Fishery Data Series No. 06-07

Estimation of the Escapement of Chinook Salmon in the Unuk River in 2004

by

Jan L. Weller

and

Scott A. McPherson

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

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Jan L. Weller
Division of Sport Fish, Ketchikan
and
Scott A. McPherson
Division of Sport Fish, Douglas

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

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Jan L. Weller [a]
Alaska Department of Fish and Game, Division of Sport Fish
2030 Sea Level Dr. Suite 205, Ketchikan, AK 99901, USA

Scott A. McPherson,
Alaska Department of Fish and Game, Division of Sport Fish
802 3rd St., Douglas, AK 99824, P.O. Box 110024, Juneau, AK 99811-0024, USA
[a]Author to whom all correspondence should be addressed: e-mail: *red_weller@fishgame.state.ak.us*

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ABSTRACT

Abundance of medium and large Chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Unuk River in 2004 was estimated using a two-event mark-recapture experiment. Biological data were collected during both events. Fish were captured during event 1 in the lower Unuk River using set gillnets from 11 June through 16 August. Each apparently healthy fish was marked with a numbered solid-core spaghetti tag sewn through its back and two secondary batch marks in the form of an upper-left operculum punch and removal of the left axillary appendage. In event 2, fish were examined on the spawning grounds from 14 July through 29 August to estimate the fraction of the population that had been marked. Abundance of large Chinook salmon (≥660 mm mid-eye to fork [MEF]) was estimated to be 3,963 (SE = 325), estimated from 501 marked and 105 recaptured fish out of 836 examined upstream. Abundance of medium-sized fish (401–659 mm MEF) was estimated to be 2,114 (SE = 339), estimated from 189 marked and 30 recaptured fish out of 344 examined on the spawning grounds. An estimated 29% of the spawning population was sampled during the project. Peak survey counts in August totaled 1,008 large Chinook salmon, about 25% of the mark-recapture estimate of large fish, similar to fractions seen in previous years. The mean expansion factor through 2004 is 4.83 (SD = 0.59) for estimating total escapement from survey counts. Of the spawning population of 6,077 Chinook salmon >400 mm MEF, 48.3% (SE = 3.1%) were age-1.2 fish, 21.2% (SE = 1.6%) were age-1.3 fish, and 28.9% (SE = 2.1%) were age-1.4 fish. Females constituted an estimated 41.5% (1,645 fish) of large spawners (SE = 1.7%) with an estimated 98% of these comprised of fish age 1.3 and 1.4.

Key words: escapement, large and medium Chinook salmon, Unuk River, mark-recapture, set gillnet, spaghetti tag, operculum punch, axillary appendage, peak survey counts, expansion factor.

INTRODUCTION

The Unuk, Chickamin, Blossom, and Keta rivers in Southeast Alaska (SEAK) are four of eleven escapement indicator streams for Chinook salmon *Oncorhynchus tshawytscha* (Pahlke 1997b). These four systems traverse the Misty Fjords National Monument and flow into Behm Canal, a narrow saltwater passage east of Ketchikan (Figure 1). Peak single-day aerial and foot survey counts of “large” Chinook salmon ≥660 mm mid-eye to fork of tail (MEF) have been used as indices of escapement in each of these systems. These indices were roughly dome-shaped when plotted against time (1975–1999) with peak values occurring between 1987 and 1990 (Pahlke 1997b). Since 1999, survey counts and estimated total escapement have increased to near the former peak values in the Unuk and Chickamin rivers.

Several consecutive low survey counts in the early 1990s generated concern for the health of the Chinook salmon stocks in Behm Canal. In 1992, the Division of Sport Fish of the Alaska Department of Fish and Game (ADF&G) began a research program on the Unuk River, which is the largest Chinook salmon producer in Behm Canal. Goals of the program were to estimate production of smolt, overwinter survival of fingerlings, marine survival of smolts, escapement and harvest of adults, total run size, and exploitation rates. These goals are being accomplished with inriver mark-recapture experiments on adults and smolts and with marine catch sampling programs.

The current escapement goal for the Unuk River is 650–1,400 large fish counted in surveys, or about 3,000–7,000 actual large fish (McPherson and Carlile 1997). Only large fish are counted in aerial surveys, because smaller Chinook salmon are readily mistaken for other salmon species of similar size and color. For our purposes, Chinook salmon ≥660 mm MEF are considered large and generally are fish 3-ocean age (age-.3) or older. Nearly all females in the spawning population are large in size. Chinook salmon 401–659 mm MEF are considered medium fish, and Chinook salmon ≤400 mm MEF are considered small fish. An index of escapement on the Unuk River is determined each year as the peak count of large spawners observed during several aerial and foot surveys of six tributaries: Cripple, Gene’s Lake, Kerr, Clear, and Lake creeks plus the Eulachon River (Pahlke 1997b; Figure 2). Mark-recapture and radiotelemetry studies were conducted in 1994 (Pahlke et al. 1996). Mark-recapture studies

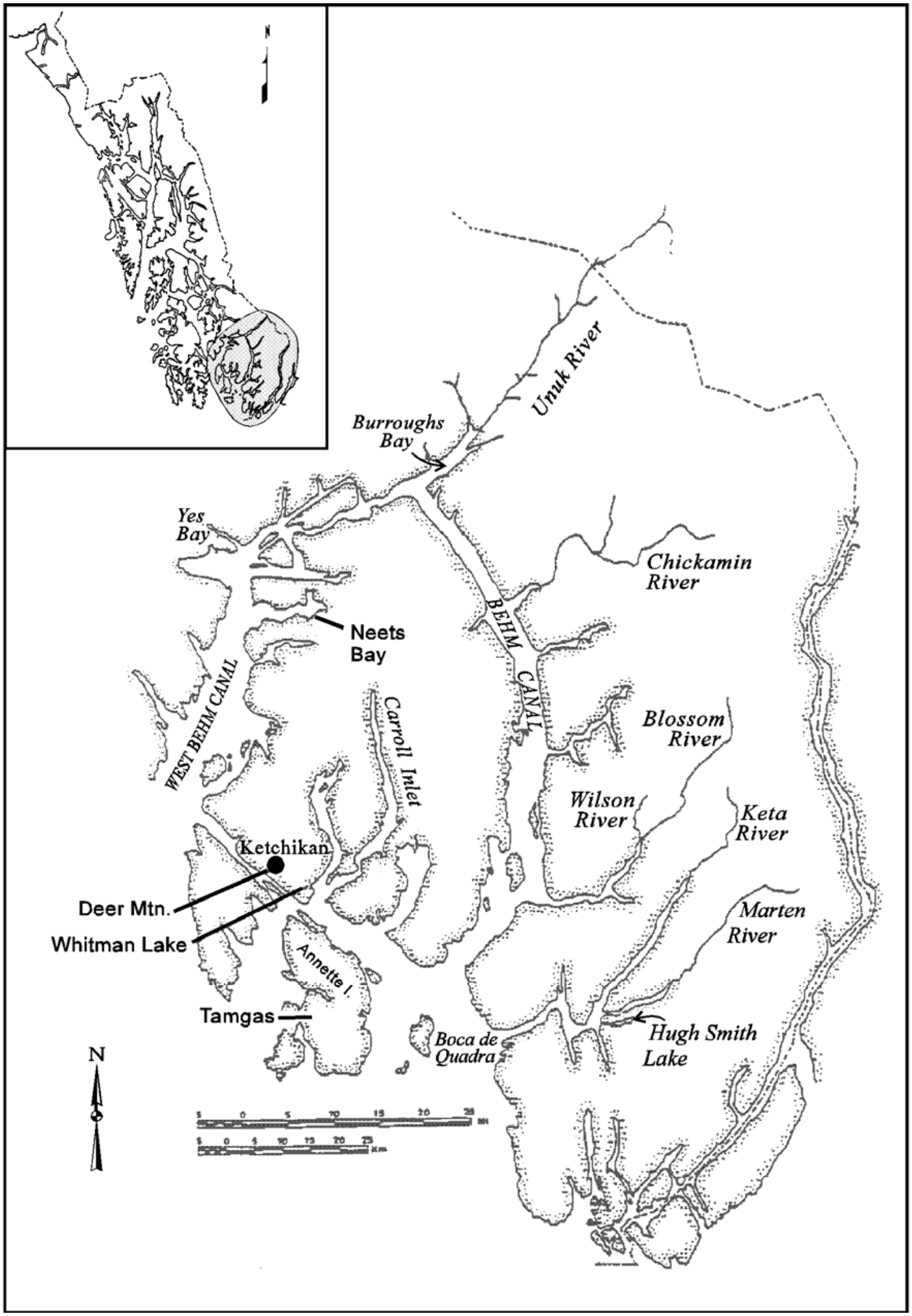


Figure 1.–Behm Canal area in Southeast Alaska and location of selected Chinook salmon systems and hatcheries.

have also been conducted annually from 1997 through 2003 (Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002; Weller and McPherson 2003a, 2003b; Weller and McPherson 2004). The radiotelemetry study indicated that 83% (SE = 9%) of all spawning occurred in the six tributaries surveyed. The mark-recapture experiments from 1997 through 2003 estimated that an average of 5,709 large Chinook salmon entered the river during those years with a range of 2,970 (1997) to 10,541 (2001). Indices during those years averaged 1,076 large Chinook salmon, or 19.2% of the mark-recapture estimates, with a range of 636 (1997) to 2,019 (2001). The highest recorded index of 2,126 large fish occurred in 1986 (Pahlke 1997b, Appendix A1). Average peak survey counts in the six index tributaries of the Unuk River from 1977–2004 are distributed as follows: Cripple Creek (413 fish, 37%), Gene's Lake Creek (363 fish, 33%), Eulachon River (165 fish, 15%), Clear Creek (102 fish, 9%), Kerr Creek (41 fish, 4%), and Lake Creek (32 fish, 3%). Cripple Creek and Gene's Lake Creek are not surveyed from the air because of heavy canopy cover; surveys of these areas are made on foot. All other index areas are surveyed by helicopter or on foot (Pahlke *In prep.*).

Other studies on the Unuk River were based on coded-wire tags (CWTs) inserted into Chinook salmon juveniles from the 1982–1986 brood years (Pahlke 1995). This research showed 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 factor of 6.5 (~15% of spawners counted) and an alternative expansion factor of 4.0 (25% of spawners counted).

Starting in 1993, young-of-the-year (YOY) fingerlings were tagged with CWTs. From 1993 through 2004, 428,651 Chinook (fall) fingerlings have been tagged, at an annual average of 35,721 and a range of 13,789 (1993) to 61,905 (1997). Tagging of smolt commenced in spring 1994, and 119,007 smolt have been tagged through 2004 at an annual average of 10,819 and a range of 2,642 (1994) to 17,121 (1998) (Appendix A2).

The current stock assessment program for adult escapement of Chinook salmon to the Unuk River has three primary objectives: (1) to estimate escapement; (2) to estimate age, sex, and length distribution in the escapement; and (3) to estimate the fraction of fish possessing CWTs by brood year. Meeting this last objective is essential to estimating harvest of this stock in current and future sport and commercial fisheries. Together harvest and escapement data will enable us to estimate run size, exploitation rates, harvest distribution, and return rates for this indicator stock.

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 Unuk River drainage encompasses an area of approximately 3,885 km^2 (Pahlke et al. 1996). The lower 39 km of the Unuk River are in Alaska (Figure 2), and in most years, the Unuk River is the fourth or fifth largest producer of Chinook salmon in Southeast Alaska.

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 2004. Fish were captured using set gillnets in the lower river for the 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 captured using set gillnets as they immigrated into the lower Unuk River between 11 June and 16 August 2004. The set gillnets were 37 m (120 ft) long by 4 m (14 ft) deep with 18 cm (7¼ in.) stretch mesh and a loose hanging ratio of about 2.2:1. One site (SN1) was used exclusively for set gillnet fishing in 2004 and has remained the same since 1997. This site (SN1) is located approximately 2 miles upstream of saltwater on the south channel, mainstem of

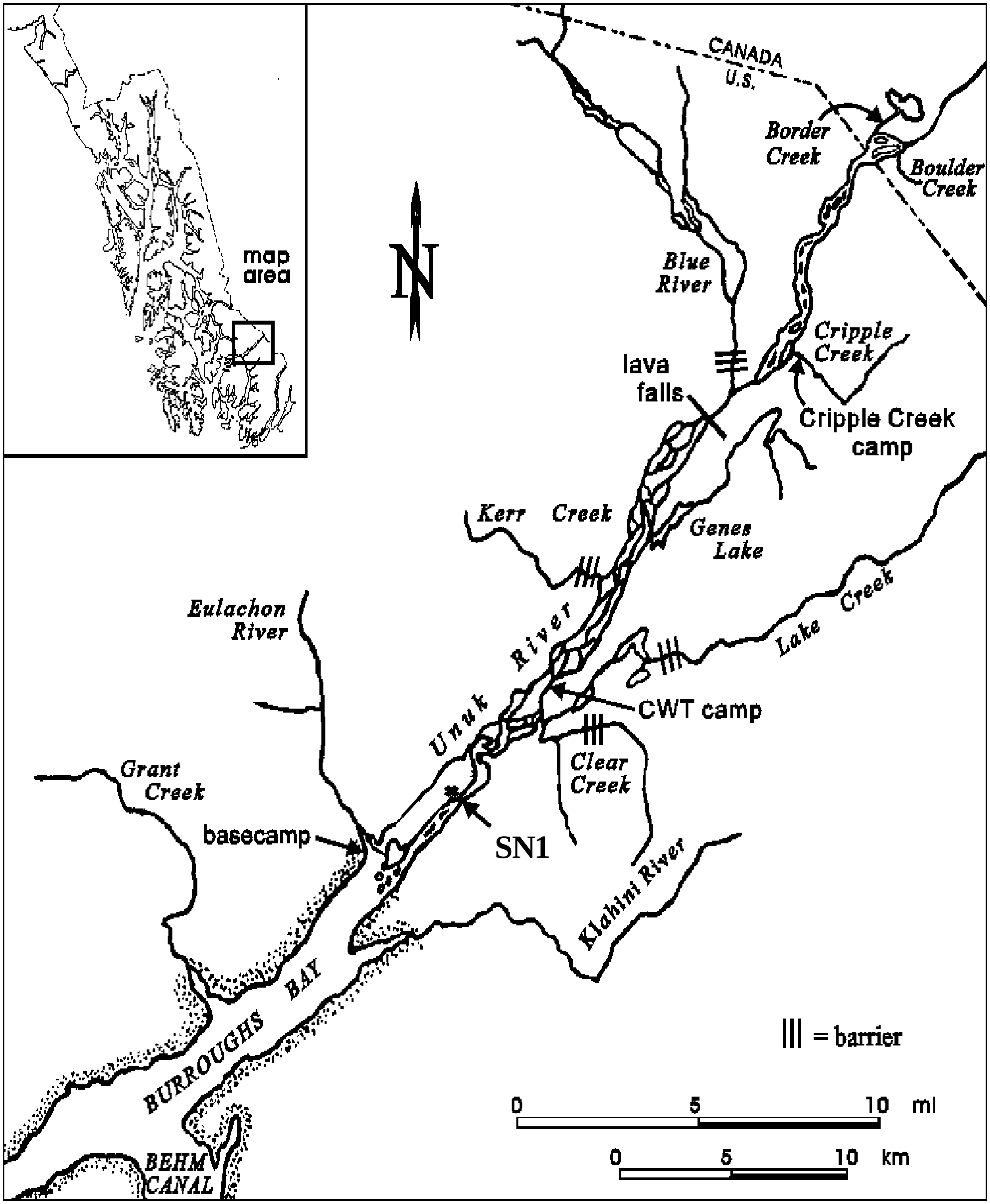


Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to Chinook salmon migration, and location of ADF&G research sites.

the lower Unuk River well below all known spawning areas except the Eulachon River (Figure 3).

Two back-to-back shifts of personnel fished two set gillnets at SN1 (Figure 4) 12 hours per day, 6 days per week. Crew shifts were staggered during the week so that at least one shift fished each day of the week whenever possible. One net was set perpendicular to the main flow of the Unuk River; it was attached to shore and ran directly across a small slough to a fixed buoy placed about 3 m downstream of a small island. Another net was attached to the same fixed buoy and trailed downstream along the eddy line formed between the mainstem and the side slough. Fish captured in the set gillnet were immediately and carefully untangled or cut loose and placed in a live tank aboard the set gillnet skiff.

All fish captured, regardless of health, were sampled to estimate the age, sex, and length (ASL) composition of the escapement. Length in MEF was measured to the nearest 5 mm, and sex was determined from external, dimorphic characteristics. Five scales were taken about 1″ apart within the preferred area on the left side of each 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 that held scales from ten fish, as described in ADF&G (ADF&G *Unpublished*). The age of each fish was later determined from the pattern of circuli (Olsen 1995), 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 and <700 mm MEF (jacks) were sacrificed, and their heads were sent to the ADF&G Tag and Otolith Lab for detection and decoding of CWTs.

All captured fish judged healthy and possessing an adipose fin were marked in three ways: a uniquely numbered solid-core spaghetti tag sewn through the back, a clip of the left axillary appendage (LAA), and a left upper operculum punch (LUOP) 0.63 cm (¼″) in diameter then released. The axillary clip and operculum punch enable the detection of tag loss. The spaghetti tag consisted of a 5.71 cm (2¼″) section of laminated Floy[1] tubing shrunk onto a 38 cm (15″) piece of 80-lb-test monofilament fishing line. The monofilament was sewn through the back just behind the dorsal fin and secured by crimping both ends of the monofilament in a line crimp. 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

Chinook salmon of all sizes were sampled on Boundary Lake Creek (also known as Border Creek); on Clear, Cripple, Gene's Lake, Kerr, and Lake creeks; and on the Eulachon River in 2004 (Figure 2). Various methods were used to capture fish, including rod and reel, spears, dip nets, gillnets, and carcass surveys. Use of a variety of gear types has been shown to produce unbiased estimates of age, sex, and length composition (McPherson et al. 1997; Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002). A hole was punched into the left lower operculum (LLOP) of all inspected fish to prevent double sampling. These fish were closely examined for presence of a tag, an LUOP, an LLOP, and an LAA, and for a missing adipose fin. They were sampled to obtain ASL data by the same techniques employed in the lower river. For Chinook salmon missing adipose fins, all fish <700 mm MEF as well as spawned-out fish of all sizes were sacrificed to retrieve CWTs. Heads so collected were sent to the ADF&G Tag Lab for dissection and decoding of tags. Foot surveys were also conducted on each of the sampled tributaries on at least one occasion. Multiple surveys were spaced approximately one week apart and when possible, coincided with the historical peak of observed abundance.

ABUNDANCE BY SIZE

Abundance of medium (401-659 mm MEF) and large (≥660 mm MEF) fish was estimated

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

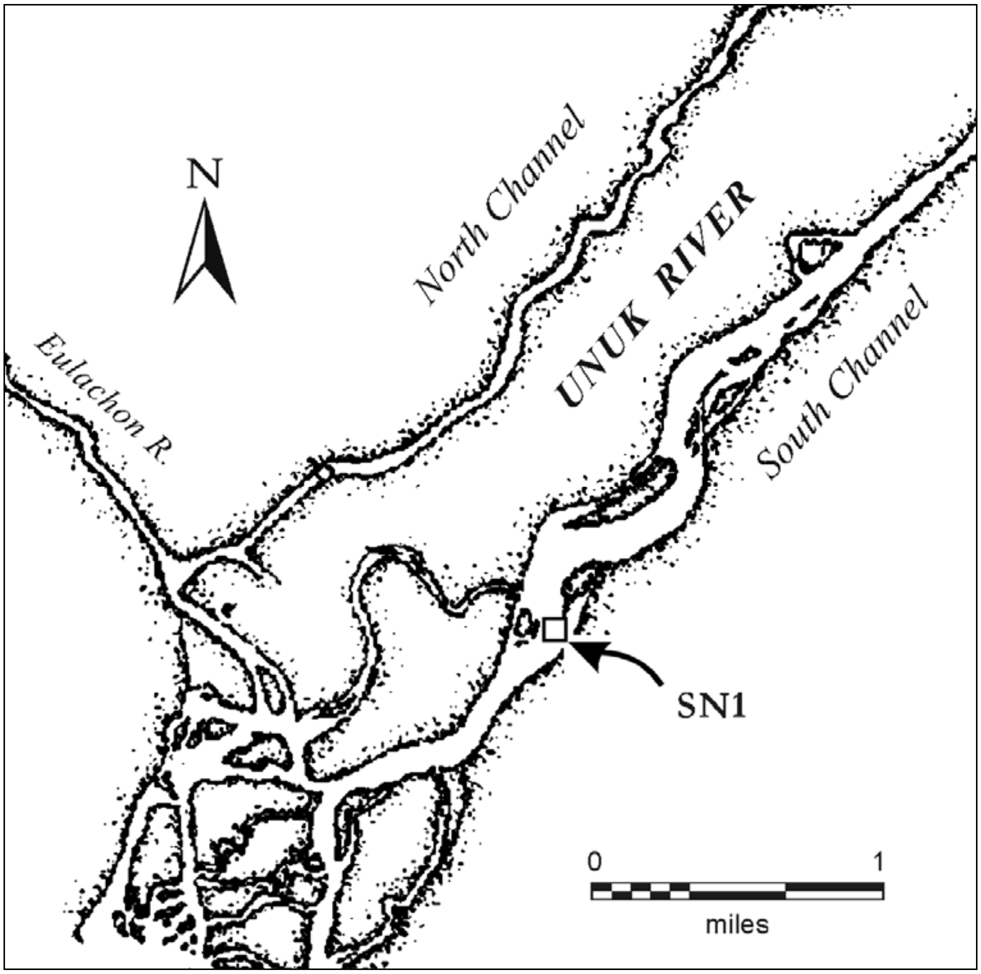


Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River in 2004.

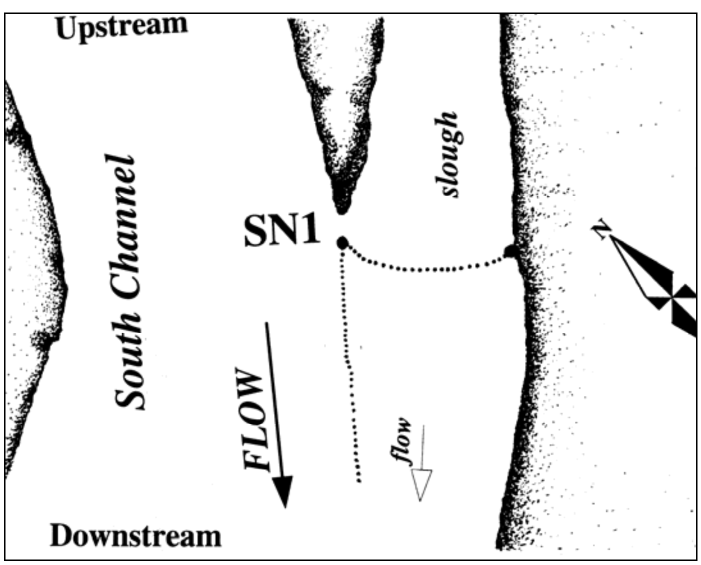


Figure 4.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River in 2004**.**

separately so that the estimate for large fish $\hat{N}_L$ could be compared to the index. Using Chapman's modification of the Petersen estimator (Seber 1982), estimated abundance $\left(\hat{N}_i\right)$ for each group 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* (medium or large) 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. The general conditions that must hold for $\hat{N}_i$ to be a consistent 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 every fish had an equal probability of being inspected for marks in event 2, or marked fish mixed completely with unmarked fish in the population between events; and

(b) There is no mark-induced mortality; and

(c) Fish did not lose their marks in the time between events and all marks are recognizable; and

(d) There is no recruitment to the population between events.

To provide evidence that condition *a* was met, two chi-square tests were performed with the following null hypotheses: (1) for equal proportions of marked fish in samples across areas sampled in event 2; and (2) for equal probabilities of recapture in event 2 independent of when fish had been marked. If the null hypothesis of either test was not rejected, the pooled Petersen estimator (equation 1) should be a consistent estimator; otherwise a temporally or spatially stratified estimator should be employed. Tests were made separately using the SPAS software program (Arnason et al. 1996).

Because condition *a* is relevant to other attributes of salmon besides when and where they are captured, the possibility of size- and gender-selective sampling was also investigated. The hypothesis that fish of different sizes were captured with equal probability was tested using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.1$) to compare size distributions of marked, captured, and recaptured fish (Appendix A3). Evidence for gender-selective sampling was sought using simple chi-square analyses.

Regarding condition *d*, recruitment of fish into the population should be moot if efforts at SN1 span the entire immigration. We were not able to investigate condition *b*; however, we were careful to not harm or stress fish, and we did not mark obviously injured fish. Radiotelemetry studies in 1994 and 1996 showed that Chinook salmon survive and spawn after having been captured as in this project (Pahlke et al. 1996; Pahlke 1997a). The effect of tag loss (condition *c*) is virtually eliminated by using the two secondary marks, and all fish captured during event 2 were inspected for marks. Double sampling 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 $\{\hat{M}_i^*, \hat{C}_i^*, \hat{R}_i^*\}$ was generated, along with a new estimate for abundance $\hat{N}_i^*$. A thousand such bootstrap samples were drawn, creating the empirical distribution $F(\hat{N}_i^*)$, 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). Confidence intervals were estimated from $\hat{F}(\hat{N}_i^*)$ with the percentile method (Efron and Tibshirani 1993, Section 13.3). Variance was estimated as:

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

where B is the number of bootstrap samples (1,000).

Table 1.–Capture histories for large Chinook salmon in the population spawning in the Unuk River in 2004 (notation explained in text).

Capture history	Medium	Large	Source of Statistics
Marked and not recaptured in tributaries	159	396	$M_i - R_i$
Marked and recaptured in tributaries	30	105	R_i
Not marked, but captured in tributaries	314	731	$C_i - R_i$
Not marked and not sampled in tributaries	1,611	2,731	$\hat{N}_i - M_i - C_i + R_i$
Effective population for simulations	2,114	3,963	$\hat{N}_i$

AGE AND SEX COMPOSITION

The proportion of the spawning population composed of a given age within the medium or large fish size classes was estimated as a binomial variable:

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

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

where $\hat{p}_{ij}$ is the estimated proportion of the population of age j in size group i, n_{ij} is the number of Chinook salmon of age j of size group i, and n_i is the number of Chinook salmon in the sample n of size group i. Information gathered during event 1 was not used to estimate age or sex composition as tests (described above) showed sampling in event 1 was biased towards catching large fish. Samples gathered at each spawning tributary were pooled together because no differences in age composition were apparent among tributaries sampled. Numbers of spawning fish by age were estimated as the sum of the products of estimated age composition and estimated abundance within a size category

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

and

$$\text{var}(\hat{N}_j) = \sum_i \begin{pmatrix} \text{var}(\hat{p}_{ij})\hat{N}_i^2 + \text{var}(\hat{N}_i)\hat{p}_{ij}^2 \\ -\text{var}(\hat{p}_{ij})\,\text{var}(\hat{N}_i) \end{pmatrix} \qquad (6)$$

with variance calculated according to procedures in Goodman (1960).

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

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}} \qquad (7)$$

and

$$\text{var}(\hat{p}_j) = \frac{\sum_i(\text{var}(\hat{p}_{ij})\hat{N}_i^2 + \text{var}(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2)}{\hat{N}^2} \qquad (8)$$

where variance is approximated according to procedures in Seber (1982, p. 8–9).

Sex composition and age-sex composition for the entire spawning population and its associated variances were also estimated using the above equations 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 $\sum_{jk} \hat{p}_{jk} = 1$.

EXPANSION FACTOR

An expansion factor ($\hat{\pi}$) for Unuk River Chinook salmon in a calendar year is

$$\hat{\pi}_i = \hat{N}_i / C_i \tag{9}$$

$$\text{var}(\hat{\pi}_i) = \text{var}(\hat{N}_i) / C_i^2 \tag{10}$$

where i is the year (with a mark-recapture experiment), $\hat{N}_i$ is the mark-recapture estimate of large Chinook salmon and C_i is the peak aerial survey count.

The mean expansion factor ($\overline{\pi}$) and its estimated variance are

$$\overline{\pi} = \sum_{i=1}^{k} \hat{\pi}_i \, / \, k \tag{11}$$

$$\text{var}(\pi) = \sum_{i=1}^{k} \left(\hat{\pi}_i - \overline{\pi}\right)^2 / \ (k-1) \tag{12}$$

where k is the number of years with mark-recapture experiments (six for the Unuk River at present, from 1997 to 2004, omitting 2002).

The estimator for expanding peak survey counts into estimates of spawning abundance is

$$\hat{N}_t = \overline{\pi} \ C_t \tag{13}$$

$$\text{var}(\hat{N}_t) = C_t^2 \ \text{var}(\pi) \tag{14}$$

MIGRATORY TIMING

Migratory timing is defined as a time density function of the relative abundance of the individual Unuk River Chinook salmon stocks (Boundary, Clear, Cripple, Genes Lake, Kerr, and Lake creeks and the Eulachon River) w as they pass the set gillnet site (SN1) during discrete time interval i (Mundy *Unpublished*):

$$f\left(w_i\right) = \frac{d_i}{d} \tag{15}$$

where: $f\left(w_i\right)$ is the probability distribution of those fish spawning in location w, d is the number of marked fish recovered in location w, and d_i is the number of fish bound for location w that were marked on the i^{th} day.

The mean day of migration past SN1 for a particular population is defined as:

$$\overline{w} = \sum_{i=1}^{l} w_i \, f\left(w_i\right) \tag{16}$$

with

$$\text{var}\left(\overline{w}\right) = \sum_{i=1}^{l} \left(w_i - \overline{w}\right)^2 f\left(w_i\right) \tag{17}$$

where: l equals the total number of days (subsequently recaptured) fish were captured and marked at SN1. Skewness, a measure of the deviation of $f\left(w_i\right)$ from a normal curve was estimated as:

$$z = \frac{\sum_{i=1}^{d} \left(w_i - \overline{w}\right)^3 f\left(w_i\right)}{\text{var}\left(\overline{w}\right)^3} \tag{18}$$

Kurtosis, a measure of the peakedness or flatness of $f\left(w_i\right)$ compared to a normal distribution was estimated as:

$$g = \frac{\sum_{i=1}^{d} \left(w_i - \overline{w}\right)^4 f\left(w_i\right)}{\text{var}\left(\overline{w}\right)^4} \tag{19}$$

RESULTS

TAGGING, RECOVERY AND ABUNDANCE

Of 716 Chinook salmon sampled in the lower river, 690 were marked and released (Table 2). Approximately 93% of the Chinook salmon marked during the first sampling event were captured between 20 June (statistical week 26) and 31 July (statistical week 31), a period of time also characterized by relatively constant fishing effort at the set gillnets (Figure 5). Eight (8) fish died during or immediately following the marking event. Of the 690 fish marked, 189 were medium and 501 were large. Of the fish caught and sampled at SN1, 59 were missing adipose fins, of which 18 were sacrificed; the rest were marked and released in good condition (Appendix A4). One sacrificed fish had no CWT, the remaining

17 had valid tags for this stock. Of the fish that were missing adipose fins and of those sacrificed, 56% and 94%, respectively, were males. Of 1,151 fish sampled in event 2, 21 were small, 344 were medium, 836 were large, and three were not measured.

During event 2, we recaptured 135 fish (i.e., fish previously marked in event 1), of which 30 were medium and 105 were large. Only one (1) recaptured fish was missing a spaghetti tag, a tag loss rate of 0.7%. This fish was identified as being previously marked by the presence of the left upper operculum punch and a missing left axillary appendage. In addition, the tag number from one recaptured fish was inadvertently not recorded. Adipose fins were missing on 123 fish sampled during event 2, of which 45 were sacrificed. Of the 45 adipose clipped fish sacrificed, 44 carried a valid tag for this stock and the remaining fish had been mistakenly tagged in the Unuk River as a coho salmon.

Length distributions of marked medium and large fish were not significantly different than length distributions for fish recaptured on the spawning grounds (P = 1.00, P = 0.94; Figures 6 and 7). Sampling on the spawning grounds was therefore not size selective and the mark-recapture data did not require length stratification. Length distributions of marked large fish were not significantly different than length distributions for fish sampled on the spawning grounds (P = 0.32, Figure 7), however similar distributions for medium-sized fish differed significantly (P = 0.00, Figure 6), indicating partial recruitment of medium fish at SN1.

There was evidence of gender selectivity between sampling events for large fish (χ^2 = 7.64, df = 1, P < .01) but not medium fish (χ^2 = 1.15, df = 1, P = 0.28). However, the recapture rates were similar for large males and females during event 2 (χ^2 = 0.30, df = 1, P = 0.58) indicating that the selectivity occurred during event 1 and the mark-recapture data therefore did not require stratification by gender. Due to event 1 gender (large fish) and size (medium fish) selectivity, only fish sampled on the spawning grounds were used to estimate length and age compositions of the escapement.

Recapture of marked fish indicated that the pooled estimator (equation 1) was appropriate for estimating abundance of both medium and large salmon. Samples from spawning grounds had near equal fractions of marked fish regardless of where

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 2004, by size group (includes recoveries with missing tags).

	Length (MEF)			
	0–400 mm	**401–659 mm**	**>659 mm**	**Total**
Released in event 1 with marks (M)	2	189	0501	690
Inspected at:				
1. Upriver [a]				
Inspected (C)[b]	2	117	0179	299
Recaptured (R)	0	8	22	30
Recaptured/captured		0.068	00.123	0.100
2. Downriver [c]				
Inspected (C)[d]	19	227	657	905
Recaptured (R)	0	22	83	105
Recaptured/captured		0.097	0.126	0.116
Total Inspected				
Inspected (C)	21	344	836	1,205
Recaptured (R)	0	30	105	135
Recaptured/captured		0.087	0.126	0.112

[a] Includes Boundary and Cripple creeks.

[b] Total inspected includes one fish not measured for length.

[c] Includes Clear, Gene's Lake, Kerr, and Lake creeks and the Eulachon River.

[d] Total inspected includes two fish not measured for length.

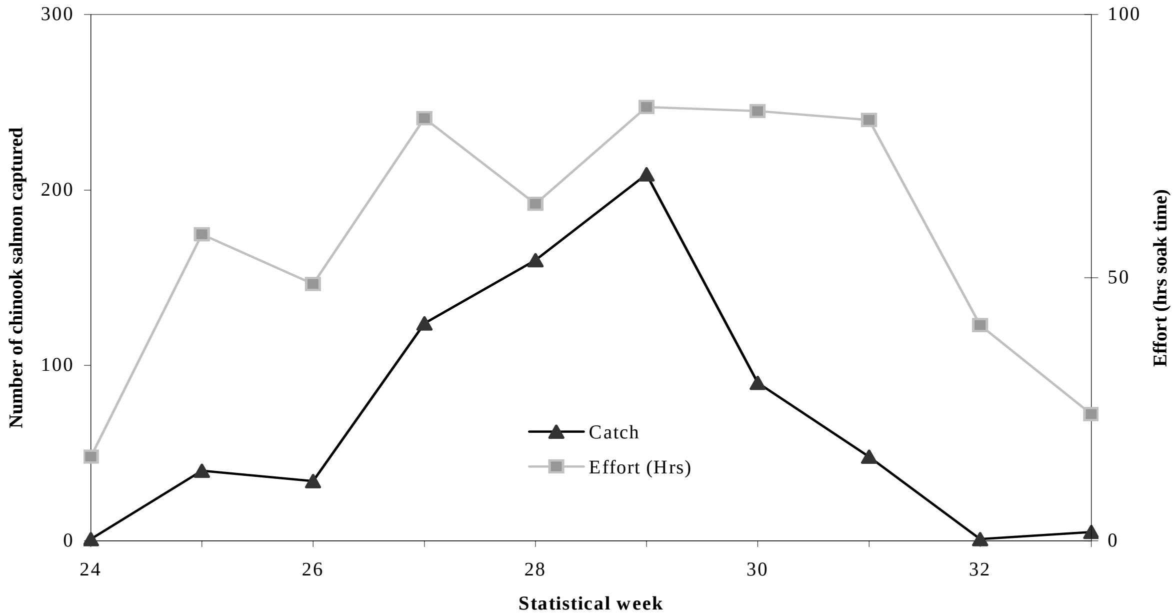


Figure 5.–Effort (in hours of soak-time) and catch of Chinook salmon by statistical week at SN1 on the Unuk River, 2004.

samples were taken (Table 2), and marked fish a near equal chance of being recaptured regardless of when they were marked (Table 3). Estimated abundance of medium fish was 2,114 (n_1 = 189; n_2 = 344; m_2 = 30; SE = 339); estimated abundance of large fish was 3,963 (n_1 = 501; n_2 = 836; m_2 = 105; SE = 325) (Table 4). Estimated bias in both estimates was <1.4%, and 95% confidence intervals were 1,602–2,907 and 3,406–4,684 for estimated abundance of medium and large fish, respectively. Together the estimated abundance of all Chinook salmon >400 mm MEF was 6,077 (SE = 470) (Table 5).

ESTIMATES OF AGE AND SEX COMPOSITION

Due to evidence of gender (large fish) and size (medium-sized fish) selectivity during event 1, only event 2 samples were used to estimate the age, sex, and length composition of the spawning population. In 2004, an estimated 48.3% of the spawning population of Chinook salmon was comprised of age-1.2 fish, double the average of the preceding seven years (Appendix A5, Figure 8). During the same 7-year period, age-1.3 fish comprised an average of 45.9% of the spawning population (range 33.1%-62.9%) but only 21.2% of the estimated population in 2004.

Approximately 73% of the spawning population was male in 2004, in contrast to the previous 7-year average of 59% (Table 5, Appendix A5). There were an estimated 1,658 (SE = 151) spawning females in 2004 (Table 5).

Estimated average lengths by age and sex were similar between events 1 and 2 in 2004, although age-1.1 fish were generally larger in event 1 (Table 6).

PEAK SURVEY COUNTS AND THE EXPANSION FACTOR

The peak survey count of large Chinook salmon in the six index streams of the Unuk River was 1,008 fish in 2004 (Pahlke *In prep.*). Cripple and Gene's Lake creeks accounted for 56% of these fish, compared to an average of 70% from 1977 to 2004 (Figure 9). The Cripple Creek population has experienced a downward trend in relative contribution to the peak survey count since 1977, while the contribution from the Eulachon River has decreased from an average of 19% (1977–1989)

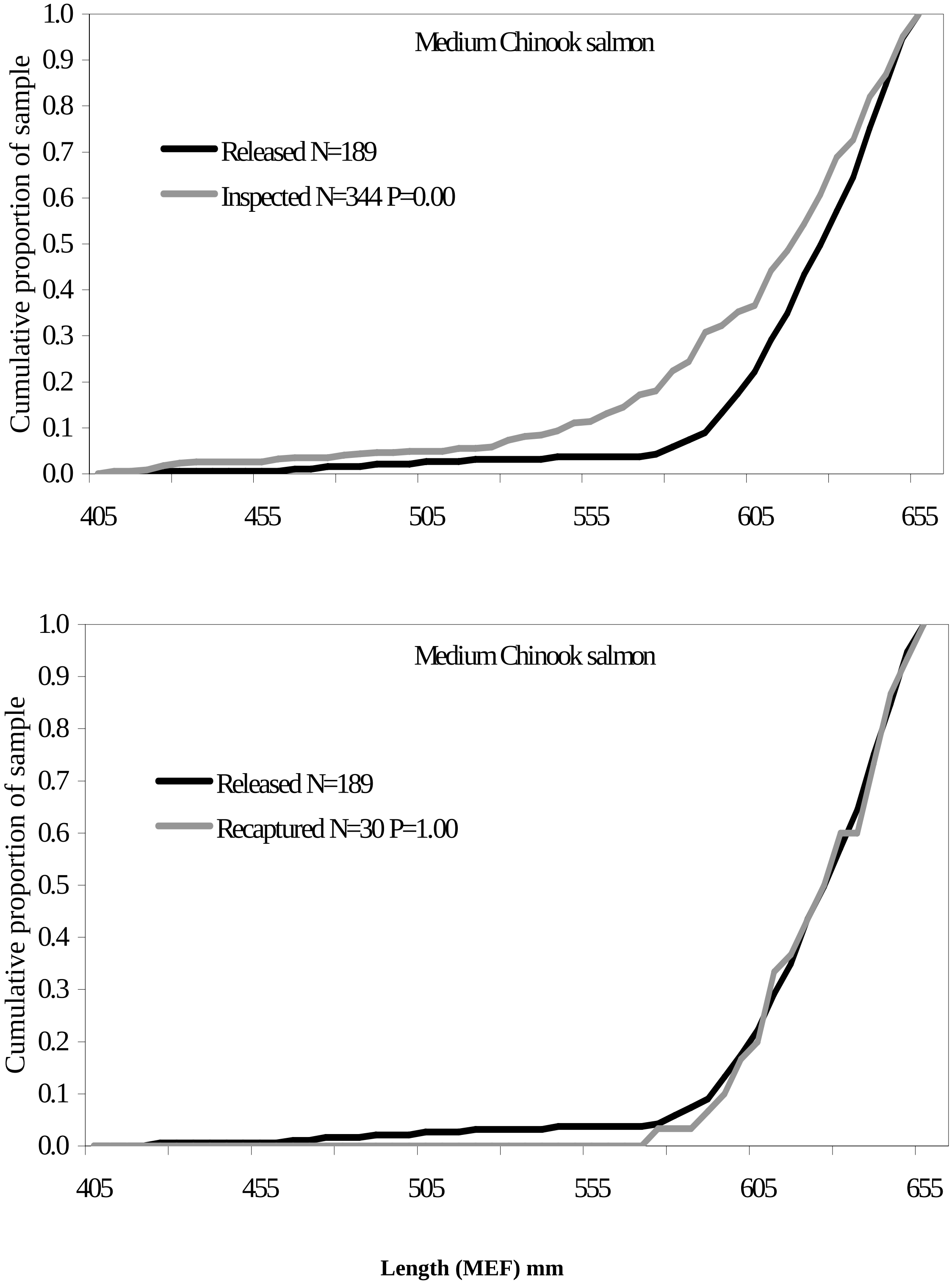
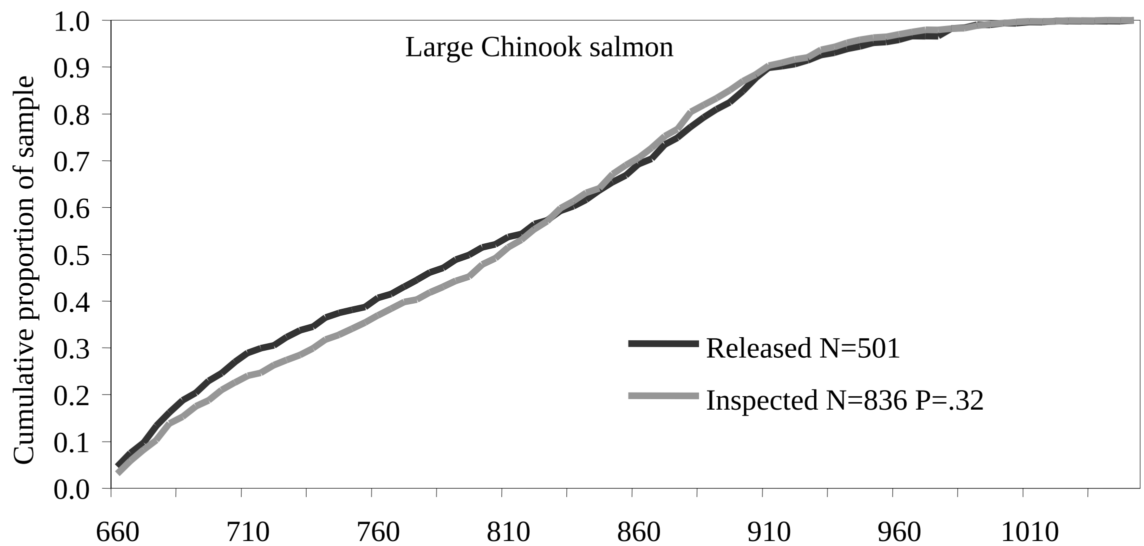


Figure 6.–Cumulative relative frequencies of medium Chinook salmon (401–659 mm MEF) marked in the lower Unuk River in 2004 compared with those inspected and recaptured on the spawning grounds.



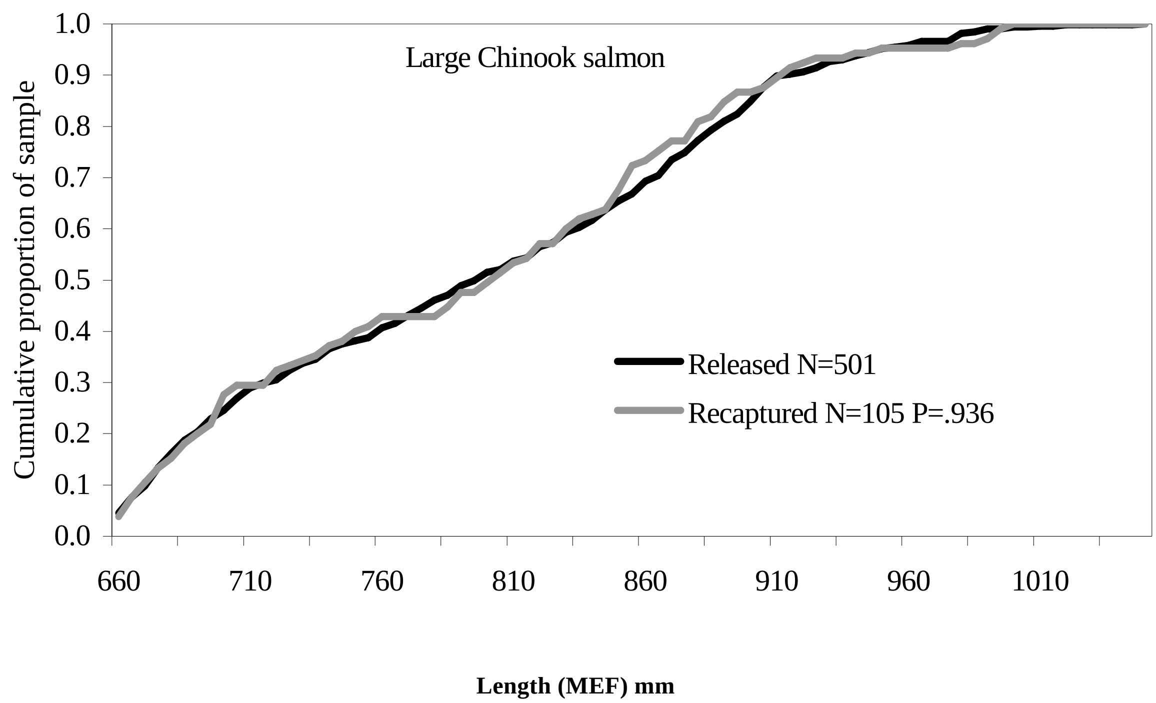


Figure 7.–Cumulative relative frequencies of large Chinook salmon (>659 mm MEF) marked in the lower Unuk River in 2004 compared with those inspected and recaptured on the spawning grounds.

Table 3.–Number of marked large and medium Chinook salmon released in the lower Unuk River and recaptured, by marking period, and the number examined for marks at each recovery location, 2004. Does not include recoveries with missing primary tags.

Marking dates	Number marked	Estimated fraction recovered	Recovery location Downriver[a]	Upriver[b]	Total
LARGE CHINOOK SALMON					
6/11 to 7/10	271	0.192	38	14	52
7/11 to 8/16	230	0.222	45	6	51
Total/proportion	501	0.206	83	20	103
Number inspected			657	179	836
Fraction marked			0.126	0.112	0.123
MEDIUM CHINOOK SALMON					
6/11 to 7/10	73	0.151	10	1	11
7/11 to 8/16	116	0.164	12	7	19
Total/proportion	189	0.159	22	8	30
Number inspected			227	117	344
Fraction marked			0.097	0.068	0.087

[a] Includes Clear, Gene's Lake, Kerr, and Lake creeks and the Eulachon River.

[b] Includes Boundary and Cripple creeks.

to 9% (1990–2004). Populations in Clear, Lake, and Genes Lake creeks have all demonstrated upward trends in relative contribution since 1977 while Kerr Creek's contribution has increased from an average of 2% (1977–1992) of the peak survey count to 7% (1993–2004) (Figure 9).

Of the estimated 3,963 large Chinook salmon immigrating to the Unuk River in 2004, 25% were counted during peak survey counts. This percentage is similar to that of previous years, which ranged from 15% in 1994 to 23% in 2000 (Table 4). Using the 1997–2001 and 2003–2004 mark recapture estimates and peak survey counts, the mean expansion factor would therefore be 4.83 (SD = 0.59) (Table 4). The expansion factor for 2002 is not included because of the relatively poor quality of the survey counts compared to those from other years (Weller and McPherson 2003b).

Migratory Timing

Migration past SN1 in 2004 was similar to migration in other years. The mean date of migration past SN1 in 2004 was estimated to be 10 July for those Chinook salmon marked at the setnet site and subsequently recovered on the spawning grounds and for all fish marked at SN1 (Appendix A6). This compares to an average date of 11 July from 1997 through 2004. The earliest estimated mean migration dates were for fish destined for Gene's Lake Creek (8 July) and Clear Creek (9 July). The latest mean migration date was 19 July for the Eulachon River stock (Figure 10, Appendix A6). The migratory timing distribution for the Cripple Creek stock was slightly leptokurtic; all other stocks displayed platykurtosis. The migratory timing distribution of the Lake Creek stock skewed slightly right while the migratory timing distributions of the remaining stocks skewed left (Appendix A6).

DISCUSSION

In previous years of study, Chinook salmon tagged and released during Event 1 have shown a "sulking" behavior or a delay in upstream migration (Pahlke et al. 1996; Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002, Weller and McPherson 2003a, 2003b). In 2004, 37 fish were marked, released, and subsequently recaptured in Event 1. For these fish, the average time between release and recapture (e.g., an estimate of the "sulk" rate) was approximately 4 days and 13 hours, with a maximum period of over 21 days and a minimum of 16 minutes (Table 7). This rate does not appear to vary by length or age; however, a trend exists when examined by

Table 4.–Peak survey counts, mark-recapture estimates of abundance, expansion factors and other statistics for medium (401–659 mm MEF) and large (>659 mm MEF) Chinook salmon in the Unuk River (1997–2004).

	1997		**1998**		**1999**		**2000**		**2001**		**2002**		**2003**		**2004**		**Average 1997–2004**	
	Med.	**Large**	**Med.**	**Large**	**Med.**	**Large**	**Med.**	**Large**	**Med.**	**Large**	**Med.**	**Large**	**Med.**	**Large**	**Med.**	**Large**	**Med.**	**Large**
Survey count		636		840		680		1,341		2,019		897		1,121		1,008		1,068
m_2	16	78	15	79	13	50	8	69	3	74	9	66	2	114	30	105	12	79
n_1	75	307	87	466	125	380	128	570	71	778	148	725	52	646	189	501	109	547
n_2	156	761	217	707	251	523	158	719	74	1,014	109	644	124	985	344	836	179	774
Mark-recapture (M-R) estimate	701	2,970	1,198	4,132	2,267	3,914	2,278	5,872	769	10,541	1,638	6,988	698	5,546	2,114	3,963	1,458	5,491
SE (M-R)	158	277	290	413	602	490	968	644	124	1,181	690	805	80	433	339	325	406	571
Survey count/(M-R) (%)		21.4		20.3		17.4		22.8		19.2		12.8		20.2		25.4		19.9
CV (M-R) (%)	22.5	9.3	24.2	10.0	26.6	12.5	42.5	11.0	16.1	11.2	42.1	11.5	11.5	7.8	16.0	8.2	25.2	10.2
95% RP M-R estimate (%)	44.2	18.3	47.4	19.6	52.0	24.5	83.3	21.5	31.6	22.0	82.6	22.6	22.5	15.3	31.4	16.1	49.4	20.0
Expansion factor (EF) [a]		4.67		4.92		5.76		4.38		5.22		7.79		4.95		3.93		4.83
SE (EF) [a]		0.44		0.49		0.72		0.48		0.58		0.90		0.39		0.32		0.59
CV (EF) [a]		9		10		13		11		11		12		8		8		12
95% RP (EF) [a]		18		20		25		21		22		23		15		16		24
M-R lower 95% C.I.	489	2,499	815	3,433	1,506	3,110	1,358	4,848	557	8,705	1,017	5,775	557	4,814	1,602	3,406	988	4,574
M-R upper 95% C.I.	1,109	3,636	1,903	4,974	3,811	5,071	5,042	7,347	1,068	13,253	3,331	8,845	1,068	6,530	2,907	4,684	2,530	6,793
Estimated bias (%)	2.3	0.1	3.0	0.6	3.4	1.5	9.6	1.1	1.5	0.9	7.5	0.6	0.4	0.03	1.4	0.5	3.6	0.7

[a] Average expansion factor and associated statistics are for 1997–2001 and 2003–2004.

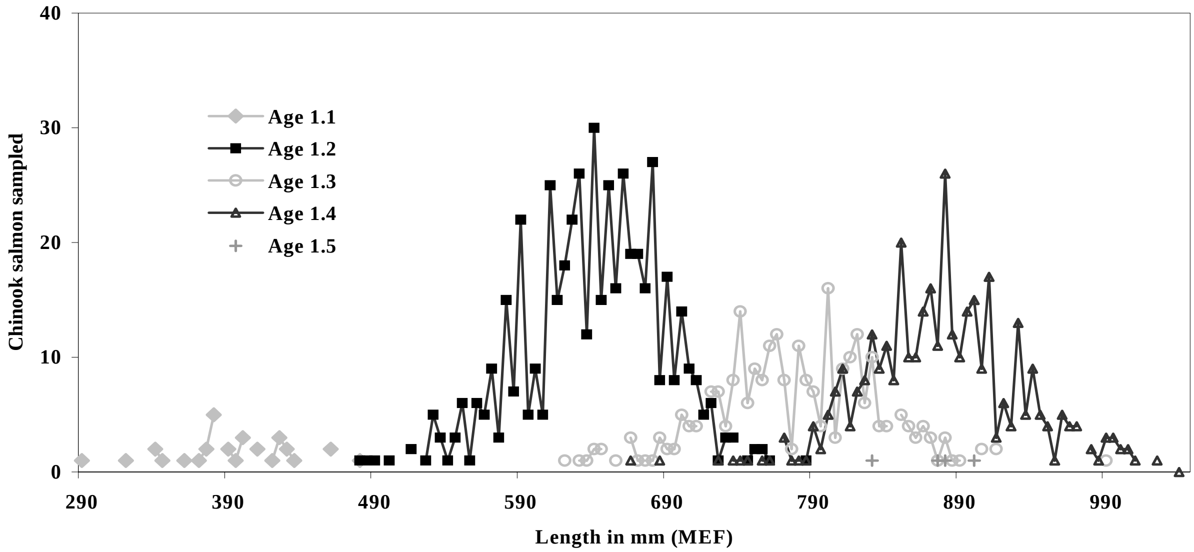


Figure 8.–Numbers of Chinook salmon sampled by length and age at all seven tributary spawning sites sampled on the Unuk River in 2004.

marking date. The "sulk" rate appears to be higher for fish marked earlier versus later in the project, and averaged 7.4 days for fish released through 6 July and 3.2 days for those released after that date (Figure 11). This phenomenon has been observed in other studies (Milligan et al. 1984; Johnson et al. 1992; Bendock and Alexandersdottir 1993; Johnson et al. 1993; Eiler et al., *personal communication.*) and has been shown to be a benign result of handling-induced behavior (Bernard et al. 1999).

Loss of tags was greatly reduced from previous years. Only one (1) of the 135 recaptures seen in event 2 (<1.0%) was missing a tag. The average rate of tag loss from 1997 to 2002 was 9%, with a range of 3% observed in 1997 to 15% in 2002. Tag retention was likely a result of samplers applying greater attention to the amount of pressure exerted with the crimping tool; too much pressure can burn the monofilament leader and decrease its strength, not enough pressure on the crimping tool results in an inadequate crimp. Four (4) tag numbers from recaptured fish were incorrectly recorded during data collection efforts however, an error rate of approximately 3%. In all cases, secondary marks were clearly visible on recaptured fish, once fish were in hand.

The validity of the abundance estimate for medium-sized Chinook salmon rests upon the degree to which the second sampling event was devoid of size-selectivity. Size-selective sampling occurred during the spawning grounds surveys in 1994, primarily as a result of a complete reliance on sampling carcasses and spearing spent females, and small sample size (Pahlke et al. 1996). Beginning in 1997 sample sizes were increased and diverse techniques were used to obtain spawning grounds samples to reduce bias in age, gender, and length composition estimates. The approach apparently worked since there is no indication of size-selective sampling on the spawning grounds after 1994 (Appendix A7).

Partial counts of large Chinook salmon have been conducted on the Unuk River since 1977. Using the expansion factor of 4.83 to estimate the spawning abundance for those years when no mark–recapture estimate is available (1977–1993 and 1995–1996), the estimated abundance of large Chinook salmon on the Unuk River has averaged 5,680 from 1979 to 2002 with a range of 2,870 in 1979 to 10,592 in 1986 (Appendix A1). The 2004 abundance estimate of 3,963 large Chinook salmon would therefore indicate a smaller than average spawning population.

Table 5.–Estimated age and sex composition of the escapement of medium (401–659 mm MEF) and large (>659 mm MEF) Chinook salmon in the Unuk River in 2004 as determined from spawning grounds samples.

		Brood year and age class					
		2001	2000	1999	1998	1997	
		1.1	1.2	1.3	1.4	1.5	**Total**
PANEL A: AGE COMPOSITION OF MEDIUM CHINOOK SALMON							
Males	Sample size	12	314	8			334
	$\hat{p}_{ijk}$ x100	3.6	93.5	2.4			99.4
	SE$\left(\hat{p}_{ijk}\right)$x100	1.0	1.3	0.8			0.4
	$\hat{N}_{ijk}$	75	1,975	50			2,101
	SE$\left(\hat{N}_{ijk}\right)$	24	318	19			337
Females	Sample size		2				2
	$\hat{p}_{ijk}$ x100		0.6				0.6
	SE$\left(\hat{p}_{ijk}\right)$x100		0.4				0.4
	$\hat{N}_{ijk}$		13				13
	SE$\left(\hat{N}_{ijk}\right)$		9				9
Sexes combined	Sample size	12	316	8			336
	$\hat{p}_{ij}$ x100	3.6	94.0	2.4			100.0
	SE$\left(\hat{p}_{ij}\right)$x100	1.0	1.3	0.8			
	$\hat{N}_{ij}$	75	1,988	50			2,114
	SE$\left(\hat{N}_{ij}\right)$	24	320	19			339
PANEL B: COMPOSITION OF LARGE CHINOOK SALMON							
Males	Sample size		193	178	108		479
	$\hat{p}_{ijk}$ x100		23.6	21.7	13.2		58.5
	SE$\left(\hat{p}_{ijk}\right)$x100		1.5	1.4	1.2		1.7
	$\hat{N}_{ijk}$		934	861	523		2,318
	SE$\left(\hat{N}_{ijk}\right)$		96	91	63		202
Females	Sample size		3	78	255	4	340
	$\hat{p}_{ijk}$ x100		0.4	9.5	31.1	0.5	41.5
	SE$\left(\hat{p}_{ijk}\right)$x100		0.2	1.0	1.6	0.2	1.7
	$\hat{N}_{ijk}$		15	377	1,234	19	1,645
	SE$\left(\hat{N}_{ijk}\right)$		8	51	120	10	151
Sexes combined	Sample size		196	256	363	4	819
	$\hat{p}_{ij}$ x100		23.9	31.3	44.3	0.5	100.0
	SE$\left(\hat{p}_{ij}\right)$x100		1.5	1.6	1.7	0.2	
	$\hat{N}_{ij}$		948	1,239	1,756	19	3,963
	SE$\left(\hat{N}_{ij}\right)$		98	120	160	10	325

-continued-

Table 5.–Page 2 of 2.

		Brood year and age class					
		2001	2000	1999	1998	1997	
		1.1	1.2	1.3	1.4	1.5	**Total**
PANEL C: AGE COMPOSITION OF MEDIUM AND LARGE CHINOOK SALMON							
Males	Sample size	12	507	186	108		813
	$\hat{p}_{jk}$ x100	1.2	47.9	15.0	8.6		72.7
	$\text{SE}(\hat{p}_{jk})$x100	0.4	3.1	1.3	0.9		2.0
	$\hat{N}_{jk}$	75	2,909	912	523		4,419
	$\text{SE}(\hat{N}_{jk})$	24	332	93	63		393
Females	Sample size		5	78	255	4	342
	$\hat{p}_{jk}$ x100		0.4	6.2	20.3	0.3	27.3
	$\text{SE}(\hat{p}_{jk})$x100		0.2	0.8	1.7	0.2	2.0
	$\hat{N}_{jk}$		27	377	1,234	19	1,658
	$\text{SE}(\hat{N}_{jk})$		12	51	120	10	151
Sexes	Sample size	12	512	264	363	4	1,155
combined	$\hat{p}_{j}$ x100	1.2	48.3	21.2	28.9	0.3	100.0
	$\text{SE}(\hat{p}_{j})$x100	0.4	3.1	1.6	2.1	0.2	
	$\hat{N}_{j}$	75	2,936	1,289	1,756	19	6,077
	$\text{SE}(\hat{N}_{j})$	24	334	122	160	10	470

Table 6.–Estimated average length (MEF in mm) by age, sex and sampling event of Chinook salmon sampled in the Unuk River in 2004.

		Brood year and age class					
		2001	2000	1999	1998	1997	
		1.1	1.2	1.3	1.4	1.5	Total
PANEL A: EVENT 1, LOWER UNUK RIVER SET GILLNET							
Males	Sample size	2	316	72	54		444
	Avg. length	445	647	756	903		695
	SD	28	39	152	66		99
	SE	20	2	18	9		5
Females	Sample size		22	67	155	3	247
	Avg. length		684	791	878	917	838
	SD		32	39	49	62	76
	SE		7	5	4	36	5
Sexes	Sample size	2	338	139	209	3	691
combined	Avg. length	445	650	773	884	917	746
	SD	28	40	51	55	62	114
	SE	20	2	4	4	36	4
PANEL B: EVENT 2, SPAWNING GROUNDS							
Males	Sample size	32	507	186	108		833
	Avg. length	394	640	770	885		691
	SD	41	48	62	73		120
	SE	7	2	5	7		4
Females	Sample size		5	78	255	4	342
	Avg. length		669	794	873	871	852
	SD		36	45	45	30	60
	SE		16	5	3	15	3
Sexes	Sample size	32	512	264	363	4	1,175
combined	Avg. length	394	640	777	877	871	738
	SD	41	48	58	55	30	129
	SE	7	2	4	3	15	4

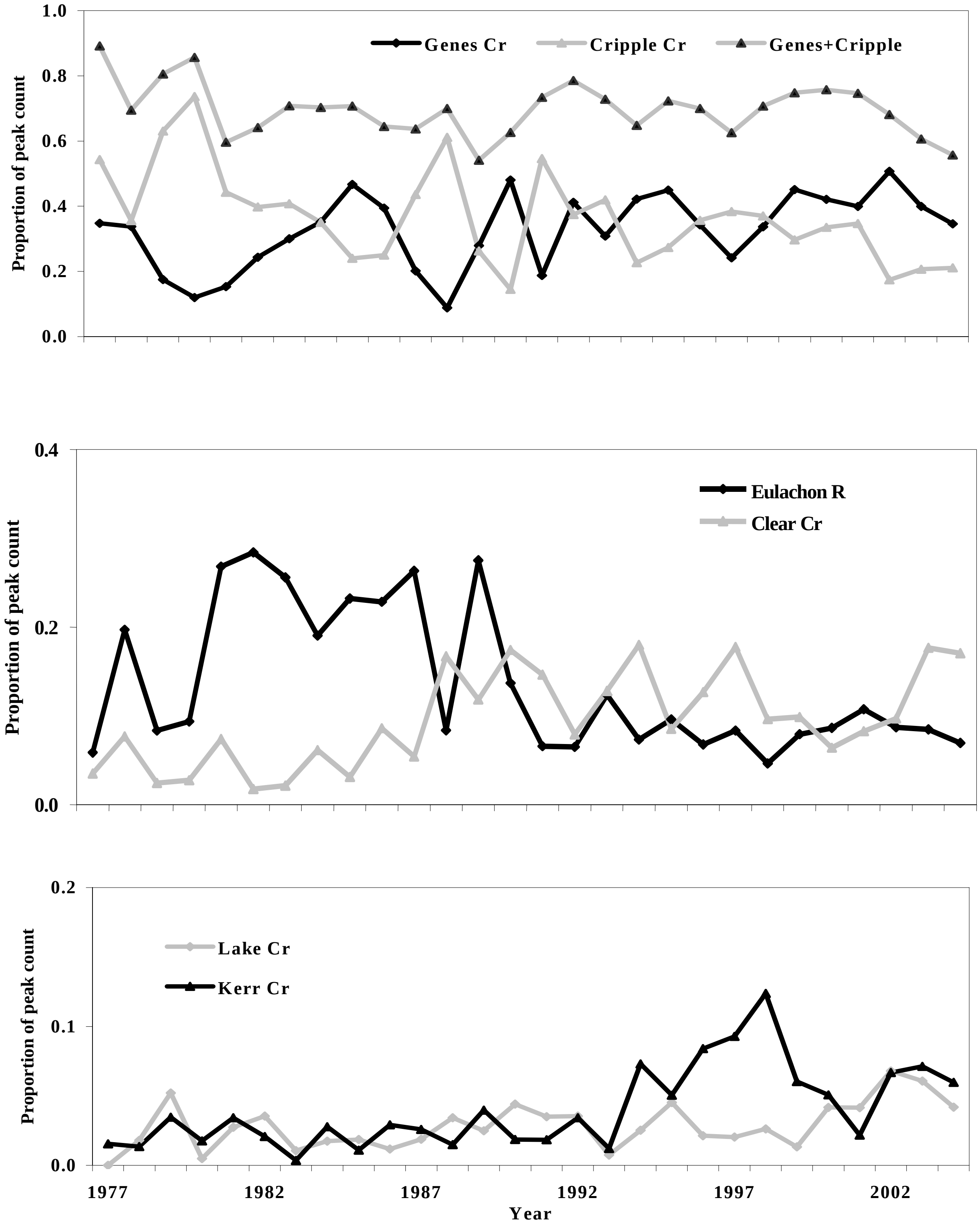


Figure 9.–Proportional contributions of the six index streams to the Unuk River Chinook salmon peak survey count, 1977–2004.

Table 7.–Elapsed time between release and recapture of Chinook salmon in the lower Unuk River in 2004.

Spaghetti tag no.	Release date/time	Recapture date/time	Sulking period	Day	Hour	Min
8044	07/20/04 09:15	07/20/04 10:00	0 days, 0 hours, and 45 minutes	0	0	45
8046	07/20/04 13:09	07/20/04 17:07	0 days, 3 hours, and 58 minutes	0	3	58
8050	06/21/04 06:20	07/01/04 14:39	10 days, 8 hours, and 19 minutes	10	8	19
8052	06/21/04 16:17	07/12/04 16:05	20 days, 23 hours, and 48 minutes	20	23	48
8059	06/22/04 15:26	6/30/04 17:30	8 days, 2 hours, and 4 minutes	8	2	4
8071	06/25/04 15:24	06/27/04 16:22	2 days, 0 hours, and 58 minutes	2	0	58
8072	06/25/04 18:00	07/02/04 14:57	6 days, 20 hours, and 57 minutes	6	20	57
8153	07/02/04 07:53	07/07/04 15:56	5 days, 8 hours, and 3 minutes	5	8	3
8197	07/04/04 09:15	07/18/04 16:45	14 days, 7 hours, and 30 minutes	14	7	30
8205	07/04/04 12:30	07/09/04 16:15	5 days, 3 hours, and 45 minutes	5	3	45
8219	07/05/04 13:35	07/14/04 15:14	9 days, 1 hour, and 39 minutes	9	1	39
8229	07/05/04 16:12	07/07/04 13:18	1 day, 21 hours, and 6 minutes	1	21	6
8232	07/06/04 05:57	07/10/04 18:51	4 days, 12 hours, and 54 minutes	4	12	54
8237	07/06/04 09:01	07/06/04 12:02	0 days, 3 hours, and 1 minute	0	3	1
8256	07/08/04 10:44	07/08/04 11:30	0 days, 0 hours, and 46 minutes	0	0	46
8267	07/09/04 13:01	07/09/04 17:01	0 days, 4 hours, and 0 minutes	0	4	0
8308	07/10/04 11:29	07/10/04 11:45	0 days, 0 hours, and 16 minutes	0	0	16
8321	07/10/04 14:30	07/21/04 17:08	11 days, 2 hours, and 38 minutes	11	2	38
8323	07/10/04 15:04	07/11/04 14:25	0 days, 23 hours, and 21 minutes	0	23	21
8351	07/11/04 06:40	07/11/04 07:10	0 days, 0 hours, and 30 minutes	0	0	30
8355	07/11/04 08:34	07/11/04 14:55	0 days, 6 hours, and 21 minutes	0	6	21
8372	07/11/04 13:40	07/12/04 14:05	1 day, 0 hours, and 25 minutes	1	0	25
8395	07/12/04 14:07	07/18/04 15:58	6 days, 1 hour, and 51 minutes	6	1	51
8399	07/12/04 15:23	07/15/04 05:55	2 days, 15 hours, and 32 minutes	2	15	32
8442	07/14/04 12:05	07/14/04 13:56	0 days, 1 hour, and 51 minutes	0	1	51
8459	07/14/04 14:38	07/25/04 16:05	11 days, 1 hour, and 27 minutes	11	1	27
8461	07/14/04 14:56	07/15/04 17:15	1 day, 2 hours, and 19 minutes	1	2	19
8478	07/15/04 07:50	07/15/04 09:50	0 days, 2 hours, and 0 minutes	0	2	0
8483	07/15/04 11:10	07/25/04 10:00	9 days, 22 hours, and 50 minutes	9	22	50
8513	07/16/04 06:56	07/18/04 16:40	2 days, 9 hours, and 45 minutes	2	9	45
8531	07/16/04 14:10	07/22/04 17:42	6 days, 3 hours, and 32 minutes	6	3	32
8542	07/17/04 12:35	07/17/04 14:35	0 days, 2 hours, and 0 minutes	0	2	0
8556	07/18/04 06:46	07/20/04 17:40	2 days, 10 hours, and 54 minutes	2	10	54
8569	07/19/04 07:07	07/22/04 17:15	3 days, 10 hours, and 8 minutes	3	10	8
8599	07/21/04 07:22	07/25/04 18:10	4 days, 10 hours, and 48 minutes	4	10	48
8643	07/26/04 09:40	07/26/04 10:55	0 days, 1 hours, and 15 minutes	0	1	15
8643	07/26/04 10:55	07/30/04 14:15	4 days, 3 hours, and 20 minutes	4	3	20
8655	07/27/04 09:00	08/12/04 14:22	16 days, 5 hours, and 22 minutes	16	5	22

Average = 4 days, 13 hours, 13 minutes; maximum = 20 days, 23 hours, 48 minutes; minimum = 16 minutes.

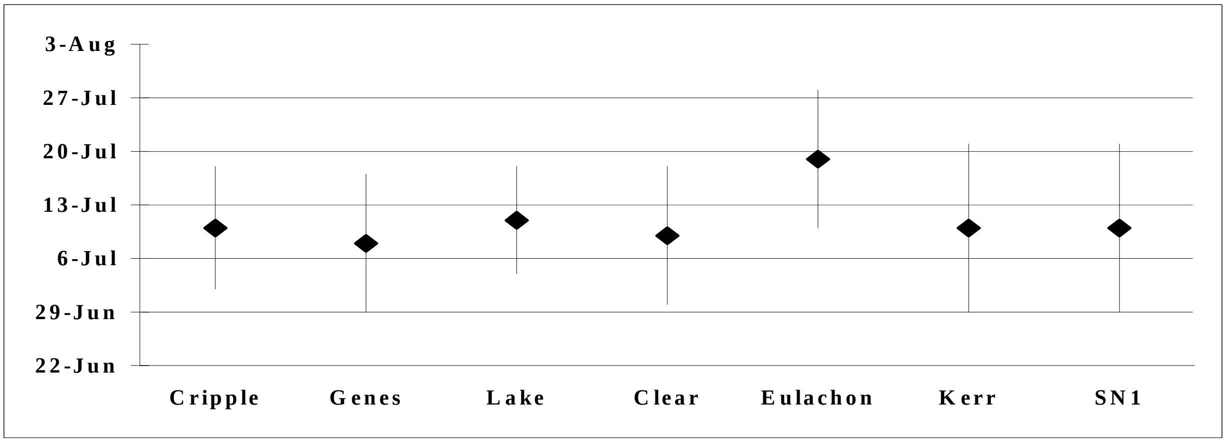


Figure 10.–Mean date of migration and standard deviation for Chinook salmon marked at SN1 on the Unuk River and recovered on the spawning grounds in 2004.

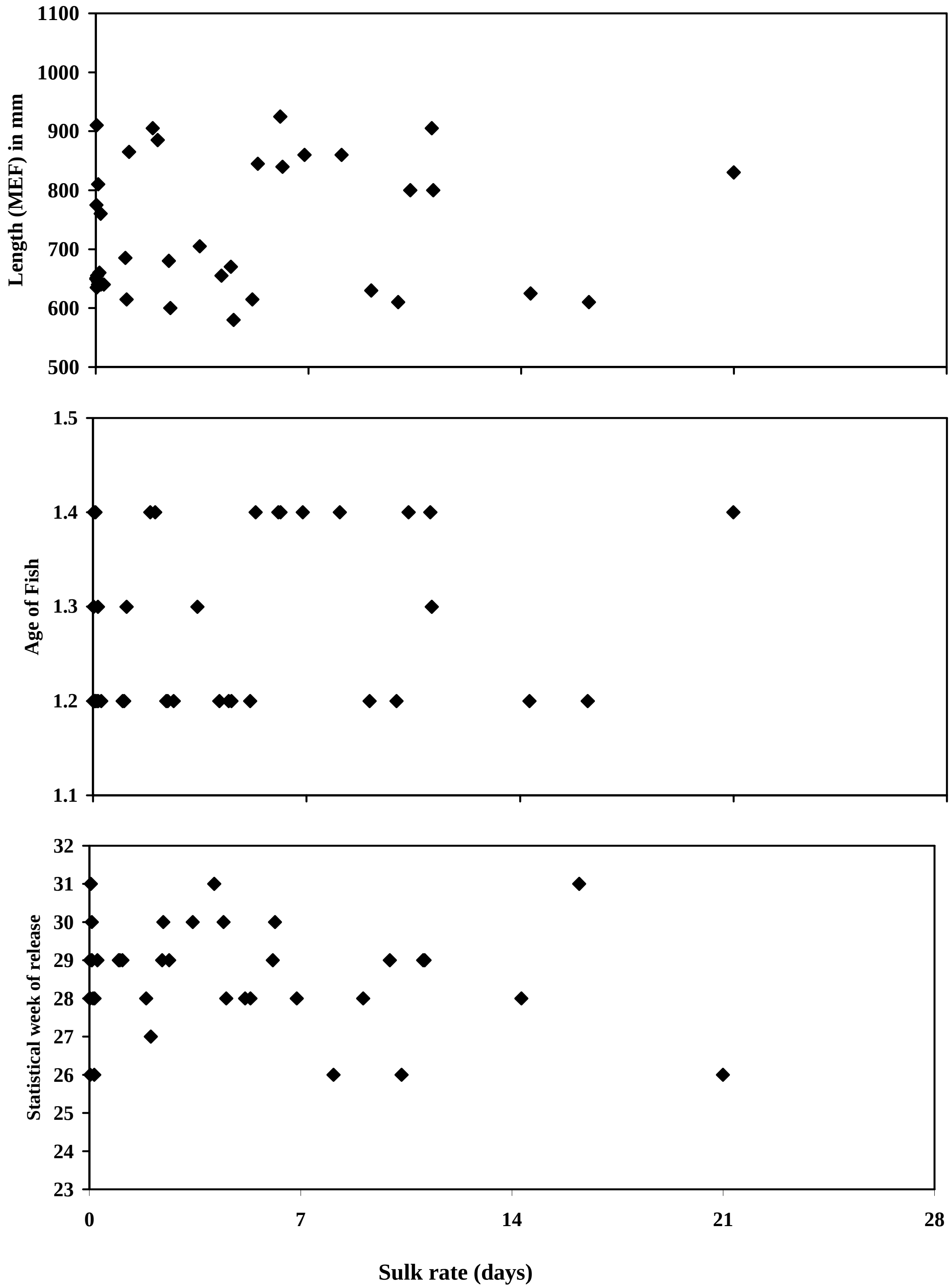


Figure 11.–Elapsed time between release and recapture of Chinook salmon caught multiple times in the lower Unuk River set gillnets in 2004 by date of release, fish length, and age of fish.

CONCLUSIONS AND RECOMMENDATIONS

Because this project will be repeated in 2005, we recommend some strategies for continued success. As in previous years, effort should concentrate on maximizing the numbers of fish tagged during Event 1 and those sampled for tags in Event 2. SN1 should continue to be used as the tagging site since it has produced more than adequate results in prior years. Knowledge of run timing gathered in prior years should be used as an indicator of peak spawning abundance and optimum sampling periods. We recommend that survey counts continue in a similar manner as those made in the past and that observers attempt to maintain consistency in counting efficiency from year to year. Finally, the age, sex, and length composition estimates from previous years of study have been relatively unbiased, which can be directly attributed to the use of the multiple gear types during spawning grounds sampling. We recommend continuing this practice in future years.

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APPENDIX A

Appendix A1.–Estimated abundance of the spawning population of large (>659 mm MEF) Chinook salmon in the Unuk River, 1977–2004. Mean expansion factor is 4.83 (SD = 0.59). Expansion factor calculated from m-r experiment and survey results, 1997–2001, and 2003–2004.

		Abundance estimated from expanded count		Abundance estimated from m–r experiment		Preferred abundance estimate	
Year	**Peak count from surveys**	$\hat{N}$	SE ($\hat{N}$)	$\hat{N}$	SE ($\hat{N}$)	$\hat{N}$	SE ($\hat{N}$)
1977	974	4,852	461			4,852	461
1978	1,106	5,510	524			5,510	524
1979	576	2,870	273			2,870	273
1980	1,016	5,062	481			5,062	481
1981	731	3,642	346			3,642	346
1982	1,351	6,731	640			6,731	640
1983	1,125	5,605	533			5,605	533
1984	1,837	9,152	870			9,152	870
1985	1,184	5,899	561			5,899	561
1986	2,126	10,592	1,007			10,592	1,007
1987	1,973	9,830	935			9,830	935
1988	1,746	8,699	827			8,699	827
1989	1,149	5,724	544			5,724	544
1990	591	2,944	280			2,944	280
1991	655	3,263	310			3,263	310
1992	874	4,354	414			4,354	414
1993	1,068	5,321	506			5,321	506
1994	711	3,542	337	4,623	1,266	3,542	337
1995	772	3,846	366			3,846	366
1996	1,167	5,814	553			5,814	553
1997	636	3,174		2,970	271	2,970	271
1998	840	4,192		4,132	394	4,132	394
1999	680	3,393		3,914	480	3,914	480
2000	1,341	6,692		5,872	620	5,872	620
2001	2,019	10,075		10,541	1,181	10,541	1,181
2002	897	4,469		6,988	805	6,988	805
2003	1,121	5,585		5,546	433	5,546	433
2004	1,008	4,871		3,963	325	3,963	325

Appendix A2.–Number of fingerlings and smolt captured and tagged with coded-wire tags, 1992 brood year to present in the Unuk River.

Brood year	Year tagged	Fall/spring	Tag code	Dates tagged	Number tagged	Valid tagged
1992	1993	Fall	04-38-03	10/13–10/22/93	10,316	10,263
1992	1993	Fall	04-38-04	10/25/1993	441	433
1992	1993	Fall	04-38-05	10/16–10/21/93	3,202	3,093
1992	1994	Spring	04-42-06	5/05–5/23/94	2,653	2,642
1992 Brood year total					16,612	**16,431**
1993	1994	Fall	04-33-49	10/07–10/24/94	1,706	1,700
1993	1994	Fall	04-33-50	10/07–10/22/94	11,152	11,139
1993	1994	Fall	04-35-57	10/22–11/01/94	7,688	7,687
1993	1995	Spring	04-42-13	4/10–5/05/95	3,228	3,227
1993 Brood year total					23,774	**23,753**
1994	1995	Fall	04-35-56	10/07–10/10/95	11,540	11,476
1994	1995	Fall	04-35-58	10/11–10/16/65	11,654	11,645
1994	1995	Fall	04-35-59	10/17–10/24/95	10,825	10,825
1994	1995	Fall	04-42-31	10/25–10/26/95	6,324	6,260
1994	1996	Spring	04-42-07	4/13–4/23/96	6,143	6,099
1994	1996	Spring	04-42-08	4/23–4/27/96	1,362	1,357
1994 Brood year total					47,848	**47,662**
1995	1996	Fall	04-47-12	9/30–9/15/96	24,252	24,224
1995	1996	Fall	04-42-36	10/16–10/19/96	11,202	11,200
1995	1996	Fall	04-42-18	10/20–10/21/96	3,755	3,753
1995	1997	Spring	04-38-29	3/31–4/18/97	12,521	12,517
1995 Brood year total					51,730	**51,694**
1996	1997	Fall	04-47-13	10/04–10/11/97	24,309	24,176
1996	1997	Fall	04-47-14	10/06–10/11/97	22,996	22,583
1996	1997	Fall	04-47-15	10/11–10/20/97	15,401	15,146
1996	1998	Spring	04-46-46	3/29–4/05/98	11,193	11,134
1996	1998	Spring	04-43-39	4/08–4/13/98	5,991	5,987
1996 Brood year total					79,890	**79,026**
1997	1998	Fall	04-01-39	10/04–10/13/98	22,389	22,366
1997	1998	Fall	04-01-40	10/13–10/23/98	11,664	11,522
1997	1999	Spring	04-01-44	4/08–5/01/99	7,954	7,948
1997 Brood year total					42,007	**41,836**
1998	1999	Fall	04-01-42	10/04–10/17/99	16,677	16,661
1998	2000	Spring	04-02-56	4/01–4/27/00	11,127	11,124
1998	2000	Spring	04-02-57	4/29–5/4/00	2,209	2,209
1998 Brood year total					30,013	**29,994**
1999	2000	Fall	04-03-74	10/06–10/20/00	21,918	21,853
1999	2000	Fall	04-02-88	10/20–10/29/00	10,082	10,072
1999	2001	Spring	04-01-45	4/2–4/23/01	16,565	16,561
1999 Brood year total					48,565	**48,486**
2000	2001	Fall	04-02-92	9/29–10/05/01	10,967	10,950
2000	2001	Fall	04-04-57	10/05–10/09/01	11,252	11,231
2000	2001	Fall	04-04-58	10/09–10/14/01	11,259	11,201
2000	2001	Fall	04-04-60	10/14–10/23/01	11,007	10,990
2000	2002	Spring	04-05-38	4/4–4/24/02	10,908	10,904
2000	2002	Spring	04-05-39	4/25–4/26/02	1,093	1,067
2000 Brood year total					56,486	**56,343**

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Brood year	Year tagged	Fall/spring	Tag code	Dates tagged	Number tagged	Valid tagged
2001	2002	Fall	04-05-23	9/28–10/05/02	11,449	11,402
2001	2002	Fall	04-05-24	10/05–10/13/02	11,564	11,538
2001	2002	Fall	04-05-25	10/13–10/17/02	11,798	11,778
2001	2002	Fall	04-05-26	10/17–10/20/02	11,467	11,425
2001	2002	Fall	04-46-52	10/20–10/25/02	8,419	8,403
2001	2003	Spring	04-08-07	04/08–5/10/03	11,360	11,354
2001	2003	Spring	04-08-43	5/10/03	483	483
2001 Brood year total					66,540	**66,383**
2002	2003	Fall	04-08-42	9/29–10/10/03	23,416	23,255
2002	2003	Fall	04-08-10	10/10–10/14/03	11,609	11,464
2002	2003	Fall	04-04-61	10/14–10/18/03	9,792	9,779
2002	2004	Spring	04-09-75	3/29–4/10/04	11,678	11,666
2002	2004	Spring	04-09-76	4/10–4/17/04	2,732	2,730
2002 Brood year total					58,227	**58,894**
2003	2004	Fall	04-09-77	09/19–10/03/04	11,799	11,789
2003	2004	Fall	04-09-78	10/3–10/19/04	11,464	11,417
2003	2004	Fall	04-09-81	10/19–10/21/04	3,923	3,923
2003 Brood year total					27,186	**27,129**

Appendix A3.–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 A4.–Numbers of adult Unuk River Chinook salmon examined for adipose finclips, sacrificed for CWT sampling purposes, valid CWT tags decoded, percent of the marked fraction carrying germane CWTs, percent adipose clipped, and estimated fraction of the sample carrying valid CWTs, 1992 brood year to present.

						Number of valid tags					Marked fraction (θ)	
Brood year	**Age class**	**Year examined**	**Number examined**	**Adipose clips**	**Number sacrificed**	**Fall**	**Spring**	**Total**	**Valid**	**Percent adipose**	**Valid**	**Event**
1992	1.2	1996	33	0								1&2
1992	1.3	1997	432	13	13	12	1	11	100.0%	3.0%	3.0%	1&2
1992	2.2	1997	1									1&2
1992	1.4	1998	324	15	11	4	4	8	72.7%	4.6%	3.4%	1&2
1992	1.5	1999	1									1&2
1992 Brood year total			791	28	24	16	5	21	87.5%	3.5%	3.1%	
1993	1.1	1996	4	1	1	1		1	100.0%	25.0%	25.0%	1&2
1993	1.2	1997	296	32	32	25	3	28	87.5%	10.8%	9.5%	1&2
1993	1.3	1998	736	63	48	36	8	44	91.7%	8.6%	7.8%	1&2
1993	2.2	1998	1									1&2
1993	1.4	1999	335	34	19	14	4	18	94.7%	10.1%	9.6%	1&2
1993	1.5	2000	9									1&2
1993 Brood year total			1,381	130	100	76	15	91	91.0%	9.4%	8.6%	
1994	1.1	1997	51	4	4	2	2	4	100.0%	7.8%	7.8%	1&2
1994	1.2	1998	311	31	28	14	11	25	89.3%	10.0%	8.9%	1&2
1994	2.1	1998	1									1&2
1994	1.3	1999	421	45	14	6	5	11	78.6%	10.7%	8.4%	1&2
1994	1.4	2000	247	12	7	3	3	6	85.7%	4.9%	4.2%	1&2
1994	1.5	2001	4									1&2
1994 Brood year total			1,035	92	53	25	21	46	86.8%	8.9%	7.7%	
1995	1.1	1998	81	15	14	8	5	13	92.9%	18.5%	17.2%	1&2
1995	1.2	1999	462	54	45	29	16	45	100.0%	11.7%	11.7%	1&2
1995	1.3	2000	742	77	20	9	7	16	80.0%	10.4%	8.3%	1&2
1995	1.4	2001	512	53	19	12	7	19	100.0%	10.4%	10.4%	1&2
1995	1.5	2002	6	1	1	1		1	100.0%	16.7%	16.7%	1&2
1995	2.4	2002	1									1&2
1995 Brood year total			1,804	200	99	59	35	94	94.9%	11.1%	10.5%	
1996	0.1	1998	2									1&2
1996	1.1	1999	65	6	6	4	1	5	83.3%	9.2%	7.7%	1&2
1996	1.2	2000	541	69	49	33	14	47	95.9%	12.8%	12.2%	1&2
1996	1.3	2001	1,177	137	43	27	11	38	88.4%	11.6%	10.3%	1&2
1996	1.4	2002	551	58	15	11	4	15	100.0%	10.5%	10.5%	1&2
1996	1.5	2003	7	1	0							1&2
1996 Brood year total			2,343	271	113	75	30	105	92.9%	11.6%	10.7%	
1997	1.1	2000	12	1	1		1	1	100.0%	8.3%	8.3%	1&2
1997	1.2	2001	189	26	23	12	5	17	73.9%	13.8%	10.2%	1&2
1997	0.4	2002	1									1&2
1997	1.3	2002	598	56	7	4	3	7	100.0%	9.4%	9.4%	1&2
1997	2.2	2002	1									1&2
1997	1.4	2003	379	31	6	4		4	66.7%	8.2%	5.5%	1&2
1997	1.5	2004	6	2						33.3%		1&2
1997 Brood year total			1,186	116	37	20	9	29	78.4%	9.8%	7.7%	1&2

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						Number of valid tags					Marked fraction (θ)	
Brood year	**Age class**	**Year examined**	**Number examined**	**Adipose clips**	**Number sacrificed**	**Fall**	**Spring**	**Total**	**Valid**	**Percent adipose**	**Valid**	**Event**
1998	1.1	2001	31	3	3	0	3	3	100.0%	9.7%	9.7%	1&2
1998	1.2	2002	419	26	21	12	9	21	100.0%	6.2%	6.2%	1&2
1998	0.4	2003	1									1&2
1998	1.3	2003	1,112	117	28	11	17	28	100.0%	10.5%	10.5%	1&2
1998	2.2	2003	1									1&2
1998	1.4	2004	527	50	1	1		1	100.0%	9.5%	9.5%	1&2
1998 Brood year total			2,091	196	53	24	29	53	100.0%	9.4%	9.4%	1&2
1999	0.2	2002	1									1&2
1999	1.1	2002	3									1&2
1999	1.2	2003	147	15	13	7	5	12	92.3%	10.2%	9.4%	1&2
1999	1.3	2004	381	47	3	2	1	3	100.0%	12.3%	12.3%	1&2
1999 Brood year total			532	62	16	9	6	15	93.8%	11.7%	10.9%	1&2
2000	1.1	2003	72	4	4	2	2	4	100.0%	5.6%	5.6%	1&2
2000	1.2	2004	787	61	51	29	21	50	98.0%	7.8%	7.6%	1&2
2000 Brood year total			859	65	55	31	23	54	98.2%	7.6%	7.4%	1&2
2001	1.1	2004	34	7	7	5	2	7	100.0%	20.6%	20.6%	1&2
2001 Brood year total			34	7	7	5	2	7	100.0%	20.6%	20.6%	1&2

Appendix A5.–Estimated annual escapement of Chinook salmon in the Unuk River by age class and sex, 1997–2004**.**

Year		Age class								Total
		1.1	1.2	2.2	1.3	0.4	1.4	1.5	2.4	
	Male	46	881	5	724		323	14		1,992
1997	%	1.3	24.0	0.1	19.7		8.8	0.4		54.3
Estimated	Female		5		526		1,102	46		1,679
escapement	%		0.1		14.3		30.0	1.3		45.7
	Total	46	885	5	1,250		1,425	60		3,671
	%	1.3	24.1	0.1	34.0		38.8	1.6		100.0
	Male	232	1,299	6	1,392		325	6		3,259
1998	%	4.4	24.4	0.1	26.1		6.1	0.1		61.2
Estimated	Female				1,172		870	29		2,071
escapement	%				22.0		16.3	0.5		38.8
	Total	232	1,299	6	2,564		1,195	35		5,330
	%	4.4	24.4	0.1	48.1		22.4	0.7		100.0
	Male	211	2,189		1,134		492	9		4,036
1999	%	3.4	35.4		18.3		8.0	0.1		65.3
Estimated	Female		26		914		1,196	9		2,145
escapement	%		0.4		14.8		19.3	0.1		34.7
	Total	211	2,216		2,049		1,688	18		6,181
	%	3.4	35.8		33.1		27.3	0.3		100.0
	Male	9	2,444		2,312		517	19		5,302
2000	%	0.1	30.0		28.4		6.3	0.2		65.1
Estimated	Female		47		1,636		1,128	38		2,848
escapement	%		0.6		20.1		13.8	0.5		34.9
	Total	9	2,491		3,948		1,645	56		8,150
	%	0.1	30.6		48.4		20.2	0.7		100.0
	Male	83	936		3,680		894	21		5,613
2001	%	0.7	8.3		32.5		7.9	0.2		49.6
Estimated	Female		10		3,243		2,443			5,697
escapement	%		0.1		28.7		21.6			50.4
	Total	83	946		6,923		3,337	21		11,310
	%	0.7	8.4		61.2		29.5	0.2		100.0
	Male		2,437		1,675		1,146	22		5,280
2002	%		28.3		19.4		13.3	0.3		61.2
Estimated	Female		48		1,212		2,042	33	11	3,346
escapement	%		0.6		14.1		23.7	0.4	0.1	38.8
	Total		2,485		2,887		3,188	55	11	8,626
	%		28.8		33.5		37.0	0.6	0.1	100.0
	Male	192	580	6	2,135	0	447	11		3,371
2003	%	3.1	9.3	0.1	34.2	0.0	7.2	0.2	0.0	54.0
Estimated	Female	0	11	0	1,795	6	1,027	34		2,874
escapement	%	0.0	0.2	0.0	28.7	0.1	16.4	0.5	0.0	46.0
	Total	192	592	6	3,930	6	1,474	46		6,245
	%	3.1	9.5	0.1	62.9	0.1	23.6	0.7	0.0	100.0
	Male	75	2,909		912		523			4,419
2004	%	1.2	47.9		15.0		8.6			72.7
Mean annual	Female		27		377		1,234	19		1,658
estimated	%		0.4		6.2		20.3	0.3		27.3
escapement	Total	75	2,936		1,289		1,756	19		6,077
	%	1.2	48.3		21.2		28.9	0.3		100.0

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Year		Age class								Total
		1.1	1.2	2.2	1.3	0.4	1.4	1.5	2.4	
	Male	106	1,709	1	1,746	1	583	13		4,159
1997-2004	%	1.5	24.6	0.0	25.1	0.0	8.4	0.2		59.9
Estimated	Female		22	1	1,359	1	1,380	26	1	2,790
mean	%		0.3	0.0	19.6	0.0	19.9	0.4	0.0	40.1
escapement	Total	106	1,731	2	3,105	1	1,963	39	1	6,949
	%	1.5	24.9	0.0	44.7	0.0	28.3	0.6	0.0	100.0

Appendix A6.–Estimated mean date of migration of Chinook salmon stocks past SN1 on the Unuk River from 1997–2004 (Panel A), with the associated statistics of standard deviation (Panel B), skewness (Panel C), kurtosis (Panel D), and sample size (Panel E).

		Tributary							
Year	SN1	Eulachon River	Clear Creek	Lake Creek	Kerr Creek	Genes Lake Creek	Cripple Creek	Boundary Creek	Tributaries combined
PANEL A: ESTIMATED MEAN DATE OF MIGRATION AT SN1									
2004	10-Jul	19-Jul	9-Jul	11-Jul	10-Jul	8-Jul	10_Jul		10-Jul
2003	12-Jul	14-Jul	13-Jul	13-Jul	14-Jul	9-Jul	6-Jul	8-Jul	11-Jul
2002	15-Jul	19-Jul	11-Jul	22-Jul	20-Jul	17-Jul	17-Jul	26-Jul	17-Jul
2001	15-Jul	21-Jul	16-Jul	4-Jul	17-Jul	15-Jul	10-Jul	9-Jul	13-Jul
2000	12-Jul	16-Jul	12-Jul	11-Jul	15-Jul	14-Jul	16-Jul		14-Jul
1999	12-Jul		11-Jul		14-Jul	11-Jul	13-Jul		12-Jul
1998	3-Jul	10-Jul	5-Jul	21-Jun	29-Jun	2-Jul	4-Jul	3-Jul	3-Jul
1997	7-Jul	11-Jul	6-Jul		7-Jul	6-Jul	9-Jul		8-Jul
97–03 Mean	11-Jul	15-Jul	11-Jul	8-Jul	12-Jul	11-Jul	11-Jul	12-Jul	11-Jul
PANEL B: STANDARD DEVIATION (in days)									
2004	11	9	9	7	11	9	8		9
2003	10	6	9	8	8	8	9	13	9
2002	10	10	4	7	5	7	8	6	8
2001	11	5	11	10		6	8	9	9
2000	13		9	12	8	9	6		9
1999	10		5		9	6	9		8
1998	10	3	11		6	9	8		9
1997	7	7	7		4	6	4		5
PANEL C: SKEWNESS ESTIMATION									
2004	0.14	-0.89	-0.78	0.03	-0.56	-0.43	-0.23		-0.37
2003	0.59	0.03	-1.12	1.09	0.34	-0.34	-0.59	-0.10	-0.33
2002	-0.48	0.47	-0.82	0.03	-0.20	0.50	-0.32	0.03	0.10
2001	-0.24	0.71	-1.90	0.50	-0.71	-0.01	-0.76	-0.67	-0.95
2000	-0.10		-0.15	-0.44	-0.48	-0.54	-0.41		-0.61
1999	1.36		0.28		0.92	-0.13	1.27		1.20
1998	0.50	0.01	1.70		-0.05	-0.85	-0.36		0.61
1997	-0.66	-0.13	-0.16		-1.61	-0.82	-1.45		-0.63
PANEL D: KURTOSIS ESTIMATION [a]									
2004	3.38	2.64	2.77	1.91	2.25	2.73	3.34		2.83
2003	4.34	1.00	5.26	3.70	2.39	3.25	2.57	2.02	3.80
2002	3.75	1.23	2.71	1.00	2.31	3.18	3.52	1.00	3.12
2001	3.59	1.49	7.75	1.49	1.50	2.78	2.05	1.52	4.43
2000	2.48		1.48	2.84	1.83	1.94	3.12		2.84
1999	5.41		1.82		2.50	1.39	4.18		4.48
1998	4.68	1.00	7.30		1.63	3.45	3.08		6.25
1997	4.46	2.27	3.02		5.32	3.76	6.18		4.29
PANEL E: NUMBER OF FISH MARKED AT SN1 AND RECAPTURED ON TRIBUTARIES									
2004	690	9	17	10	13	53	27		129
2003	703	2	22	9	21	37	10	4	105
2002	873	5	5	2	5	25	22	2	66
2001	853	3	13	3	3	15	28	3	68
2000	697	1	15	7	6	19	18		66
1999	504		13		6	11	29		59
1998	550	2	21	1	13	18	37	1	93
1997	383	5	20		9	18	38		90

[a] Normal distributions have a kurtosis of 3.00.

Appendix A7.–Numbers by sex and age for Chinook salmon sampled on the Unuk River spawning grounds in 2004 by location (Panel A), gear (Panel B), and size group (Panel C), and in the lower river gillnet samples (Panel D). Results were not stratified by size class; for the age composition of the escapement, see Table 5.

			Brood year and age class					
			2001	**2000**	**1999**	**1999**	**1997**	
			1.1	**1.2**	**1.3**	**1.4**	**1.5**	**Total**
PANEL A: EVENT 2 SAMPLES BY LOCATION								
Boundary Creek	Males	n		5		2		7
		%		62.5		25.0		87.5
	Females	n			1			1
		%			12.5			12.5
	Total	n		5	1	2		8
		%		62.5	12.5	25.0		100.0
Clear Creek	Males	n	2	67	24	11		104
		%	1	48.2	17.3	7.9		74.8
	Females	n	.4		13	22		35
		%			9.4	15.8		25.2
	Total	n	2	67	37	33		139
		%	1.4	48.2	26.6	23.7		100.0
Cripple Creek	Males	n	1	170	43	15		229
		%	0.4	60.1	15.2	5.3		80.9
	Females	n		3	22	29		54
		%		1.1	7.8	10.2		19.1
	Total	n	1	173	65	44		283
		%	0.4	61.1	23.0	15.5		100.0
Eulachon River	Males	n	2	26	6	6		40
		%	3.3	43.3	10.0	10.0		66.7
	Females	n			3	16	1	20
		%			5.0	26.7	1.7	33.3
	Total	n	2	26	9	22	1	60
		%	3.3	43.3	15.0	36.7	1.7	100.0
Gene’s Lake Creek	Males	n	5	172	80	42		299
		%	1.1	37.9	17.6	9.3		65.9
	Females	n		2	28	123	2	155
		%		0.4	6.2	27.1	0.4	34.1
	Total	n	5	174	108	165	2	454
		%	1.1	38.3	23.8	36.3	0.4	100.0
Kerr Creek	Males	n	2	41	20	22		85
		%	1.5	30.1	14.7	16.2		62.5
	Females	n			6	45		51
		%			4.4	33.1		37.5
	Total	n	2	41	26	67		136
		%	1.5	30.1	19.1	49.3		100.0
Lake Creek	Males	n		26	13	10		49
		%		34.7	17.3	13.3		65.3
	Females	n			5	20	1	26
		%			6.7	26.7	1.3	34.7
	Total	n		26	18	30	1	75
		%		34.7	24.0	40.0	1.3	100.0

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			Brood year and age class					
			2001	**2000**	**1999**	**1998**	**1997**	
			1.1	**1.2**	**1.3**	**1.4**	**1.5**	**Total**
PANEL B: EVENT 2 SAMPLES BY GEAR								
Carcass	Males	n		6		3		9
		%		20.7		10.3		31.0
	Females	n			5	15		20
		%			17.2	51.7		69.0
	Total	n		6	5	18		29
		%		20.7	17.2	62.1		100.0
Dip net	Males	n		1		1		2
		%		50.0		50.0		100.0
	Females	n						
		%						
	Total	n		1		1		2
		%		50.0		50.0		100.0
Rod and reel lure	Males	n	2	21	7	1		31
		%	4.4	46.7	15.6	2.2		68.9
	Females	n			3	11		14
		%			6.7	24.4		31.1
	Total	n	2	21	10	12		45
		%	4.4	46.7	22.2	26.7		100.0
Rod and reel snag	Males	n	8	378	130	77		593
		%	1.0	45.9	15.8	9.4		72.1
	Females	n		4	55	168	3	230
		%		0.5	6.7	20.4	0.4	27.9
	Total	n	8	382	185	245	3	823
		%	1.0	46.4	22.5	29.8	0.4	100.0
Gill net	Males	n	2	92	47	26		167
		%	0.8	37.6	19.2	10.6		68.2
	Females	n		1	15	61	1	78
		%		0.4	6.1	24.9	0.4	31.8
	Total	n	2	93	62	87	1	245
		%	0.8	38.0	25.2	35.5	0.4	100.0
Other/Unknown	Males	n		9	2			11
		%		81.8	18.2			100.0
	Females	n						
		%						
	Total	n		9	2			11
		%		81.8	18.2			100.0

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				Brood year and age class					
				2001	2000	1999	1998	1997	
				1.1	1.2	1.3	1.4	1.5	Total
PANEL C: ALL TRIBUTARIES COMBINED									
Spawning grounds	Medium-sized	Males	n	12	314				326
			%	3.7	95.7				99.4
		Females	n		2				2
			%		0.6				0.6
		Total	n	12	316				328
			%	3.7	96.3				100.0
	Large-sized	Males	n		193	186	108		487
			%		23.3	22.5	13.1		58.9
		Females	n		3	78	255	4	340
			%		0.4	9.4	30.8	0.5	41.1
		Total	n		196	264	363	4	827
			%		23.7	31.9	43.9	0.5	100.0
	Medium- and large-sized	Males	n	12	507	186	108		813
			%	1.0	43.9	16.1	9.4		70.4
		Females	n		5	78	255	4	342
			%		0.4	6.8	22.1	0.3	29.6
		Total	n	12	512	264	363	4	1,155
			%	1.0	44.3	22.9	31.4	0.3	100.00
PANEL D: EVENT 1, LOWER UNUK RIVER SET GILLNET SAMPLES									
Event 1	Medium-sized	Males	n	2	187	3			192
			%	1.0	95.4	1.5			98.0
		Females	n		4				4
			%		2.0				2.0
		Total	n	2	191	3			196
			%	1.0	97.4	1.5			100.0
	Large-sized	Males	n		129	69	54		252
			%		26.1	13.9	10.9		50.9
		Females	n		18	67	155	3	243
			%		3.6	13.5	31.3	0.6	49.1
		Total	n		147	136	209	3	495
			%		29.7	27.5	42.2	0.6	100.0
	Medium- and large-sized	Males	n	2	316	72	54		444
			%	0.3	45.7	10.4	7.8		64.3
		Females	n		22	67	155	3	247
			%		3.2	9.7	22.4	0.4	35.7
		Total	n	2	338	139	209	3	691
			%	0.3	48.9	20.1	30.2	0.4	100.0

Appendix A8.–Computer files used to estimate the spawning abundance of Chinook salmon in the Unuk River in 2004.

File name	Description
04unk41a.xls	Spreadsheet containing Tables 1 and 4– 7, Figures 5 and 11, Appendices A1, A2, A4, and A7, and chi-squared analyses.
04unuk41b.xls	Spreadsheet containing Appendix A5.
04unuk41c.xls	Spreadsheet containing Tables 2 and 3.
Ks04unuk41.xls	Spreadsheet containing Figures 6 and 7.
U41migratory04.xls	Spreadsheet containing Figure 10 and Appendix A6.
Unuk41surveys.xls	Spreadsheet containing Figure 9.
04Unuk41ASL.xls	Spreadsheet containing mark-recapture data.
Unuk04bootstraps41.xls	File containing bootstrap results.