_{\text{lg}}$ on the spawning grounds in 1997 was 2,970 (SE = 277) based on 307 fish being marked in the lower river ($\hat{M}_{\text{lg}}$) and 761 fish being inspected for marks ($\hat{C}_{\text{lg}}$) on the spawning grounds, 78 of which were recaptured fish ($\hat{R}_{\text{lg}}$) (Table 2). With a bias of 0.09%, the 95% confidence interval for the estimated abundance of large fish is 2,499 to 3,636. Only three (3%) of the 94 recovered

Table 2.–Numbers of chinook salmon marked in the lower Unuk River and inspected for marks on the spawning grounds of the Unuk River in 1997 by size group.

	Length (MEF)			
	0–400 mm	401–659 mm	≥660 mm	Total
A. Released in event 1 with marks (*M*)	0	76	307[a]	**383**
B. Inspected at:				
1. Cripple Creek				
Inspected (C)	7	60	305	**372**
Recaptured (R)	0	8	32	**40**
Recaptured/captured	0	0.133	0.105	**0.120**
2. Gene's Lake Creek				
Inspected (C)	22	68	230	**320**
Recaptured (R)	0	6	13	**19**
Recaptured/captured	0	0.088	0.057	**0.059**
3. All others[b]				
Inspected (C)	19	28	226	**273**
Recaptured (R)	0	2	33	**35**
Recaptured/captured	0	0.071	0.146	**0.128**
Total inspected				
Inspected (C)	48	156	761	**965**
Recaptured (R)	0	16	78	**94**
Recaptured/captured	0	0.103	0.103	**0.097**

[a] Does not include one bright large male chinook salmon (MEF = 675 mm) in good condition that was removed from the study because it was caught on sport gear near Bell Island Narrows.

[b] Includes Kerr, Clear, Boundary, Dog Salmon, and Lake creeks and the Eulachon River.

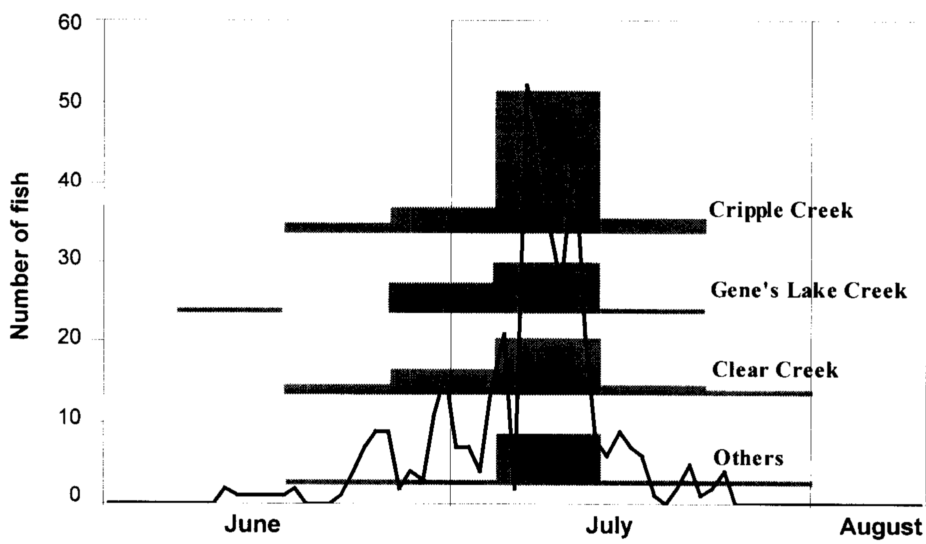

Figure 5.–Weekly numbers of marked chinook salmon sampled in 1997 at eight locations (bar graphs) and associated time of marking, set against the daily set gillnet catches in the lower Unuk River (line graph). X-axis pertains to time of marking; 'others' include Kerr, Boundary, Dog Salmon, and Lake creeks and the Eulachon River.

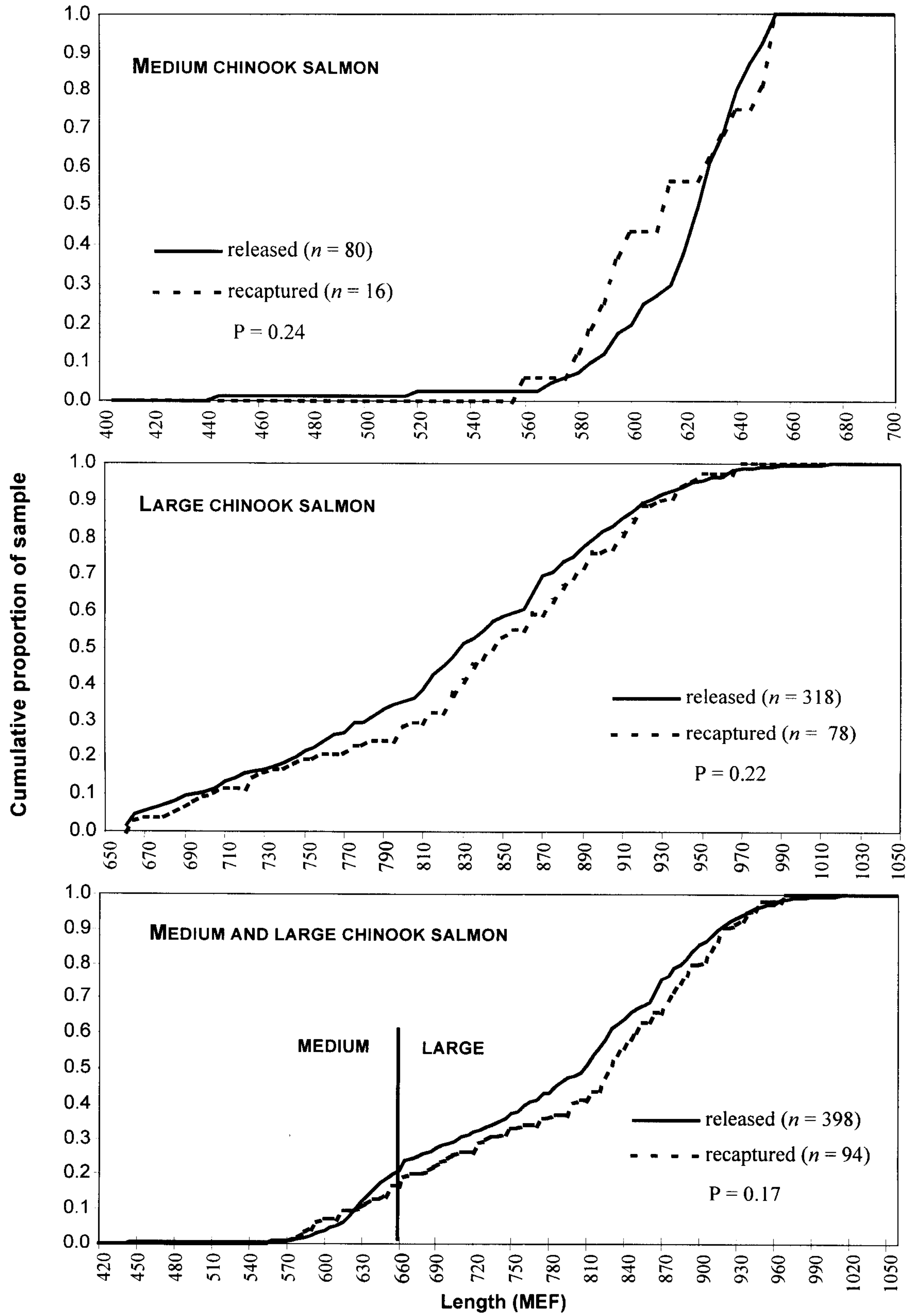

Figure 6.–Cumulative relative frequencies of medium, large, and medium and large chinook salmon (combined) marked in the lower Unuk River in 1997 versus those recaptured on the spawning grounds at eight tributary sampling sites.

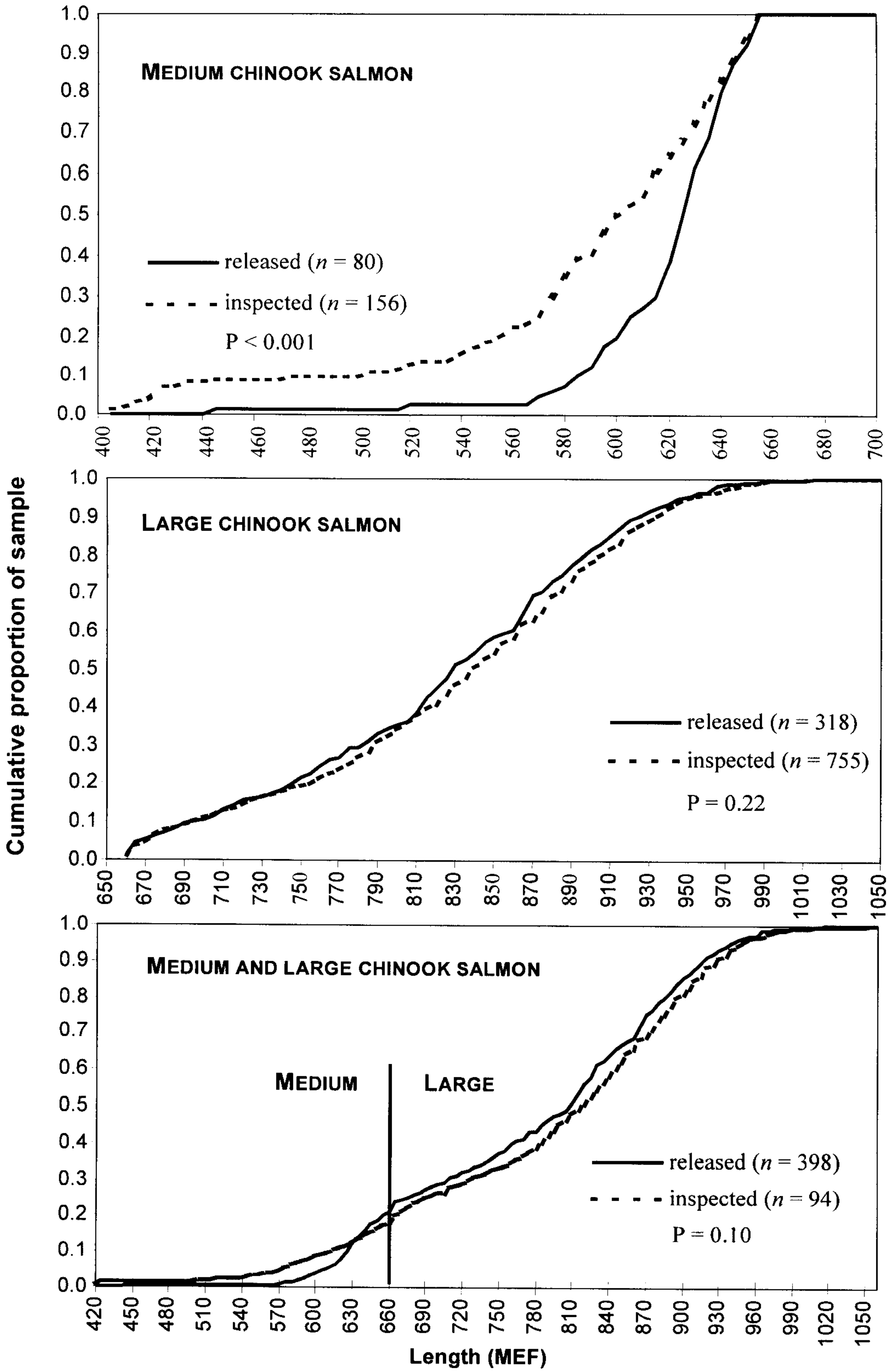

Figure 7.–Cumulative relative frequencies of medium, large, and medium and large chinook salmon (combined) marked in the lower Unuk River in 1997 versus those inspected on the spawning grounds at eight tributary sampling sites.

medium and large fish had lost the primary tag, and these were detected as marked fish from the presence of the left upper operculum punch (LUOP) and a missing left axillary appendage (LAA).

With a bias of 0.51%, the estimated abundance of all fish >400 mm MEF ($\hat{N} = \hat{N}_{med} + \hat{N}_{lg}$) for 1997 was 3,671 (SE = 320), with a 95% confidence interval is 3,167 to 4,422.

Estimates of Age and Sex Composition

Age-1.3 and age-1.4 chinook salmon dominated the age and sex compositions of fish >400 mm MEF (Appendix A2). Age-1.2 fish were 25% (SE = 3.2%), age-1.3 fish 34% (SE = 2.2%), and age-1.4 fish 38% (SE = 2.4%) of the escapement of medium and large fish; 55% (SE = 2.6%) of these were males (Table 3). Age-1.2 fish constituted 91% (SE = 2.4%) of the medium fish, which were 100% males (Figure 8). Age-1.3 fish accounted for 41% (SE = 1.9%) and age-1.4 fish accounted for 47% (SE = 2.0%) of all large fish in the escapement; males composed 44% (SE = 1.9%) of these fish.

In the gillnet sampling, mostly large fish were captured consisting of 10% age-1.2 fish, 48% age-1.3 fish, and 40% age-1.4 fish (Appendix A2). Among the medium fish sampled, 91% were age-1.2 and the remaining 9% were age-1.3 fish. In general, sex compositions of large fish sampled in the lower river were the same as those from the combined spawning grounds samples (males 46%). Table 4 lists average lengths by age of all fish sampled for length and successfully aged on the spawning grounds. For the most part, length compositions between samples gathered in the lower river and on the spawning grounds were very similar—one exception being in the age-1.4 male component, where larger fish were sampled in the lower river (avg. length = 926 mm MEF; $n = 28$), compared to those sampled on the spawning grounds (avg. length = 887 mm MEF; $n = 70$).

DISCUSSION

Initially, a concern existed that the fish bound for the various spawning tributaries might be unevenly distributed across the lower river entry channels and that fish bound for some areas (i.e., Eulachon River) may be disproportionately sampled. In the 1994 study, two set gillnet sampling sites were used to capture and mark fish. It was evident from that study, from both radio telemetry and spaghetti tag recoveries, that fish bound for the various spawning tributaries were tagged in nearly equal proportions at both set gillnet sites (Pahlke et al. 1996).

This year we used only one sampling site, which was located on the mainstem of the lower Unuk River. As was the case in the 1994 study, fish bound for the Eulachon River migrated into and matured in the Unuk mainstem and thus were susceptible to capture. In fact, the marked fraction of fish sampled from the Eulachon River (12.8%) was higher than the average marked fraction observed in all of the other sampling sites (9.6%), although these values are not significantly different ($\chi^2 = 0.44$, df = 1, P = 0.51).

In a related observation, predators such as bald eagles *Haliaeetus leucocephalus*, harbor seals *Phoca vitulina*, brown bears *Ursus arctos*, black bears *U. americana*, and river otters *Lutra canadensis* were commonly seen in the study area. In response to the presence of these predators, Eulachon River fish, as well as fish from other sampling sites, may have developed the behavior of milling in the deep glacial waters, pools, or in lake areas of the Unuk River for extended periods of time while ripening prior to spawning, in order to minimize contact with predators. This would provide one explanation for the higher ratio of marked/unmarked fish observed in the Eulachon River, as this spawning site is one of the closest to the gillnet site. The 1994 study noted such behavior by fish tagged with radio transmitters—in some cases, the fish remained in the lower Unuk River for extended periods of time or even returned to the ocean or backed-down prior to moving upriver (Pahlke et al. 1996). This backing-down phenomenon of tagged chinook salmon has been observed in

Table 3.–Age and sex composition of medium (401 mm–659 mm MEF) and large (≥660 mm MEF) chinook salmon escapement in the Unuk River in 1997, determined using data gathered from the spawning grounds.

		Brood year and age class						
		1994	1993	1992		1991	1990	
		1.1	1.2	2.2	1.3	1.4	1.5	Total
PANEL A: AGE AND SEX COMPOSITION OF MEDIUM CHINOOK SALMON								
Males	n	10	131	0	2	1	0	144
	%	6.9	91.0	0.0	1.4	0.7	0.0	100.0
	SE of %	2.1	2.4	0.0	1.0	0.7	0.0	0.0
	Escapement	49	638	0	10	5	0	701
	SE of Esc.	18	144	0	7	5	0	158
PANEL B: AGE AND SEX COMPOSITION OF LARGE CHINOOK SALMON								
Males	n	0	60	1	155	69	3	288
	%	0.0	20.8	0.3	53.8	24.0	1.0	44.2
	SE of %	0.0	2.4	0.3	2.9	2.5	0.6	1.9
	Escapement	0	273	5	706	314	14	1,312
	SE of Esc.	0	49	5	106	55	8	184
Females	n	0	1	0	114	239	10	364
	%	0.0	0.3	0.0	31.3	65.7	2.7	55.8
	SE of %	0.0	0.3	0.0	2.4	2.5	0.9	1.9
	Escapement	0	5	0	519	1,089	46	1,658
	SE of Esc.	0	5	0	76	142	15	207
Sexes combined	n	0	61	1	269	308	13	652
	%	0.0	9.4	0.2	41.3	47.2	2.0	100.0
	SE of %	0.0	1.1	0.2	1.9	2.0	0.5	0.0
	Escapement	0	278	5	1,225	1,403	59	2,970
	SE of Esc.	0	43	5	128	143	17	277
PANEL C: AGE AND SEX COMPOSITION OF MEDIUM AND LARGE CHINOOK SALMON								
Males	n	10	191	1	157	70	3	432
	%	2.4	45.3	0.2	35.6	15.9	0.7	54.8
	SE of %	0.5	2.5	0.1	2.0	1.2	0.2	2.6
	Escapement	49	911	5	716	319	14	2,013
	SE of Esc.	18	153	5	107	55	8	243
Females	n	0	1	0	114	239	10	364
	%	0.0	0.3	0.0	31.3	65.7	2.7	45.2
	SE of %	0.0	0.1	0.0	1.1	1.1	0.4	2.8
	Escapement	0	5	0	519	1,089	46	1,658
	SE of Esc.	0	5	0	76	142	15	207
Sexes combined	n	10	192	1	271	309	13	796
	%	1.3	24.9	0.1	33.6	38.4	1.6	100.0
	SE of %	0.5	3.2	0.1	2.2	2.4	0.4	3.9
	Escapement	49	915	5	1,235	1,408	59	3,671
	SE of Esc.	18	150	5	128	143	17	319

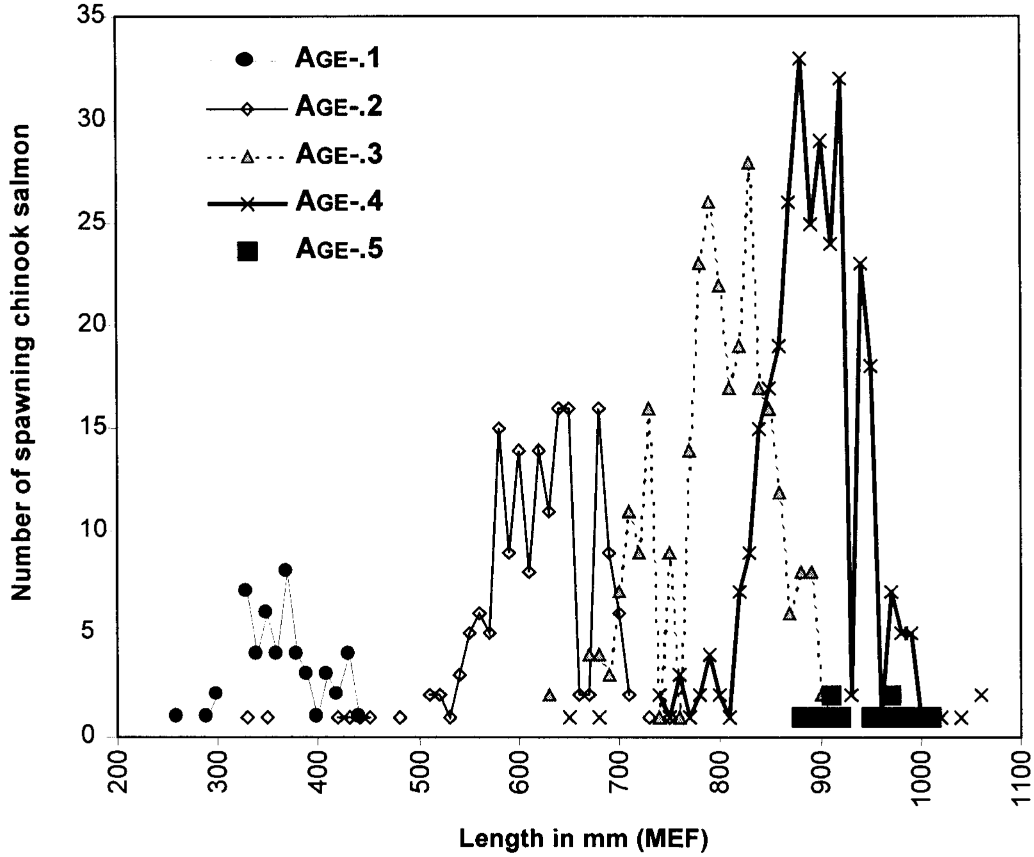

Figure 8.–Numbers of chinook salmon sampled by length and ocean-age at all eight tributary spawning sites on the Unuk River in 1997.

other studies (Milligan et al. 1984; Johnson et al. 1992, 1993; Bendock and Alexandersdottir 1993; Eiler et al. *In prep*).

Pahlke et al. (1996) showed that 86% of fish tagged with radio transmitters were successfully tracked to the spawning grounds, although some fish displayed a "sulking" behavior or a delay in upstream migration. Such behavior may have been present in this year's study; however, we feel confident over the long term that marked and unmarked fish died at the same rate, and that the estimated abundance is therefore unbiased (Seber 1982, p. 71). Loss of primary tags was not a problem in this study, as only two large and one medium fish (all males), were captured missing a primary tag. In all cases, secondary tags were clearly visible on recaptured fish.

The success of this mark-recapture experiment depended heavily on marking adequate numbers of fish and on doing so in proportion to their passing abundance. For our estimates of abundance to be unbiased and consistent, every fish must have had an equal chance of being marked in the lower Unuk River, or every fish on the spawning grounds must have had an equal chance of being inspected, or marked and unmarked fish must have mixed completely between the lower Unuk River and the tributaries (Seber 1982, pp. 437-9). The statistical tests performed and the output from SPAS (Arnason et al. 1996) suggest that fish were marked in proportion to their abundance and that complete mixing of these fish occurred before they had a chance of being recaptured upriver. Furthermore, because our sampling spanned most or all

Table 4.–Estimated average length (MEF in mm) by age and sex of chinook salmon sampled on the Unuk River in 1997.

		Brood year and age class							
		1994	1993	1992			1990		
		1.1	1.2	2.2	1.3	1.4	2.4	1.5	Total
Panel A: Length composition of medium and large chinook salmon sampled by gillnet on the lower Unuk River									
Males	*n*		85		76	28		2	191
	Avg. length		636		776	926		913	
	SD		46		71	48		4	
	SE		5		8	9		3	
Females	*n*		1		61	81	1	4	148
	Avg. length		675		802	889	815	906	
	SD		0		53	38	0	38	
	SE		0		7	4	0	19	
Sexes combined	*n*		86		137	109	1	6	339
	Avg. length		637		788	898	815	908	
	SD		46		65	44	0	29	
	SE		5		6	4	0	12	
Panel B: Length composition of medium and large chinook salmon sampled on the Unuk River spawning grounds									
Males	*n*	51	193	1	157	70		3	475
	Avg. length	363	622	700	777	887		962	
	SD	39	60	0	58	79		71	
	SE	5	4	0	5	9		41	
Females	*n*		1		114	239		10	364
	Avg. length		665		811	890		944	
	SD		0		42	46		33	
	SE		0		4	3		10	
Sexes combined	*n*	51	194	1	271	309		13	839
	Avg. length	363	622	700	791	889		948	
	SD	39	60	0	55	55		41	
	SE	5	4	0	3	3		11	

of the known immigration of fish into the Unuk River (Keith Pahlke, Alaska Department of Fish and Game, Douglas, personal communication), nearby proportional tagging of all stocks likely occurred; thus, our estimates of abundance pertain to all chinook salmon spawning in the Unuk River.

It was apparent from length and sex composition data that some size-selective sampling occurred, both in the gillnet sampling and in the spawning grounds sampling. Gillnets are typically size selective and in our study the gillnets appeared to be selective toward the bigger medium fish, but caught almost all sizes of large fish. Not a single age-1.1 fish, and only those larger than average age-1.2, were captured in the gillnet sampling. In addition, the gillnets appear to be biased against sampling the extremely large fish. Out of 404 fish captured in gillnets, only one exceeded 1,000 mm MEF (0.25%); conversely, 965 fish were captured on the spawning grounds and 7 of those exceeded 1,000 mm MEF (0.73%).

For the fish of interest in this experiment (≥660 mm MEF), however, very little difference in age and sex composition occurred between gillnet and spawning ground samples (Appendix A2, panels C and D), and there was no significant difference between length distributions of large fish tagged vs. those fish recaptured or inspected (Figures 6 and 7).

Because male chinook salmon tend to drift downstream in a moribund state after spawning, whereas females tend to die near their redds (Kissner and Hubartt 1986), estimates of age, sex, and size composition for fish sampled in carcass-only surveys tend to be biased towards females, which are larger fish on average. During this study, however, various sampling techniques were used on the spawning grounds, such as rod and reel snagging and lure fishing, spear, gillnet, dipnet, and carcass-only surveys were used because McPherson et al. (1997) found that using a variety of gear types will reduce bias in age, sex, and length composition estimates. Foot surveys of abundance were used to estimate the amount of effort needed to approximately sample the various spawning sites in proportion to abundance as a whole. Therefore, in estimating abundance and age and sex composition for the watershed, we presumed that the combined samples from the various spawning tributaries for medium and large fish were representative of the total population.

During the 1994 study, the mark-recapture estimate of abundance for medium and large fish resulted in a 95% relative precision (RP) of ±54%. One of our research objectives this year was to attain an RP of at least ±33% (Table 5). In reality, we did far better than this in achieving an RP of ±17%, a vast improvement over the 1994 results. A similar improvement in RP occurred over consecutive years of study (1995 and 1996) on the Chickamin River (Pahlke 1996, 1997b). In the 1995 study, an RP of ±61% occurred, and in the following year the RP improved to ±25% (Table 5). These results suggest that the knowledge gained from previous mark-recapture studies is beneficial and positively influences the success of future studies.

Estimated abundance of large fish was considerably greater than corresponding estimates from the peak survey counts. Observer bias resulting in underestimation of the actual abundance is a common pattern seen in other studies of chinook salmon in Southeast Alaska and in northern British Columbia (Johnson et al. 1992; Pahlke et al. 1996; McPherson et al. 1997) and of salmon in general (Jones 1995). This year, about 21% (636) of the estimated 2,970 large fish immigrating to the Unuk River in 1997 were counted in the peak survey count. This percentage compares favorably with the results seen in the 1994 study and the 1995 and 1996 Chickamin River studies (Table 5) (Pahlke 1996, 1997b, Pahlke et al. 1996).

This ongoing study is designed to estimate the escapement of chinook salmon in the Unuk River and is an integral part of a larger full stock assessment program which estimates the total run size, harvest rates, and harvest distribution for these fish. In a separate study in the Unuk

Table 5.–Peak survey counts compared to mark-recapture estimates of abundance and other statistics for large chinook salmon (≥660 mm MEF) in the Unuk River (1994 and 1997) and the Chickamin River (1995 and 1996).

	1994 Unuk River	1995 Chickamin River	1996 Chickamin River	1997 Unuk River	Average
Survey count	711	356	422	636	531
Mark-recapture estimate (M-R)	4,623	2,309	1,587	2,970	2,872
Survey count/(M-R) (%)	**15**	**15**	**27**	**21**	**20**
M-R SE	1,26	723	199	271	615
95% RP	54	61	25	18	39
M-R lower 95% CI	2,992	1,388	1,279	2,499	2,040
M-R upper 95% CI	9,425	4,650	2,089	3,636	4,950

River, fall juvenile and spring chinook salmon smolt have been tagged with CWTs since the fall of 1993 (1992 brood year). Significant returns of these fish occurred in 1997 as evidenced by the 50 CWTs recovered during this study (Appendix A1, A3). Since juvenile and smolt tagging was initiated, greater numbers of fish have been tagged with CWTs in each subsequent brood year (Appendix A3). This has translated into a higher ratio of marked:unmarked adults sampled from each of these brood years: the ratio for the 1992 brood year was 2.8% vs. 11.5% for the 1993 brood year (Appendix A3).

In recent years, peak survey counts of escapement have been at or below the 20-year average of 1,120 large fish: 711 in 1994, 772 in 1995, 1,167 in 1996, and 636 in 1997. An estimated 915 (SE = 150) age-1.2 (1993 brood year) fish returned to the Unuk River in 1997 (Table 3). This is an unusually high percentage (25%) of the overall escapement and nearly doubles the percentage (13%) seen in the previous work performed in 1994 (Pahlke et al. 1996). In 1998, age-1.3 fish will be returning from the 1993 brood year, and if this brood year continues to make a strong showing, then we should expect to see slightly higher numbers of chinook salmon in 1998 when compared to those seen in 1997.

CONCLUSIONS AND RECOMMENDATIONS

Because this project will be performed again in 1998, we recommend some strategies for continued success. As in 1997, at least the same number of medium and large fish should be tagged in both the marking and recapturing events. In 1998, the same routine as the one used in 1997 will be used while fishing the set gillnets. The set gillnets will be fished twice daily using two-person crews, one crew in the morning and a separate crew in afternoon/evening. Knowledge of run-timing gathered in 1994 and 1997 should be used as an indicator of peak spawning abundance and optimum sampling periods, while sampling is being conducted at the various spawning sites. In 1997, very few fish lost their primary tags, and we feel that this is primarily due to the use of the stronger, more durable 80-lb test monofilament in spaghetti tags and to increased efficiency in their application. Thus, we will use the same primary tag and the same secondary marks in 1998, inasmuch as the combination of these three proved failsafe in detecting marked fish. We recommend that survey counts continue in similar fashion as those made in the past and that observers attempt to maintain consistency in counting efficiency from year to year. Finally, we recommend the continued use of multiple capture gear at the various spawning tributaries, which has likely contributed most to unbiased results in age, sex, and length composition estimates.

ACKNOWLEDGMENTS

We thank Tim Schantz, Paul Overturf, and Tina Evert of ADF&G for operating the gillnets used to capture and tag fish in the lower Unuk River and for their efforts in searching for tagged fish during the spawning grounds sampling effort; David Dryer for his help with the spawning grounds sampling effort; Amy Holm for helping plan the project, logistic support, and an outstanding job in expediting equipment and materials needed to run this project; Keith Pahlke for performing the aerial counts of spawning abundance and for project assistance; Bob Marshall for his biometric support; Dale Brandenburger for assistance in data entry; and Alma Seward for help in preparation of the final manuscript.

LITERATURE CITED

ADF&G (Alaska Department of Fish and Game). 1993. Length, sex, and scale sampling procedure for sampling using the ADF&G adult salmon age-length mark-sense form version 3.0. Commercial Fisheries Management and Development Division, Douglas.

Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Canadian Technical Report of Fisheries and Aquatic Sciences. 2106: 37 p.

Bendock, T. and M. Alexandersdottir. 1993. Hooking mortality of chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management 13:540-549.

Buckland, S. T. and P. H. Garthwaite. 1991. Quantifying precision of mark-recapture estimates using the bootstrap and related methods. Biometrics 47:255-268.

Clutter R. and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin of the International Pacific Salmon Fisheries Commission 9, New Westminster, British Columbia.

Efron, B. and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, New York.

Eiler, J., M. M. Masuda, J. Pella, H. R. Carlson, R. F. Bradshaw, and B. D. Nelson. *In prep.* Stock composition, escapement estimate, and timing of chinook salmon returns in the Taku River, Alaska and British Columbia.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

Johnson, R. E. 1993. Chilkat River chinook salmon studies, 1992. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series 93-50, Anchorage.

Johnson, R. E., R. P. Marshall, and S. T. Elliott. 1992. Chilkat River chinook salmon studies, 1991. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series 92-49, Anchorage.

Jones, E. L., III. 1995. Observer variability and bias in estimation of Southeast Alaska pink salmon escapement. Master's thesis, University of Alaska Fairbanks, Juneau.

Kissner, P. D., Jr. and D. J. Hubartt. 1986. A study of chinook salmon in Southeast Alaska. Alaska Department of Fish and Game, Annual Report 1985-1986, Project F-10-1, 27 (AS-41).

McPherson, S. A. and J. K. Carlile. 1997. Spawner-recruit analysis of Behm Canal chinook salmon stocks. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 1J97-08, Juneau.

McPherson, S. A., D. R. Bernard, M. S. Kelley, P. A. Milligan, and P. Timpany. 1997. Spawning abundance of chinook salmon in the Taku River in 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-14, Anchorage.

Milligan, P. A., W. O. Rublee, D. D. Cornett, and R. A. C. Johnston. 1984. The distribution and abundance of chinook salmon in the upper Yukon River basin as determined by a radio-tagging and spaghetti tagging program: 1982–1983. Department of Fisheries and Oceans, Yukon River Basin Study, Technical Report 35. Whitehorse, Yukon Territory.

Olsen, M. A. 1992. Abundance, age, sex and size of chinook salmon catches and escapements in Southeast Alaska in 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 92-07, Juneau.

Pahlke, K. A. 1995. Coded-wire tagging studies of chinook salmon on the Unuk and Chickamin rivers, 1983-1993. Alaska Department of Fish and Game, Alaska Fishery Research Bulletin Series 2(2):93-113.

Pahlke, K. A. 1996. Abundance of the chinook salmon escapement on the Chickamin River, 1995. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 96-37, Anchorage.

Pahlke, K. A. 1997a. Escapements of chinook salmon in Southeast Alaska and transboundary rivers in 1996. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 97-33, Anchorage.

Pahlke, K. A. 1997b. Abundance and distribution of the chinook salmon escapement on the Chickamin River, 1996. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 97-28, Anchorage.

Pahlke, K. A., S. A. McPherson, and R. P. Marshall. 1996. Chinook salmon research on the Unuk River, 1994. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 96-14, Anchorage.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters, second edition. MacMillan and Company, New York.

Welander, A. D. 1940. A study of the development of the scale of the chinook salmon (*Oncorhynchus tshawytscha*). Master's thesis, University of Washington, Seattle.

APPENDIX A

Appendix A1.–Date, time, sex, length, age, tag code, and recovery location for chinook salmon caught in set gillnets on the Unuk River in 1997.

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
1	6/11/97	1205	M	830	Large, Bright, Slight Bleed	1.3				1001		
2	6/11/97	1438	F	965	Large, Sea Lice, Bright	1.4				1002		
3	6/12/97	1139	M	665	Large, Bright	1.2				1003		
4	6/13/97	1445	M	635	Medium, Bright, Good Cnd.	1.2				1004		
5	6/15/97	0940	F	840	Large, Sea Lice, Bright, Good Cnd.	1.3				1005		
6	6/16/97	1322	F	910	Large, Sea Lice, Bright, Good Cnd.	R.4				1006		
7	6/17/97	1231	F	865	Large, Dark Pink, Good Cnd.	1.4				1007		
8	6/17/97	1457	F	830	Large, Sea Lice, Bright, Good Cnd.	1.3				1008		
9	6/21/97	1405	M	585	Medium, Bright, Good Cnd.	1.2				1009	Gene's Lk. Ck.	7/29/97
10	6/22/97	1513	M	770	Large, Dark Pink, Good Cnd.	1.3				1010		
11	6/22/97	1602	M	665	Large, Gray, Good Cnd.	1.2				1011		
12	6/22/97	1608	M	815	Large, Sea Lice, Seal Scar L Side	1.3				1012		
13	6/22/97	1849	F	775	Large, Gray, Good Cnd.	1.3				1013		
14	6/23/97	1235	M	870	Large, Sea Lice, Red-Gray	1.4				1014	Clear Ck.	8/4/97
15	6/23/97	1355	M	910	Large, Gray, Slight Bleeder	1.5				1015		
16	6/23/97	1402	M	575	Medium, Sea Lice, Bright	R.2				1016		
17	6/23/97	1510	F	675	Large, Bright, Hard Body	1.2				1017		
18	6/23/97	1545	F	845	Large, Sea Lice, Bright, Good Cnd.	1.3				1018	Cripple Ck.	8/7/97
19	6/23/97	1558	M	965	Large, Sea Lice, Gray, Good Cnd.	1.4				1019	Clear Ck.	7/21/97
20	6/23/97	1612	F	920	Large, Sea Lice, Bright Gray	1.4				1020		
21	6/24/97	0549	F	815	Large, Bright, Good Cnd.	R.3				1021		
22	6/24/97	0632	M	655	Medium, Bright, Good Cnd.	R.2				1022		
23	6/24/97	0651	M	815	Large, Sea Lice, Gray, Good Cnd.	1.3				1023		
24	6/24/97	0702	M	895	Large, Sea Lice, Bright Gray	1.3				1024		
25	6/24/97	0710	F	795	Large, Gray, Good Cnd.	R.3				1025		
26	6/24/97	0731	M	775	Large, Bright, Good Cnd.	1.3				1026		
27	6/24/97	1135	M	750	Large, Bright Gray	1.3				1027		
28	6/24/97	1331	F	805	Large, Sea Lice, Pink - Gray	1.3				1028		
29	6/24/97	1736	F	815	Large, Sea Lice, Bright, Good Cnd.	1.3				1029		
30	6/25/97	0606	M	880	Large, Good Cnd.	1.3				1030		
31	6/25/97	0607	M	675	Large, Sea Lice, Bright, Good Clip	1.2	77213	43350	1993			
32	6/25/97	0714	F	905	Large, Darkish Gray, Good Cnd.	1.4				1031		
33	6/25/97	0714	F	660	Large, Bright	1.3				1032		
34	6/25/97	0835	M	735	Large, Bright, Pinkish	1.3				1033		
35	6/25/97	1015	M	715	Large, Sea Lice, Bright, Tired	R.2				1034		
36	6/25/97	1430	M	675	Large, Bright, Good Cnd.	1.2				1035		
37	6/25/97	1600	M	790	Large, Sea Lice, Dark, Good Cnd.	1.3				1036		
38	6/25/97	1815	F	705	Large, silver-gray, Good Cnd.	R.3				1037		
39	6/26/97	0509	F	870	Large, Bright, Good Cnd.	1.4				1038		
40	6/26/97	0646	F	870	Large, Bright, Good Cnd.	1.4				1039		
41	6/27/97	1240	M	815	Large, Sea Lice, Pink, Good Cnd.	R.3				1040		
42	6/27/97	1410	M	825	Large, Pink-Gray, Good Cnd.	1.3				1041		
43	6/27/97	1726	M	760	Large, Gray, Good Cnd.	1.3				1042	Cripple Ck.	8/6/97
44	6/27/97	1812	M	680	Large, Bright, Good Cnd.	1.3				1043		
45	6/28/97	1111	M	865	Large, Dark, Good Cnd.	R.4				1044	Kerr Ck.	8/2/97
46	6/28/97	1130	M	810	Large, Bright Gray, Good Cnd.	1.3	77214	43803	1992			
47	6/28/97	1320	M	940	Large, Dark, Good Cnd.	1.4				1045		
48	6/29/97	0616	M	625	Medium, Sea Lice, Bright	1.2				1046		
49	6/29/97	0713	M	820	Large, Pinkish Gray, Good Cnd.	1.3				1047	Clear Ck.	8/4/97
50	6/29/97	0907	M	640	Medium, Pinkish Gray, Good Cnd.	1.2				1048		
51	6/29/97	1139	F	880	Large, Pinkish Gray, Good Cnd.	1.4				1049	Clear Ck.	7/21/97
52	6/29/97	1306	F	830	Large, Sea Lice, Bright	R.3				1050		
53	6/29/97	1330	M	635	Medium, Sea Lice, Bright	1.2				1051		

-continued-

Appendix A1.–(Page 2 of 8).

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
54	6/29/97	1354	M	720	Large, Bright, Good Cnd.	1.2				1052	Gene's Lk. Ck.	8/1/97
55	6/29/97	1420	M	660	Large, Sea Lice, Bright, Good Cnd.	1.2				1053		
56	6/29/97	1518	F	855	Large, Sea Lice, Gray, Good Cnd.	1.4				1054		
57	6/29/97	1528	F	965	Large, Bright,	R.4				1055		
58	6/29/97	1558	M	815	Large, Sea Lice, Pink, Good Cnd.	1.3				1056		
59	6/30/97	0500	M	670	Large, Sea Lice, Bright, Good Cnd.	1.3				1057		
60	6/30/97	0557	M	880	Large, Pinkish Gray, Good Cnd.	1.3				1058		
61	6/30/97	0911	M	865	Large, Sea Lice, Bright, Pink	R.3				1059		
62	6/30/97	1240	M	830	Large, Slight Bleed, Bright	1.3				1060		
63	6/30/97	1319	M	655	Medium, Bright, Good Cnd.	1.2				1061		
64	6/30/97	1319	M	855	Large, Red, Good Clip	1.3	77215	43805	1992			
65	6/30/97	1322	F	845	Large, Sea Lice, Bright, Good Cnd.	1.4				1062		
66	6/30/97	1350	F	800	Large, Bright, Good Cnd.	1.3				1063		
67	6/30/97	1359	M	915	Large, Sea Lice, Gray, Good Cnd.	1.5				1064		
68	6/30/97	1428	M	665	Large, Bright, Pink, Good Cnd.	1.3				1065		
69	6/30/97	1506	M	775	Large, Gray, Slight Bleeder	1.3				1066	Clear Ck.	8/15/97
70	6/30/97	1516	F	835	Large, Gray, Good Cnd.	R.4				1067	Cripple Ck.	7/31/97
71	6/30/97	1644	M	895	Large, Sea Lice, Gray, Good Cnd.	1.4				1068		
72	6/30/97	1745	M	595	Medium, Bright, Slight Bleeder	1.2				1069		
73	6/30/97	1824	M	870	Large, Gray, Good Cnd.	1.4				1070	Eulachon Ri.	8/14/97
74	6/30/97	1844	M	625	Medium, Bright, Good Cnd.	1.2				1071		
75	7/1/97	0557	F	920	Large, Sea Lice, Gray, Good Cnd.	1.4				1072	Gene's Lk. Ck.	8/11/97
76	7/1/97	0622	F	830	Large, Sea Lice, Gray, Good Cnd.	1.3				1073		
77	7/1/97	1504	F	820	Large, Bright, Missing L Pectoral	1.3				1074		
78	7/1/97	1559	F	930	Large, Gray/Green Good Cnd.	1.4				1075		
79	7/1/97	1754	F	905	Large, Bright, Good Cnd.	1.4				1076		
80	7/1/97	1805	F	755	Large, Bright, Good,Tired	1.3				1077		
81	7/1/97	1820	F	965	Large, Sea Lice, Bright, Good Cnd.	1.4				1078		
82	7/2/97	0627	F	760	Large, Bright, Good Cnd.	R.3				1079		
	7/2/97	0630	M	800	Large, Gray, Dead in Net	R.3				Mortality		
83	7/2/97	0710	F	875	Large, Gray - Red, Good Cnd.	1.4				1080		
84	7/2/97	0853	M	975	Large, Sea Lice, Dark, Good Cnd.	1.4				1081		
85	7/2/97	1145	F	900	Large, Sea Lice, Bright, Good Cnd.	R.4				1082	Gene's Lk. Ck.	8/16/97
86	7/2/97	1530	M	950	Large, Red, Pink, Good Cnd.	1.4				1083		
87	7/2/97	1547	F	885	Large, Sea Lice, Gray, Good Cnd.	1.4				1084	Gene's Lk. Ck.	8/1/97
88	7/3/97	0514	F	795	Large, Gray, Good Cnd.	1.4				1085		
89	7/3/97	1252	M	890	Large, Bright, Good Cnd.	1.4				1086		
90	7/3/97	1319	F	810	Large, Bright, Good Cnd.	1.3				1087	Clear Ck.	8/12/97
91	7/3/97	1642	M	625	Medium, Bright, Good Cnd.	R.2				1088		
92	7/4/97	0759	F	785	Large, Sea Lice, Bright, Good Cnd.	1.3				1089		
93	7/4/97	0801	F	865	Large, Sea Lice, Bright, Good Cnd.	R.4				1090		
94	7/4/97	0958	M	735	Large, Sea Lice, Bright, Good Cnd.	1.3				1091	Gene's Lk. Ck.	8/2/97
95	7/4/97	1040	F	865	Large, Sea Lice, Bright, Good Cnd.	1.4				1092		
96	7/4/97	1225	F	820	Large, Sea Lice, Bright Gray	1.3				1093		
97	7/4/97	1305	M	645	Medium, Sea Lice, Bright Gray	R.2				1094		
98	7/4/97	1430	F	880	Large, Bright Gray, Good Cnd.	1.4				1095		
99	7/4/97	1442	M	625	Medium, Sea Lice, Bright, Bleeder	1.2				1096	Cripple Ck.	8/9/97
100	7/4/97	1514	F	775	Large, Sea Lice, Bright Gray	1.3				1097		
101	7/4/97	1514	F	900	Large, Sea Lice, Pink Gray	1.4				1098		
102	7/4/97	1601	M	630	Medium, Bright, Bleeder	1.3				1099		
103	7/4/97	1620	F	890	Large, Bright, Good Cnd.	1.4				1100		
104	7/4/97	1751	M	590	Medium, Gray, Old Net Scar	1.2				1101		
105	7/4/97	1802	M	865	Large, Sea Lice, Pink - Gray	1.4				1102		
106	7/5/97	0738	M	635	Medium, Sea Lice, Bright	1.3				1103		

-continued-

Appendix A1.–(Page 3 of 8).

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
107	7/5/97	0820	F	820	Large, Sea Lice, Bright, Gray	1.3				1104		
108	7/5/97	0850	M	640	Medium, Sea Lice, Gray, Bite Scar	1.2				1105	Cripple Ck.	8/12/97
109	7/5/97	1010	M	965	Large, Dark, Good Cnd.	1.4				1106		
110	7/5/97	1016	M	645	Medium, Bright, Good Cnd.	1.2				1107		
111	7/5/97	1052	F	815	Large, Sea Lice, Gray, Good Cnd.	2.4				1108	Gene's Lk. Ck.	8/4/97
112	7/5/97	1235	F	865	Large, Bright, Gray, Good Cnd.	1.4				1109		
113	7/5/97	1248	M	710	Large, Sea Lice, Bright, Good Cnd.	1.2				1110	Cripple Ck.	8/6/97
114	7/5/97	1336	M	740	Large, Gray, Good Cnd.	1.3				1112		
115	7/5/97	1353	F	865	Large, Bright, Good Cnd.	1.4				1113		
116	7/5/97	1438	M	625	Medium, Sea Lice, Bright, Pinkish	1.2				1114		
117	7/5/97	1516	F	895	Large, Dark, Good Cnd.	1.4				1115		
118	7/5/97	1538	F	920	Large, Sea Lice, Dark, Good Cnd.	1.4				1116		
119	7/5/97	1632	M	640	Medium, Sea Lice, Bright, Pinkish	1.3				1117		
120	7/5/97	1803	M	635	Medium, Bright, Killed	1.2	77216	43350	1993			
121	7/5/97	1936	F	900	Large, Bright, Good Cnd.	1.4				1118	Clear Ck.	8/18/97
122	7/5/97	1951	M	650	Medium, Sea Lice, Bright	1.2				1119		
123	7/5/97	1951	F	765	Large, Sea Lice, Bright, Good Cnd.	1.3				1120		
124	7/5/97	1951	M	630	Medium, Pink, Good Cnd.	R.				1121	Cripple Ck.	7/30/97
125	7/5/97	2031	M	705	Large, Sea Lice, Bright, Good Cnd.	1.3				1122		
126	7/5/97	1305	M	615	Medium, Bright, No Scales	R.				No Scales		
127	7/6/97	0600	F	875	Large, Gray, Good Cnd.	1.4				1123	Clear Ck.	8/4/97
128	7/6/97	0729	M	940	Large, Pink, Good Cnd.	1.4				1124		
129	7/7/97	0538	M	785	Large, Pink, Good Cnd.	1.3				1125		
130	7/7/97	0621	M	680	Large, Sea Lice, Pink, Bleeder	1.2				1126		
131	7/7/97	0638	M	650	Medium, Sea Lice, Gray, Gd. Cnd.	1.2				1127		
132	7/7/97	0643	F	935	Large, Bright, Good Cnd.	1.4				1128		
133	7/7/97	0709	F	920	Large, Sea Lice, Bright, Good Cnd.	1.4				1129		
134	7/7/97	0709	M	700	Large, Pink, Bright, Good Cnd.	1.2				1131		
135	7/7/97	0740	M	795	Large, Sea Lice, Gray (Killed)	1.3	77217	43803	1992			
136	7/7/97	0752	F	895	Large, Gray - Pink Good Cnd.	1.4				1130		
137	7/7/97	0807	F	830	Large, Bright, Good Cnd.	1.3				1132		
138	7/7/97	0824	M	745	Large, Sea Lice, Bright, Good Cnd.	R.3				1133		
139	7/7/97	0824	M	635	Medium, Gray, Good Cnd.	1.2				1134	Gene's Lk. Ck.	8/7/97
140	7/7/97	0835	F	955	Large, Sea Lice, Gray, Good Cnd.	1.5				1135	Kerr Ck.	8/5/97
141	7/7/97	0932	F	940	Large, Sea Lice, Bright, Good Cnd.	1.4				1136		
142	7/7/97	0092	F	830	Large, Bright, Good Cnd.	R.4				1137		
143	7/7/97	0952	M	745	Large, Sea Lice, Bright, Good Cnd.	1.3				1138		
144	7/7/97	1035	F	825	Large, Sea Lice, Bright, Good Cnd.	1.3				1139	Gene's Lk. Ck.	8/20/97
145	7/7/97	1050	F	870	Large, Sea Lice, Bright, Good Cnd.	1.4				1140		
146	7/7/97	1211	F	860	Large, Sea Lice, Bright, Good Cnd.	1.4				1141		
147	7/7/97	1233	F	795	Large, Sea Lice, Bright, Good Cnd.	1.3				1142	Cripple Ck.	8/8/97
148	7/7/97	1243	M	930	Large, Sea Lice, Pink, Good Cnd.	1.4				1143		
149	7/7/97	1328	F	870	Large, Sea Lice, Gray, Good Cnd.	R.4				1144		
150	7/7/97	1357	M	815	Large, Sea Lice, Pink, Good Cnd.	1.3				1145		
151	7/7/97	1400	M	760	Large, Sea Lice, Gray, Good Cnd.	1.3				1146	Cripple Ck.	8/6/97
152	7/7/97	1420	F	850	Large, Green, Gash R Side	1.3				1147		
153	7/7/97	1430	M	665	Large, Bright, Good Cnd.	R.3				1148		
154	7/7/97	1450	F	850	Large, Sea Lice, Bright, Good Cnd.	1.4				1149	Clear Ck.	8/4/97
155	7/7/97	1450	F	850	Large, Sea Lice, Gray, Good Cnd.	1.4				1150		
156	7/7/97	1455	F	870	Large, Gray, Good Cnd.	1.4				1151		
157	7/7/97	1540	F	810	Large, Sea Lice, Bright, Good Cnd.	R.3				1152		
158	7/7/97	1607	M	645	Medium, Bright, Good Cnd.	1.2				1153		
159	7/7/97	1607	M	640	Medium, Pink, Gray, Good Cnd.	1.2				1154	Cripple Ck.	7/30/97
160	7/7/97	1625	F	950	Large, Sea Lice, Bright, Good Cnd.	1.4				1155		

-continued-

Appendix A1.–(Page 4 of 8).

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
161	7/7/97	1630	F	710	Large, Bright, Good Cnd.	1.3				1156	Cripple Ck.	8/5/97
162	7/7/97	1630	M	655	Medium, Gray, Good Cnd.	1.2				1157		
163	7/7/97	1755	M	830	Large, Sea Lice, Pink, Good Cnd.	1.3				1158	Clear Ck.	8/12/97
164	7/7/97	1813	F	845	Large, Sea Lice, Green, Good Cnd.	1.4				1159		
165	7/7/97	1827	F	880	Large, Gray, Good Cnd.	1.3				1160		
166	7/7/97	1827	F	820	Large, Bright, Good Cnd.	R.3				1161		
167	7/7/97	1859	F	830	Large, Sea Lice, Bright, Green	1.4				1162		
168	7/7/97	1827	F	880	Large, Bright, White Meat	1.3	77218	43803	1992			
169	7/7/97	1827	F	820	Large, Sea Lice, Bright, Good Cnd.	1.4				1163		
170	7/7/97	1957	F	825	Large, Sea Lice, Bright, Good Cnd.	R.4				1164	Gene's Lk. Ck.	8/4/97
171	7/7/97	1957	F	845	Large, Gray, Good Cnd.	1.3				1165		
172	7/7/97	2020	F	890	Large, Gold, Good Cnd.	R.4				1166		
173	7/7/97	2020	M	845	Large, Sea Lice, Pink, Red Meat	1.3	77219	43805	1992			
174	7/7/97	2119	M	655	Medium, Sea Lice, Pink, Bright	R.3				1167		
175	7/7/97	2138	M	900	Large, Gold, Downriver net	1.4				1168	Kerr Ck.	8/5/97
176	7/7/97	2147	F	890	Large, Silver-Gray	1.4				1169	Kerr Ck.	8/5/97
177	7/7/97	2151	F	895	Large, Sea Lice, Bright, Bleeder	1.4				1170		
178	7/7/97	2201	M	630	Medium, Bright, Gray, Good Cnd.	1.2				1171		
179	7/7/97	2211	M	815	Large, Sea Lice, Bright	1.3				1172		
	7/7/97	2228	M	765	Large, Bright, Net Mortality	1.3				Mortality		
180	7/8/97	0513	M	655	Medium, Bright, Good Cnd.	1.2				1173		
181	7/8/97	0528	M	815	Large, Sea Lice, Bright, Good Cnd.	1.3				1174	Cripple Ck.	8/9/97
182	7/8/97	0542	F	750	Large, Sea Lice, Bright, Good Cnd.	1.3				1175		
183	7/8/97	0548	M	935	Large, Sea Lice, Olive, Good Cnd.	1.4				1176		
184	7/8/97	0728	F	800	Large, Sea Lice, Dark, Good Cnd.	1.3				1177		
185	7/8/97	0732	M	730	Large, Sea Lice, Gray, Bleeder	R.3				1178		
186	7/8/97	0822	M	750	Large, Dark, Good Cnd.	R.4				1179		
187	7/8/97	0839	M	665	Large, Sea Lice, Bright, Good Cnd.	1.2				1180		
188	7/8/97	0845	F	900	Large, Sea Lice, Bright, Good Cnd.	1.4				1181		
189	7/8/97	0932	M	855	Large, Reddish, Good Cnd.	1.3				1182		
190	7/8/97	0950	M	860	Large, Pink-Gray, Good Cnd.	1.3				1183		
191	7/8/97	1029	F	925	Large, Sea Lice, Gray, Good Cnd.	1.4				1184		
192	7/8/97	1029	M	745	Large, Sea Lice, Bright, Good Cnd.	R.3				1185		
193	7/8/97	1045	F	925	Large, Bright, Good Cnd.	1.4				1186		
194	7/8/97	1111	M	605	Medium, Sea Lice, Bright	1.2				1187		
195	7/8/97	1132	F	840	Large, Sea Lice, Bright, Good Cnd.	1.3				1188		
196	7/8/97	1138	F	900	Large, Bright Gray, Good Cnd.	1.4				1189	Gene's Lk. Ck.	8/16/97
197	7/8/97	1204	M	665	Large, Bright, Good Cnd.	R.2				1190		
198	7/8/97	1225	F	885	Large, Sea Lice, Bright Gray	1.4				1191		
199	7/8/97	1232	F	880	Large, Tarnished Pewter	R.4				1192		
200	7/8/97	1356	F	765	Large, Gray, Slight Bleeder	1.3				1193		
201	7/8/97	1430	M	620	Medium, Ad Clip, Bright	1.2	77220	44213	1993			
202	7/8/97	1440	M	595	Medium, Bright, Good Cnd.	1.2				1194		
203	7/8/97	1456	F	825	Large, Sea Lice, Bright, Good Cnd.	1.4				1195	Clear Ck.	7/29/97
204	7/8/97	1501	M	850	Large, Sea Lice, Pink, Bright	1.3				1196		
205	7/8/97	1551	F	860	Large, Gray, Slight Bleeder	1.4				1197		
206	7/8/97	1607	M	745	Large, Sea Lice, Green, Bright	1.3				1198		
207	7/8/97	1628	M	625	Medium, Bright, Good Cnd.	1.2				1199		
208	7/8/97	1651	M	825	Large, Sea Lice, Pink, Scars	1.3				1200	Cripple Ck.	8/7/97
209	7/8/97	1705	M	645	Medium, Sea Lice, Bright, Gashes	R.2				1201		
210	7/8/97	1732	M	625	Medium, Bright, Good Cnd.	1.2				1202		
211	7/8/97	1740	F	775	Large, Sea Lice, Bright Gray	1.3				1203	Gene's Lk. Ck.	8/1/97
212	7/8/97	1845	M	700	Large, Sea Lice, Gray, Bleeder	R.				1204		
213	7/8/97	1902	M	660	Large, Sea Lice, Pink, Bright	1.2				1205		

-continued-

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
214	7/8/97	1943	F	710	Large, Bright, Good Cnd.	1.3				1206		
215	7/8/97	1943	F	840	Large, Sea Lice, Bright, Good Cnd.	1.4				1207		
216	7/8/97	2000	F	810	Large, Sea Lice, Bright, Good Cnd.	1.4				1208		
217	7/8/97	2025	M	925	Large, Sea Lice, Dark, Good Cnd.	1.4				1209	Kerr Ck.	7/27/97
218	7/8/97	2025	F	915	Large, Sea Lice, Dark, Tired, Scar	1.5				1210	Clear Ck.	8/9/97
219	7/8/97	2040	F	880	Large, Sea Lice, Pink, Bright	1.4				1211	Cripple Ck.	8/11/97
220	7/8/97	2055	F	905	Large, Bright, Good Cnd.	1.4				1212	Cripple Ck.	8/5/97
221	7/8/97	2115	F	760	Large, Green, Bright, Good Cnd.	1.3				1213		
222	7/8/97	2121	M	895	Large, Sea Lice, Pink, Bright	1.3				1214		
223	7/8/97	2133	F	710	Large, Sea Lice, Bright, Good Cnd.	1.3				1215		
	7/8/97	2133	M	955	Large, Sea Lice, Red, Net Mort.	1.4				Mortality		
224	7/8/97	2205	M	865	Large, Sea Lice, Red, Good Cnd.	R.3				1216		
225	7/9/97	0500	F	785	Large, Bright Pink, Gashes	1.3				1217		
226	7/9/97	0516	F	970	Large, Sea Lice, Pink, Bright	R.4				1218		
227	7/9/97	0555	M	790	Large, Sea Lice, Bright Pink	1.3				1219		
228	7/9/97	0600	F	910	Large, Bright, Good Cnd.	1.4				1220		
229	7/9/97	0600	M	1015	Large, Red, Good Cnd.	1.4				1221		
230	7/9/97	0635	M	595	Medium, Sea Lice, Bright, Bleeder	1.3				1222		
231	7/9/97	0700	M	640	Medium, Bright Pink, Good Cnd.	1.2				1223		
232	7/9/97	0755	F	775	Large, Sea Lice, Bright, Good Cnd.	R.3				1224		
233	7/9/97	0900	M	625	Medium, Sea Lice, Bright	R.2				1225		
234	7/9/97	1020	F	845	Large, Sea Lice, Pink, Good Cnd.	R.4				1226	Cripple Ck.	8/12/97
235	7/9/97	1020	M	640	Medium, Sea Lice, Gray Gd Cnd.	1.2				1227		
236	7/9/97	1125	F	885	Large, Bright, Good Cnd.	1.5				1228	Kerr Ck.	8/2/97
237	7/9/97	1145	F	785	Large, Sea Lice, Gray, Good Cnd.	1.3				1229		
238	7/9/97	1145	M	620	Medium, Pink, Bright, Good Cnd.	1.2				1230	Cripple Ck.	8/11/97
239	7/9/97	1145	F	710	Large, Bright, Good Cnd.	1.3				1231		
240	7/9/97	1145	M	865	Large, Sea Lice, Olive - Red	1.4				1232		
241	7/9/97	1220	M	775	Large, Sea Lice, Golden - Red	1.3				1233	Cripple Ck.	8/6/97
242	7/9/97	1251	F	915	Large, Sea Lice, Bright, Good Cnd.	1.4				1234	Kerr Ck.	8/5/97
243	7/9/97	1343	M	645	Medium, Bright, Slight Bleeder	R.2				1235		
244	7/9/97	1424	M	750	Large, Bright, Slight Bleeder	R.				1236		
245	7/9/97	1514	F	830	Large, Sea Lice, Bright, Good Cnd.	1.3				1237	Kerr Ck.	8/5/97
246	7/9/97	1613	F	815	Large, Sea Lice, Bright, Good Cnd.	1.3				1238		
247	7/9/97	1616	M	945	Large, Sea Lice, Red, Good Cnd.	1.4				1239	Clear Ck.	8/4/97
248	7/9/97	1627	M	630	Medium, Gray, Good Cnd.	1.2				1240		
249	7/9/97	1627	M	765	Large, Gray, Good Cnd.	1.3				1241		
250	7/9/97	1646	F	805	Large, Sea Lice, Pink, Good Cnd.	1.3				1243	Cripple Ck.	8/12/97
251	7/9/97	1702	M	750	Large, Sea Lice, Dark, Good Cnd.	1.3				1242		
252	7/9/97	1702	M	665	Large, Bright, Good Clip	1.2	77221	43557	1993			
253	7/9/97	1752	M	685	Large, Bright, Slight Bleeder	1.2				1244		
254	7/9/97	1810	F	815	Large, Bright, Good Cnd.	1.3				1245		
255	7/9/97	1822	F	845	Large, Sea Lice, Bright, Gray	1.3				1246		
256	7/9/97	1904	F	720	Large, Sea Lice, Bright, Good Cnd.	1.3				1247		
257	7/9/97	1942	F	870	Large, Bright, Good Cnd.	R.4				1248		
258	7/9/97	2103	F	715	Large, Sea Lice, Bright, Good Cnd.	1.3				1249		
259	7/10/97	0555	M	810	Large, Red, Good Cnd.	1.3				1250		
260	7/10/97	0619	F	790	Large, Sea Lice, Gray, Fresh Scar	1.3				1251		
261	7/10/97	0626	M	930	Large, Sea Lice, Dark, Good Cnd.	1.3				1252	Cripple Ck.	8/9/97
262	7/10/97	0649	M	585	Medium, Sea Lice, Bright, Bleeder	1.2				1253	Gene's Lk. Ck.	8/20/97
263	7/10/97	0653	F	875	Large, Bright, Good Cnd.	1.4				1254		
264	7/10/97	0703	F	885	Large, Sea Lice, Gray, Good Cnd.	1.4				1255	Clear Ck.	8/18/97
265	7/10/97	0715	M	690	Large, Sea Lice, Gray, Net Scar	1.3				1256	Cripple Ck.	8/9/97
266	7/10/97	0715	M	695	Large, Sea Lice, Pink, Good Clip	1.2	77222	43349	1993			

-continued-

Appendix A1.–(Page 6 of 8).

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
267	7/10/97	0820	M	715	Large, Sea Lice, Bright, Good Cnd.	1.3				1257		
268	7/10/97	0932	M	790	Large, Sea Lice, Bright, Good Cnd.	1.3				1258		
269	7/10/97	1032	F	760	Large, Sea Lice, Bright, Good Cnd.	1.3				1259		
270	7/10/97	1052	M	810	Large, Sea Lice, Pink, Bright	1.3				1260		
271	7/10/97	1052	M	675	Large, Sea Lice, Dark, Good Cnd.	1.3				1261	Cripple Ck.	7/31/97
272	7/10/97	1129	F	730	Large, Bright, Good Cnd.	1.3				1262	Cripple Ck.	8/6/97
273	7/10/97	1147	M	690	Large, Bright, Good Cnd.	1.2				1263		
274	7/10/97	1147	M	910	Large, Pink, Bright, Good Cnd.	1.4				1264	Cripple Ck.	8/12/97
275	7/10/97	1239	M	645	Medium, Gray, Good Clip	1.2	77223	43350	1993			
276	7/10/97	1300	M	870	Large, Gray, Bright	R.3				1265	Clear Ck.	8/15/97
277	7/10/97	1314	M	980	Large, Sea Lice, Pink, Good Cnd.	1.4				1266		
278	7/10/97	1410	F	870	Large, Pink, Bright, Gashes	1.4				1267		
279	7/10/97	1431	M	635	Medium, Bright, Good Cnd.	1.2				1268		
280	7/10/97	1431	M	620	Medium, Sea Lice, Bright, Gashes	R.3				1269		
281	7/10/97	1500	M	620	Medium, Bright, Slight Bleeder	1.2				1270		
282	7/10/97	1511	M	775	Large, Sea Lice, Olive - Pink	1.3				1271		
283	7/10/97	1900	M	680	Large, Sea Lice, Bright, Good Cnd.	1.2				1272		
284	7/10/97	2022	M	580	Medium, Bright, Good Cnd.	1.2				1273	Eulachon Ri.	8/19/97
285	7/10/97	2035	M	605	Medium, Sea Lice, Bright	R.				1274		
286	7/11/97	0620	M	570	Medium, Bright, Killed	1.2	77224	43557	1993			
287	7/11/97	0810	M	865	Large, Dark Pink, Good Cnd.	1.3				1276	Cripple Ck.	8/12/97
288	7/11/97	0810	M	725	Large, Sea Lice, Olive Pink	R.3				1277	Gene's Lk. Ck.	8/16/97
289	7/11/97	0825	F	765	Large, Dark, Good Cnd.	R.3				1278	Cripple Ck.	8/11/97
290	7/11/97	0825	M	690	Large, Bright, Good Cnd.	1.3				1279		
291	7/11/97	0825	M	630	Medium, Gray, Good Cnd.	1.2				1280		
292	7/11/97	0825	M	785	Large, Pink, Good Cnd.	1.3				1281		
293	7/11/97	0900	M	790	Large, Green, Good Cnd.	1.4				1282	Cripple Ck.	8/8/97
294	7/11/97	0900	F	945	Large, Sea Lice, Bright Gray	1.4				1283		
295	7/11/97	1010	M	830	Large, Brown, Good Cnd.	1.3				1284		
296	7/11/97	1028	M	825	Large, Sea Lice, Green - Red	1.3				1285		
297	7/11/97	1032	M	590	Medium, Bright, Good Cnd.	1.2				1286		
298	7/11/97	1038	M	630	Medium, Sea Lice, Bright	1.2				1287		
299	7/11/97	1042	F	910	Large, Bright, Good Cnd.	1.4				1288		
300	7/11/97	1100	M	600	Medium, Bright, Good Cnd.	R.				1289		
301	7/11/97	1120	F	920	Large, Sea Lice, Gold, Good Cnd.	1.4				1290		
302	7/11/97	1144	M	955	Large, Sea Lice, Gray, Good Cnd.	1.4				1291	Cripple Ck.	8/9/97
303	7/11/97	1238	M	600	Medium, Green, Good Cnd.	1.2				1292		
304	7/11/97	1300	F	870	Large, Gray, Good Cnd.	1.4				1293	Clear Ck.	8/15/97
305	7/11/97	1300	M	605	Medium, Bright, Old Net Scar	1.2				1294		
306	7/11/97	1325	M	610	Medium, Bright, Slight Bleeder	1.2				1295		
307	7/11/97	1340	M	735	Large, Sea Lice, Bright, Good Cnd.	1.3				1296		
308	7/11/97	1355	M	620	Medium, Bright, Slight Bleeder	1.2				1297		
309	7/11/97	1355	M	720	Large, Sea Lice, Semi-Bright	R.2				1298		
310	7/11/97	1411	F	830	Large, Sea Lice, Bright, Good Cnd.	1.3				1299	Clear Ck.	8/18/97
311	7/11/97	1425	F	880	Large, Bright, Good Cnd.	1.3				1300		
312	7/11/97	1446	M	665	Large, Bright, Good Cnd.	1.2				1301	Gene's Lk. Ck.	8/13/97
313	7/11/97	1446	M	710	Large, Sea Lice, Bright, Bleeder	1.3				1302		
314	7/11/97	1505	M	610	Medium, Sea Lice, Bright	1.2				1303		
315	7/11/97	1505	M	685	Large, Sea Lice, Bright, Good Cnd.	1.2				1304		
316	7/11/97	1505	F	905	Large, Sea Lice, Bright, Good Cnd.	1.4				1305	Cripple Ck.	8/9/97
317	7/11/97	1527	M	750	Large, Dark, Good Cnd.	1.2				1306		
318	7/11/97	1529	M	445	Medium, Bright, Good Cnd.	1.2				1307		
319	7/11/97	1529	M	695	Large, Sea Lice, Dark, Good Cnd.	1.3				1308	Cripple Ck.	8/11/97
320	7/11/97	1605	M	570	Medium, Bright, Good Cnd.	1.2				1309		

-continued-

Appendix A1.–(Page 7 of 8).

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
321	7/11/97	1616	M	800	Large, Sea Lice, Pink, Good Clip	1.3	77225	43803	1992			
322	7/11/97	1626	M	625	Medium, Sea Lice, Bright	1.2				1310		
323	7/11/97	1649	F	910	Large, Bright, Good Cnd.	1.4				1311		
324	7/11/97	1649	F	865	Large, Sea Lice, Gray, Good Cnd.	1.4				1312		
325	7/11/97	1702	M	825	Large, Bright, Good Cnd.	1.3				1313		
326	7/11/97	1729	M	920	Large, Sea Lice, Gray, Good Cnd.	1.4				1314	Eulachon Ri.	8/14/97
327	7/11/97	1729	F	755	Large, Bright, Good Cnd.	R.3				1315		
328	7/11/97	1824	F	805	Large, Sea Lice, Bright, Good Cnd.	1.3				1316		
329	7/11/97	2054	M	630	Medium, Sea Lice, Bright	1.2				1317		
330	7/12/97	0638	F	890	Large, Sea Lice, Pink, Good Cnd.	1.3				1318		
331	7/12/97	0708	M	665	Large, Bright, Good Cnd.	1.2				1319		
332	7/12/97	0715	M	640	Medium, Bright, Slight Bleeder	1.2				1320	Gene's Lk. Ck.	8/20/97
333	7/12/97	0748	M	725	Large, Gray, Good Cnd.	1.3				1321	Kerr Ck.	7/29/97
334	7/12/97	0748	M	820	Large, Sea Lice, Pink, Good Cnd.	1.3				1322	Cripple Ck.	8/8/97
335	7/12/97	0825	M	840	Large, Pink, Good Cnd.	1.3				1323	Cripple Ck.	8/8/97
336	7/12/97	0825	F	865	Large, Bright, Good Cnd.	1.4				1324		
337	7/12/97	1022	M	605	Medium, Bright, Good Cnd.	1.2				1325		
338	7/12/97	1039	F	870	Large, Sea Lice, Bright, Good Cnd.	R.4				1326		
339	7/12/97	1100	F	870	Large, Sea Lice, Gray, Good Cnd.	R.4				1327		
340	7/12/97	1147	M	835	Large, Silver - Pink, Killed	1.3	77226	44206	1992			
341	7/12/97	1225	F	775	Large, Sea Lice, Pink, Tired	1.3				1328	Gene's Lk. Ck.	8/11/97
342	7/12/97	1240	M	620	Medium, Bright, Bleeder	R.2				1329		
343	7/12/97	1351	F	935	Large, Sea Lice, Gray, Good Cnd.	1.4				1330	Clear Ck.	8/15/97
344	7/12/97	1400	F	915	Large, Semi-Bright, Good Cnd.	1.4				1331		
345	7/12/97	1415	M	690	Large, Sea Lice, Bright, Good Cnd.	R.2				1332	Cripple Ck.	8/11/97
346	7/12/97	1420	F	830	Large, Sea Lice, Red - Brown	1.3				1333	Cripple Ck.	8/11/97
347	7/12/97	1455	M	595	Medium, Sea Lice, Bright	1.2				1334	Cripple Ck.	8/12/97
348	7/12/97	1510	M	765	Large, Sea Lice, Red, Good Cnd.	1.3				1335		
349	7/12/97	1800	M	655	Medium, Lice, Bright, Net Scar	1.3				1336		
350	7/12/97	1840	M	520	Medium, Bright, Good Cnd.	1.2				1337		
351	7/13/97	0745	F	840	Large, Gray, Good Cnd.	1.3				1338		
352	7/13/97	0808	F	755	Large, Sea Lice, Bright, Good Cnd.	1.3				1339		
353	7/13/97	0942	M	620	Medium, Sea Lice, Bright - Pink	1.2				1340		
354	7/13/97	1445	M	835	Large, Brown, Good Cnd.	1.3				1341		
355	7/13/97	1532	F	910	Large, Bright, Good Cnd.	1.3				1342		
356	7/13/97	1542	M	665	Large, Gray, Good Cnd.	1.2				1343		
357	7/13/97	1755	M	615	Medium, Sea Lice, Semi-Bright	1.2				1344	Cripple Ck.	8/11/97
	7/13/97	1905	M	530	Medium, Net Mortality	1.2				Mortality		
358	7/14/97	1025	F	900	Large, Sea Lice, Gray, Good Cnd.	1.4				1345	Clear Ck.	8/12/97
359	7/14/97	1257	F	915	Large, Gray, Good Cnd.	1.4				1346		
360	7/14/97	1356	F	920	Large, Bright, Good Cnd.	1.4				1347	Cripple Ck.	8/8/97
361	7/14/97	1544	F	945	Large, Dark, Good Cnd.	1.4				1348		
362	7/14/97	1555	F	890	Large, Sea Lice, Bright, Good Cnd.	1.4				1349		
363	7/14/97	1614	M	640	Medium, Bright, Old Net Scar	1.2				1350		
364	7/15/97	0559	F	930	Large, Gray, Good Cnd.	1.4				1351	Eulachon Ri.	8/14/97
365	7/15/97	0612	F	785	Large, Semi-Bright, Good Cnd.	1.3				1352		
366	7/15/97	0853	F	890	Large, Bright, Good Cnd.	1.4				1353		
367	7/15/97	0856	F	790	Large, Sea Lice, Semi-Bright	R.3				1354		
368	7/15/97	1233	F	930	Large, Gray, Good Cnd.	1.3				1355		
369	7/15/97	1321	M	615	Medium, Bright, Good Cnd.	1.2				1356	Gene's Lk. Ck.	8/16/97
370	7/15/97	1416	F	835	Large, Bright, Good Cnd.	1.4				1357		
371	7/15/97	1539	F	810	Large, Dark, Good Cnd.	1.4				1358		
372	7/15/97	1753	M	740	Large, Pink, Good Cnd.	1.2				1359		

-continued-

Appendix A1.–(Page 8 of 8).

Fish no.	Marking date	Time caught	Sex	Length MEF	Comments	Age	CWT cinch no.	Tag code	Brood year	Spag. tag no.	Recovery location	Recovery date
373	7/16/97	0622	F	845	Large, Bright, Good Cnd.	1.4				1360		
374	7/16/97	0622	F	870	Large, Bright, Good Cnd.	R.4				1361		
375	7/16/97	0732	M	630	Medium, Bright, Good Cnd.	1.2				1362		
376	7/16/97	1430	M	650	Medium, Bright, Good Cnd.	1.3				1363		
377	7/16/97	1630	F	820	Large, Bright, Good Cnd.	1.3				1364		
378	7/16/97	1726	M	650	Medium, Sea Lice, Bright	1.2				1365		
379	7/16/97	1748	F	760	Large, Sea Lice, Bright, Bleeder	R.4				1366		
380	7/17/97	1010	M	1000	Large, Pink, Good Cnd.	1.4				1367		
381	7/17/97	1221	F	870	Large, Sea Lice, Gray, Good Cnd.	1.5				1368		
382	7/17/97	1233	F	990	Large, Bright, Pink, Good Cnd.	1.4				1369		
383	7/17/97	1310	M	630	Medium, Lice, Pink, Good Cnd.	1.2				1370	Cripple Ck.	8/5/97
384	7/17/97	1434	M	680	Large, Pink, Good Cnd.	1.2				1371		
385	7/17/97	1742	F	860	Large, Gray, Slight Bleeder	1.3				1372		
386	7/18/97	1440	F	810	Large, Sea Lice, Gray, Good Cnd.	1.3				1373		
387	7/20/97	0623	F	880	Large, Gray, Good Cnd.	1.4				1374		
388	7/20/97	1920	M	915	Large, Red, Good Cnd.	1.4				1375		
389	7/21/97	0555	M	960	Large, Dark, Good Cnd.	1.4				1376		
390	7/21/97	0625	M	890	Large, Sea Lice, Semi-Bright	1.4				1377		
391	7/21/97	1150	M	660	Large, Sea Lice, Semi-Bright	R.2				1378	Clear Ck.	8/18/97
392	7/21/97	1459	M	640	Medium, Sea Lice, Dark, Gd. Clip	1.2	77228	43557	1993			
393	7/21/97	1645	M	740	Large, Golden, Good Ad Clip	1.2	77229	43349	1993			
394	7/22/97	1059	F	840	Large, Gray, Good Cnd.	1.4				1379	Eulachon Ri.	8/19/97
395	7/23/97	0956	M	660	Large, Bright, Good Cnd.	1.2				1380		
396	7/23/97	1527	F	900	Large, Dark, Good Cnd.	R.4				1381		
397	7/24/97	1142	F	825	Large, Sea Lice, Pink, Good Cnd.	1.3				1382		
398	7/24/97	1322	M	670	Large, Sea Lice, Gray, Good Cnd.	1.2				1383		
399	7/24/97	1434	M	720	Large, Gray, Slight Bleeder	R.3				1384		
400	7/24/97	1544	F	945	Large, Gray, Good Cnd.	1.4				1385		

Appendix A2.–Age composition by sex and age for chinook salmon sampled in the Unuk River in 1997 by size group, location, and gear type.

Location and event	Size group	Sex		Brood year and age class: 1994	1993	1992	1992	1991	1990	1990	Total
				1.1	1.2	2.2	1.3	1.4	2.4	1.5	
PANEL A: SPAWNING GROUNDS SAMPLING BY SITE											
		Males	*n*	2	77		87	28		2	196
Spawning grounds:	Medium		%	1.0	39.3		44.4	14.3		1.0	60.3
Cripple Creek	and large	Females	*n*		1		68	56		4	129
Event 2	chinook salmon		%		0.8		52.7	43.4		3.1	39.7
		Total	*n*	2	78		155	84		6	325
			%	0.6	24.0		47.7	25.8		1.8	100.0
		Males	*n*	4	86	1	36	13		1	141
Spawning grounds:	Medium		%	2.8	61.0	0.7	25.5	9.2		0.7	55.7
Gene's Lake Creek	and large	Females	*n*				23	88		1	112
Event 2	chinook salmon		%				20.5	78.6		0.9	44.3
		Total	*n*	4	86	1	59	101		2	253
			%	1.8	34.0	0.4	23.3	39.9		0.8	100.0
		Males	*n*	4	28		34	29			95
Spawning grounds:	Medium		%	4.2	29.5		35.8	30.5			43.6
All other tributaries[a]	and large	Females	*n*				23	95		5	123
Event 2	chinook salmon		%				18.7	77.2		4.1	56.4
		Total	*n*	4	28		57	124		5	218
			%	1.8	12.8		26.1	56.9		2.3	100.0
PANEL B: SPAWNING GROUNDS SAMPLING BY GEAR											
		Males	*n*	4	139	1	120	46		1	311
Spawning grounds:	Medium		%	1.3	44.7	0.3	38.6	14.8		0.3	58.1
Gear = rod and reel	and large	Females	*n*				71	146		7	224
Event 2	chinook salmon		%				31.7	65.2		3.1	41.9
		Total	*n*	4	139	1	191	192		8	535
			%	0.7	26.0	0.2	35.7	35.9		1.5	100.0
		Males	*n*	6	16		10	5			37
Spawning grounds:	Medium		%	16.2	43.2		27.0	13.5			40.7
Gear = spear	and large	Females	*n*				11	41		2	54
Event 2	chinook salmon		%				20.4	75.9		3.7	59.3
		Total	*n*	6	16		21	46		2	91
			%	6.6	17.6		23.1	50.5		2.2	100.0
		Males	*n*		21		12	9		1	43
Spawning grounds:	Medium		%		48.8		27.9	20.9		2.3	60.6
Gear = setnet	and large	Females	*n*				9	19			28
Event 2	chinook salmon		%				32.1	67.9			39.4
		Total	*n*		21		21	28		1	71
			%		29.6		29.6	39.4		1.4	100.0
		Males	*n*		10		9	5		1	25
Spawning grounds:	Medium		%		40.0		36.0	20.0		4.0	47.2
Gear = dip net	and large	Females	*n*				11	16		1	28
Event 2	chinook salmon		%				39.3	57.1		3.6	52.8
		Total	*n*		10		20	21		2	53
			%		18.9		37.7	39.6		3.8	100.0
		Males	*n*		5		6	5			16
Spawning grounds:	Medium		%		31.3		37.5	31.3			34.8
Gear = carcass pickup	and large	Females	*n*		1		12	17			30
Event 2	chinook salmon		%		3.3		40.0	56.7			65.2
		Total	*n*		6		18	22			46
			%		13.0		39.1	47.8			100.0

-continued-

Appendix A2.–(Page 2 of 2).

Location and event	Size group	Sex		1994 1.1	1993 1.2	1992 2.2	1992 1.3	1991 1.4	1990 2.4	1990 1.5	Total
PANEL C: ALL TRIBUTARIES COMBINED, BY SIZE											
		Males	*n*	10	131		2	1			144
Spawning grounds:			%	6.9	91.0		1.4	0.7			100.0
Event 2	Medium	Females	*n*								0
	chinook salmon		%								0.0
		Total	*n*	10	131		2	1			144
			%	6.9	91.0		1.4	0.7			100.0
		Males	*n*		60	1	155	69		3	288
Spawning grounds:			%		20.8	0.3	53.8	24.0		1.0	44.2
Event 2	Large	Females	*n*		1		114	239		10	364
	chinook salmon		%		0.3		31.3	65.7		2.7	55.8
		Total	*n*		61	1	269	308		13	652
			%		9.4	0.2	41.3	47.2		2.0	100.0
		Males	*n*	10	191	1	157	70		3	432
Spawning grounds:	Medium		%	2.3	44.2	0.2	36.3	16.2		0.7	54.3
Event 2	and large	Females	*n*		1		114	239		10	364
	chinook salmon		%		0.3		31.3	65.7		2.7	45.7
		Total	*n*	10	192	1	271	309		13	796
			%	1.3	24.1	0.1	34.0	38.8		1.6	100.0
PANEL D: LOWER UNUK RIVER GILLNET SAMPLING											
		Males	*n*		60		6				6
Lower Unuk River			%		90.9		9.1				100.0
gillnet samples	Medium	Females	*n*								0
Event 1	chinook salmon		%								0.0
		Total	*n*		60		6				66
			%		90.9		9.1				100.0
		Males	*n*		25		70	28		2	125
Lower Unuk River			%		20.0		56.0	22.4		1.6	45.8
gillnet samples	Large	Females	*n*		1		61	81	1	4	148
Event 1	chinook salmon		%		0.7		41.2	54.7	0.7	2.7	54.2
		Total	*n*		26		131	109	1	6	273
			%		9.5		48.0	39.9	0.4	2.2	100.0
		Males	*n*		85		76	28		2	191
Lower Unuk River	Medium		%		44.5		39.8	14.7		1.0	56.3
gillnet samples	and large	Females	*n*		1		61	81	1	4	148
Event 1	chinook salmon		%		0.7		41.2	54.7	0.7	2.7	43.7
		Total	*n*		26		131	109	1	6	339
			%		25.4		40.4	32.2	0.3	1.8	100.0

Column header note: Brood year and age class spans columns 1994 1.1 through 1990 1.5.

[a] Includes Kerr, Clear, Boundary, Dog Salmon, and Lake creeks and the Eulachon River.

Appendix A3.–Numbers of adult chinook salmon, 1992 brood year to present, recovered and marked as juveniles and smolt with CWTs.

PANEL A: NUMBERS OF ADULT CHINOOK SALMON WITH CWTS THAT WERE MARKED AS JUVENILES AND SMOLT, 1992 BROOD YEAR TO PRESENT

Year sampled	Brood year	Age	Number examined	Valid tags	Marked/ unmarked	Recovery location
1996	1992	1.2	33	0	0.0%	spawning grounds
1997	1992	1.3	163	7	4.5%	gillnet
1997	1992	1.3	323	7	2.2%	spawning grounds
	1992 BROOD YEAR TOTAL		**519**	**14**	**2.8%**	
1996	1993	1.1	4	1	33.3%	spawning grounds
1997	1993	1.2	105	9	9.4%	gillnet
1997	1993	1.2	211	23	12.2%	spawning grounds
	1993 BROOD YEAR TOTAL		**320**	**33**	**11.5%**	
1997	1994	1.1	56	4	7.7%	spawning grounds
	1994 BROOD YEAR TOTAL		**56**	**4**	**7.7%**	

PANEL B: TOTAL NUMBERS OF FALL AND SPRING CHINOOK SALMON JUVENILES AND SMOLT TAGGED BY YEAR AND SUMMED BY BROOD YEAR

Year tagged	When tagged	Brood year	Tag code	Number tagged	Valid tags
1993	Fall	1992	043803	10,316	10,263
1993	Fall	1992	043804	441	433
1993	Fall	1992	043805	3,202	3,093
1994	Spring	1992	044206	2,653	2,642
		1992 BROOD YEAR TOTAL			**16,431**
1994	Fall	1993	043349	1,706	1,700
1994	Fall	1993	043350	11,152	11,139
1994	Fall	1993	043557	7,688	7,687
1995	Spring	1993	044213	3,228	3,227
		1993 BROOD YEAR TOTAL			**23,753**
1995	Fall	1994	043556	11,540	11,476
1995	Fall	1994	043558	11,654	11,645
1995	Fall	1994	043559	10,825	10,825
1995	Fall	1994	044231	6,324	6,260
1996	Spring	1994	044207	6,143	6,099
1996	Spring	1994	044208	1,362	1,357
		1994 BROOD YEAR TOTAL			**47,662**
1996	Fall	1995	044712	24,252	24,224
1996	Fall	1995	044236	11,202	11,200
1996	Fall	1995	044218	3,755	3,753
1997	Spring	1995	043829	12,521	12,517
		1995 BROOD YEAR TOTAL			**51,694**
1997	Fall	1996	044713	24,309	24,176
1997	Fall	1996	044714	22,996	22,583
1997	Fall	1996	044715	15,401	15,146
1998	Spring	1996	044646	11,193	11,134
1998	Spring	1996	044339	5,991	5,987
		1996 BROOD YEAR TOTAL			**79,026**

Appendix A4.–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 the first event and RECAPTURED during the second event	Results of hypothesis tests (K-S) on lengths of fish CAPTURED during the first event and CAPTURED during the second event
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 A5.–Computer files used to estimate the spawning abundance of chinook salmon in the Unuk River in 1997.

File name	Description
97unkgln.xls	Spreadsheet containing the lower Unuk River set gillnet data with various pivot table results, age-composition summaries, and Appendix A2 used in 97unkfds.doc.
97unkesc.xls	Spreadsheet containing the data gathered from the various spawning sites on the Unuk River with various age-composition summaries, chi-square test results, and Figure 8 used in 97unkfds.doc.
97unkest.xls	Spreadsheet containing the Darroch and SPAS estimates of abundance, the bootstrap variance and bias estimates, Table 5, and the data and graphs used to create Figure 5 present in 97unkfds.doc.
97unkks.xls	Spreadsheet containing the Kolmogorov-Smirnov (K-S) 2-sample test results and various figures and data sets used in these calculations. Figures 6 and 7 used in 97unkfds.doc are also included.
97unkfds.doc	WORD 7.0 (Windows) file of this FDS report.
BootVar.exe	BASIC compiled program for bootstrapping abundance estimates to estimate variance and bias.
97unklg.dat	Data file for large chinook salmon for BootVar.exe.
97unkmd.dat	Data file for medium chinook salmon for BootVar.exe.
SPAS.exe	Stratified Population Analysis System (SPAS) lets the user perform computer analysis of 2-sample mark-recovery data where each sample is from a geographically or temporally stratified population.
Spaslg.dat	Data file containing the data on large chinook salmon used in SPAS.exe.
Spasmd.dat	Data file containing the data on medium chinook salmon used in SPAS.exe.
Spaslg.out	Output from SPAS.exe on large chinook salmon.
Spasmd.out	Output from SPAS.exe on medium chinook salmon.