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Estimation of the Escapement of Chinook Salmon in the Unuk River in 2002

by

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and

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July 2003

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.

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	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	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

all commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
all commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	var

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ABSTRACT

The abundance of medium-sized and large chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Unuk River in 2002 was estimated using a two-event mark-recapture experiment. Fish were captured during event 1 in the lower Unuk River using set gillnets from June through early August. In event 2, fish were examined on the spawning grounds from July through August to estimate the fraction of the population that had been marked. An estimated 19% of the spawning population was sampled during the project. Spawning abundance of large chinook salmon (≥660 mm mid-eye to fork [MEF]) was estimated to be 6,988 (SE = 805) Estimated abundance of medium-sized fish (401–659 mm MEF) was 1,638 (SE = 690). During the annual aerial survey, the peak count of large salmon was 897, making the expansion factor 7.79 for the year (SE = 0.90), a higher factor than estimated in previous years. Of the spawning population >400 mm MEF, 28.8% (SE = 5.9%) were age-1.2 fish from the 1998 brood year, 33.5% (SE = 3.1%) were age-1.3 fish, 37.0% (SE = 3.5%) were age-1.4 fish, and 0.6% (SE = 0.3%) were age-1.5 fish. Females constituted an estimated 47.7% (3,330 fish) of large spawners (SE = 2.0%) with an estimated 98% of these composed 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, Petersen model, peak survey counts, age and sex composition, mean length

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 1997a). 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 1997a). Peak 1987–1990 values of escapement were two to five times greater than the ‘baseline’ (1975–1980) values of the index. In the past three years, index counts have increased in all four systems, particularly in the Unuk and Chickamin rivers.

Several consecutive low survey counts in the early 1990s generated concern by 1992 for the health of the Behm Canal chinook stocks. In response, 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 smolt production and overwinter survival, adult escapement, run size, exploitation rates, harvest distribution, and marine survival. These goals are being accomplished by inriver adult escapement and coded-wire tagging projects and marine harvest sampling programs to recover coded-wire tags.

The current escapement goal for the Unuk River is 650–1,400 large fish counted in surveys, or about 3,000–7,000 large fish in the escapement (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 because of their size and color. For our purposes, chinook salmon ≥660 mm MEF are considered large and generally consist of fish 3-ocean age or older. Nearly all females in the spawning population are large in size. Chinook salmon 401 mm–659 mm MEF are considered medium-sized fish, and chinook salmon ≤400 mm MEF are considered small fish. Indices of escapement on the Unuk River are determined each year by summing peak counts of large spawners observed during aerial and foot surveys in six tributaries: Cripple, Gene’s Lake, Kerr, Clear, and Lake creeks plus the Eulachon River (Pahlke 1997a).

Mark-recapture studies were conducted in 1994, 1997-2001, a radiotelemetry study in 1994 (Jones et al. 1998; Jones and McPherson 1999, 2000, 2002; Pahlke et al. 1996; Weller and McPherson 2003), and annual aerial surveys

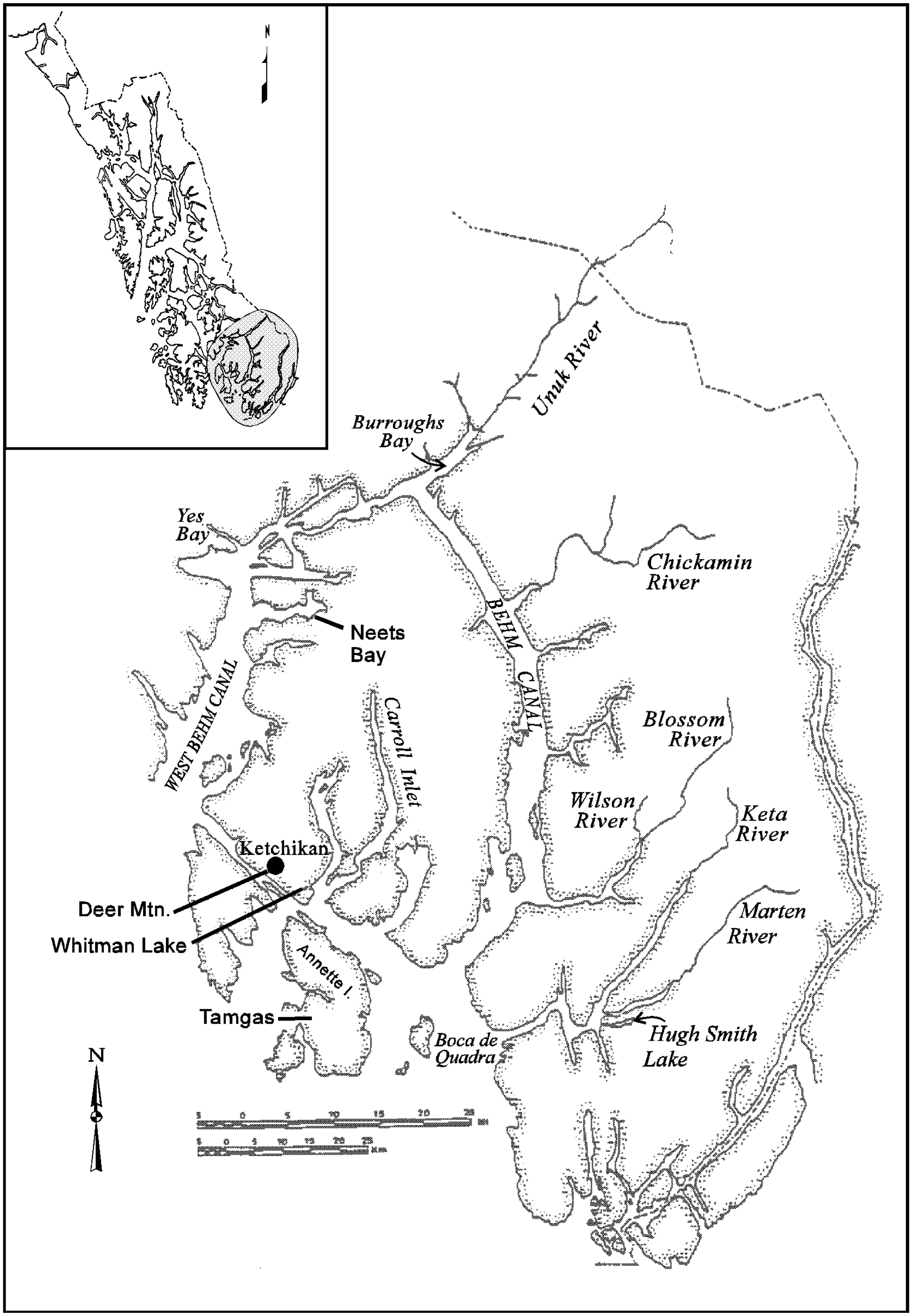

Figure 1.–Behm Canal area in Southeast Alaska and location of major chinook salmon systems and hatcheries.

beginning in 1977 (see Pahlke 2001). The radio-telemetry study indicated that 83% (SE = 9%) of all spawning occurred in the six tributaries surveyed. The mark-recapture experiments in 1994 and 1997 through 2001 estimated that an average of 5,344 large chinook salmon entered the river during those years with a range of 2,970 (1997) to 10,555 (2001). Survey counts during those years averaged 1,038 large chinook salmon, or 19.4% of the mark-recapture estimates, with a range of 636 (1997) to 2,019 (2001). The highest recorded survey count of 2,126 large fish occurred in 1986 (Pahlke 1997a). Average peak survey counts in the six index tributaries of the Unuk River from 1978–2002 are distributed as follows: Cripple Creek (413 fish, 37%), Gene's Lake Creek (327 fish, 30%), Eulachon River (187 fish, 17%), Clear Creek (96 fish, 9%), Kerr Creek (46 fish, 4%), and Lake Creek (33 fish, 3%). 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 2001).

Other studies on the Unuk River were based on coded-wire tags (CWTs) inserted in chinook salmon juveniles from the 1982–1986 brood years (Pahlke 1995). Indications from this research were 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 (about 15% counted) and an alternative expansion factor of 4.0 (25% of spawners counted).

Beginning in 1993, chinook salmon young-of-the-year (YOY) fingerlings were tagged with CWTs on the Unuk River. From 1993 through 2002, 357,025 chinook (fall) fingerlings have been tagged, with an annual average of 35,703 and a range of 13,789 (1993) to 61,915 (1997). Tagging of smolt commenced in the spring of 1994, and through 2002, 92,774 smolt have been tagged with an annual average of 10,308 and a range of 2,642 in 1994 to 17,119 smolt tagged in 1998 (Appendix A1).

The current stock assessment program of the adult escapement of chinook salmon in 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 sample escapement for the fraction of fish possessing CWTs by brood year. The results are essential for estimating the marked fraction of each brood with CWTs which will be used in turn to estimate harvest of this stock in current and future sport and commercial fisheries. These harvest and escapement data will enable us to estimate run size, exploitation rates, harvest distribution, and marine return rates for this stock of chinook salmon in southern Southeast Alaska.

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. Trapping efforts for juveniles indicate that a majority of chinook salmon from the stock rear in the U.S. portion of the river.

METHODS

A two-event mark-recapture experiment for a closed population was used to estimate the number of immigrant medium-sized and large chinook salmon to the Unuk River in 2002. Fish were captured using set gillnets in the lower river during event 1 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 11 August 2002. The set gillnets were 37 m (120 ft) long by 4 m (14 ft)

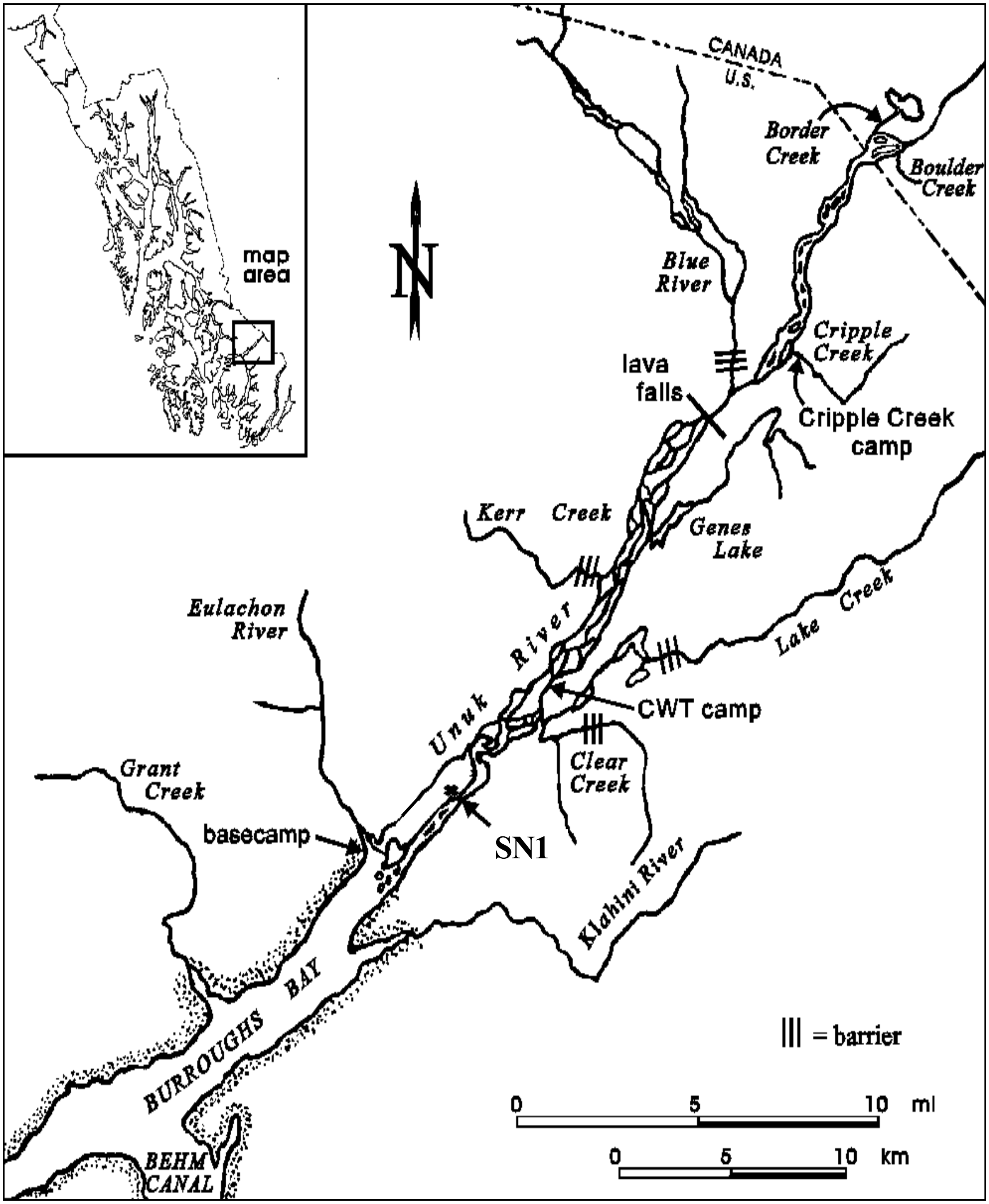

Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to chinook salmon migration, and location of ADF&G research sites.

deep with 18 cm (7¼") stretch mesh, with a loose-hanging ratio of about 2.2:1. One site (SN1) was used exclusively for set gillnets fishing in 2002 and has remained the same since 1997. This site (SN1) is located about 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 back-to-back shifts of personnel fished two set gillnets at SN1 (Figure 4) 12 hours per day, 6 days per week. Each crew shift was staggered across the week so that at least one crew fished each day of the week, conditions permitting. 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.

All fish captured, regardless of health, were sampled to determine age, sex, and length (ASL) prior to release. Length in MEF was measured to the nearest 5 mm, and sex was determined from secondary maturation characteristics. Five scales were taken about 1inch 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 that held scales from 10 fish, as described in ADF&G (1993). 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 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 adipose fins were given three different marks: a uniquely numbered solid-core spaghetti tag, a clip of the left axillary appendage (LAA), and a left upper operculum punch (LUOP) 0.63 cm (¼") in diameter then released. The two marks enable the detection of primary tag loss. The spaghetti tag consisted of a 5.71 cm (2¼") section of laminated Floy tubing shrunk onto a 38 cm (15") piece of 80-lb test monofilament fishing line. The monofilament was sewn through the back just behind the dorsal fin and secured by crimping both ends of the monofilament in a line crimp. 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 at Boundary Lake (also known as Border Lake), Clear, Cripple, Gene's Lake, Kerr, and Lake creeks, and the Eulachon River in 2002 (Figure 2). Various methods were used to capture these fish, including rod and reel, spear, dip net, 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; Jones et al. 1998; Jones and McPherson 1999, 2000, 2002). All inspected fish were marked with a punched hole in their left lower operculum (LLOP) the first time they were sampled to prevent double sampling. These fish were closely examined for the presence of the primary tag, the LUOP, the LLOP, and the LAA, for a missing adipose fin, and were sampled to obtain ASL data using the same techniques employed in the lower river. Foot survey were on each of the sampled tributaries were used to count fish 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-sized (401–659 mm MEF) and of large (≥660 mm MEF) fish was estimated separately so the estimate for large fish $\hat{N}_{lg}$ could be compared against counts from the aerial survey. Using Chapman's modification of the Petersen estimator (Seber 1982), estimated abundance ($\hat{N}_i$) for each group was calculated as

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

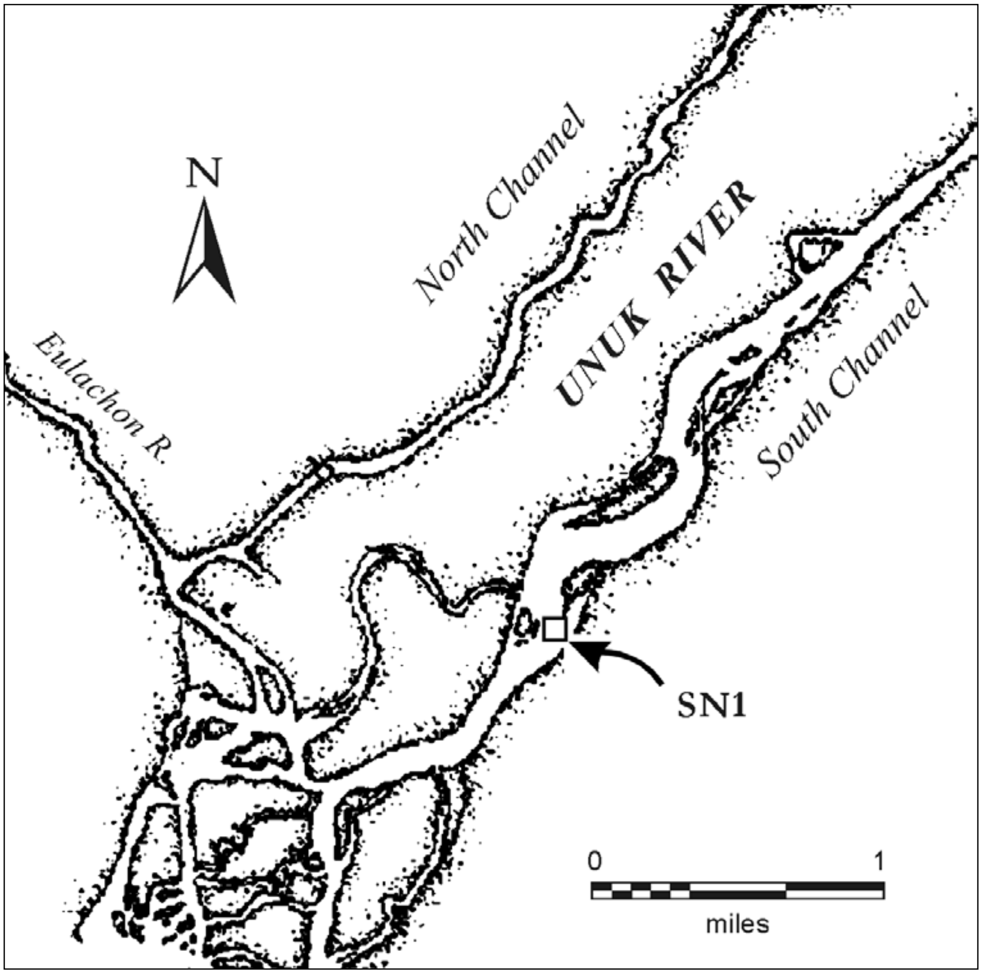

Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River in 2002.

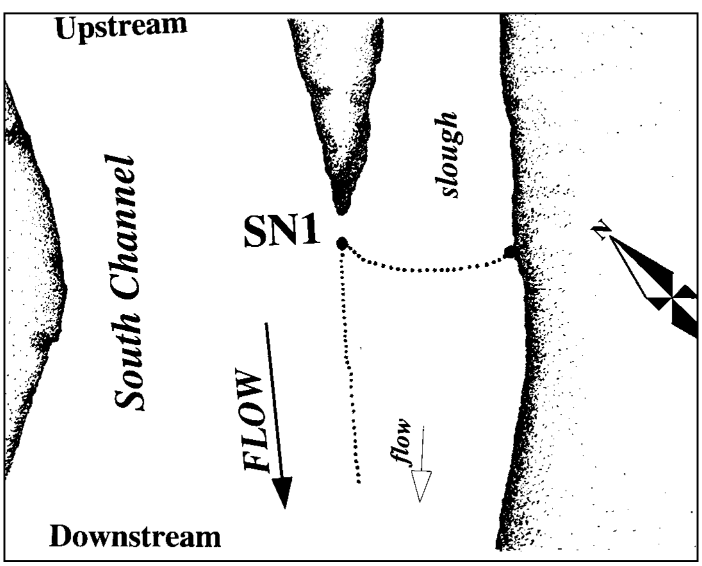

Figure 4.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River in 2002.

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 has an equal probability of being inspected for marks in event 2, or marked fish mix completely with unmarked fish in the population between events; and there is no recruitment to the population between events; and

(b) there is no tag-induced mortality; and

(c) fish do not lose their marks in the time between the two events and all marks are recognizable.

To provide evidence that condition *a* was met, two chi-square tests were performed: (1) for equal proportions of marks by capture area in event 2; and (2) equal probabilities of recapture in event 2 independent of the when fish had been tagged. If the null hypothesis of either test were 'accepted,' the pooled Petersen estimator (equation 1) would be used to model the mark-recapture data; otherwise a temporally or spatially stratified estimator would be employed. Tests were made separately using the SPAS software program (Arnason et al. 1996).

The possibility of size and sex-selective sampling was also investigated, because condition *a* encompasses how fish are captured as well as when or where. The hypothesis that fish of different sizes were captured with equal probability was tested using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.1$, Appendix A2). The possibility of sex-selective sampling was investigated using simple chi-squared analyses. 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 salmon, closed to recruitment (condition *b*). We were not able to test condition *c*; however, we were careful to not harm or stress fish and we did not mark obviously injured fish. Radiotelemetry studies in 1994 and 1996 have shown that chinook salmon survive and spawn using this type of capture method (Pahlke et al. 1996; Pahlke 1997b). The effect of tag loss (condition *d*) 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 $\hat{N}_i^*$, and 1,000 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.

AGE AND SEX COMPOSITION

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

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

with

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

where $\hat{p}_{ij}$ is the estimated proportion of the population of age *j* in sized 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 between 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:

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

and

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

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

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

and

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

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

Table 1.–Capture histories for medium-sized and large chinook salmon in the population spawning in the Unuk River in 2002 (notation explained in text)**.**

Capture history	Medium	Large	Source of statistics
Marked and not recaptured in tributaries	139	659	$M_i - R_i$
Marked and recaptured in tributaries	9	66	R_i
Not marked, but captured in tributaries	100	578	$C_i - R_i$
Not marked and not sampled in tributaries	1,390	5,685	$\hat{N}_i - M_i - C_i + R_i$
Effective population for simulations	1,638	6,988	$\hat{N}_i$

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 (π) for estimating abundance of large fish from peak counts from aerial surveys was estimated for 2002 as

$$\hat{\pi}_{2002} = \hat{N}_{lg} \big/ C_{2002} \quad (9)$$

$$\mathrm{var}(\hat{\pi}_{2002}) = \mathrm{var}(\hat{N}_{lg}) \big/ C_{2002}^2 \quad (10)$$

where C_{2002} is the peak count in 2002.

The mean expansion factor over all years ($\overline{\pi}$) was updated with information from 2002 as follows:

$$\overline{\pi} = Y^{-1} \sum_{y=1}^{Y} \hat{\pi}_y \quad (11)$$

where y is the calendar year and Y the number of years for which there are estimates of expansion factors (six for the Unuk River at present, from 1997 to 2002). Because uncertainty in expanding peak counts encompasses year-to-year variation in the factor, variance to represent that uncertainty was calculated as

$$\mathrm{var}(\pi) = \frac{\sum_{y=1}^{Y}\left(\hat{\pi}_y - \bar{\pi}\right)^2}{Y-1} \qquad (12)$$

For years with no direct estimates of abundance of large spawners, the indirect estimate from the expansion and its estimated variance can be calculated as:

$$\hat{N}_{lg,t} = \bar{\pi}C_t \qquad (13)$$

$$\mathrm{var}(\hat{N}_{lg,t}) = \mathrm{var}(\pi)C_t^2 \qquad (14)$$

where t is the calendar year without a direct estimate for large fish.

RESULTS

TAGGING, RECOVERY AND ABUNDANCE

Of 896 chinook salmon sampled in the lower river, 874 were tagged and released (Table 2); 95% of catches occurred between 19 June and 31 July. Six fish were considered unhealthy upon capture and were not tagged. Of the 874 fish tagged, none were small, 148 were medium-sized, and 725 were large. Seventy-three (73) fish sampled using gillnets were missing adipose fins; furthermore, 16 of these were sacrificed and the rest were tagged and released in good condition. Of the fish that were missing adipose fins and of those sacrificed, 62% and 94% were males, respectively.

In event 2, we sampled 757 fish: 2 were small, 109 were medium-sized, 644 large, and 2 were not measured for length. Of the 75 salmon recaptured (i.e., fish previously marked in event 1), none were small, 9 were medium-sized, and 66 were large. During event 2, we sampled 73 adipose finclipped fish, 53% of which were males. None

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 2002, by size group.

	Length (MEF)			
	0–400 mm	401–659 mm	>659 mm	Total [a]
Released in event 1 with marks (*M*)	0	148	725	874
Inspected at:				
1. Upriver [b]				
Inspected (*C*)	0	39	240	279
Recaptured (*R*)	0	4	27	31
Recaptured/captured		0.103	0.113	0.065
2. Downriver [c]				
Inspected (*C*)	2	70	404	478
Recaptured (*R*)	0	5	39	44
Recaptured/captured		0.071	0.097	0.092
Total Inspected				
Inspected (*C*)	2	109	644	757
Recaptured (*R*)	0	9	66	75
Recaptured/captured		0.083	0.102	0.099

[a] Totals include 1 fish released in event 1, and 2 fish inspected at Gene's Lake Creek without measurements.

[b] Includes Boundary and Cripple creeks.

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

of the 73 was small, 5 were medium-sized, and 68 were large salmon. Of the finclipped fish, 25 (5 medium-sized and 20 large) were post-spawn and were sacrificed to obtain a CWT. Primary tag loss was 15% for all recoveries and these fish were identified as being previously marked by the presence of the left upper operculum punch and a missing left axillary appendage. There was no instance of a secondary mark being unrecognizable.

Tests indicated size-selective sampling during event 1, but not during event 2. Length distributions of marked medium-sized, large, and medium-sized and large fish combined were not significantly different than length distributions for fish *recaptured* on the spawning grounds (P = 0.43, P = 0.62, and P = 0.99; Figures 5–7). Thus, sampling on the spawning grounds was not demonstrably size-selective, and the mark-recapture data did not require stratification. Length distributions of marked chinook salmon were not comparable to those fish *inspected* on the spawning grounds for medium-sized, large, and medium and large fish (P < 0.001, P = 0.05, P = 0.02); Figures 5–7). Since there was no selectivity in event 2, there must have been selectivity in event 1 (i.e., the set gillnets were less likely to catch fish at either end of the length continuum). Inspection of Figure 6 shows this phenomenon to be slight for large fish, perhaps not meaningful even if statistically significant. Nonetheless, only fish sampled on the spawning grounds were used to estimate length and age compositions of the escapement.

Chi-square tests suggested little evidence of gender selectivity between sampling events for medium (χ^2 = 1.67, df = 1, P = 0.20), large (χ^2 = 0.97, df = 1, P = 0.32), or medium and large chinook salmon combined (χ^2 = 0.36, df = 1, P = 0.55). The mark-recapture data did not therefore require stratification by gender.

Estimated abundance of large chinook salmon ($\hat{N}_{\lg}$) on the spawning grounds in 2002 was 6,988 (SE = 805) (Table 2). Results from tests relevant to condition (*a*) (Table 3) indicated that large chinook salmon marked early in the experiment (before July 18) and late in the experiment were equally likely to be recaptured (χ^2 = 1.27, df = 1, P = 0.26). Similarly, the recapture rate during event 2 did not significantly vary by sampling location (upriver versus downriver) (χ^2 = 0.01, df = 1, P = 0.93). From 1000 bootstrap samples, estimated statistical bias in $\hat{N}_{\lg}$ proved negligible (0.6%), and the 95% bootstrap confidence interval is 5,775 to 8,845 (Table 4).

Estimated abundance of medium-sized chinook salmon ($\hat{N}_{med}$) on the spawning grounds in 2002 was 1,638 (SE = 690) (Table 2). Medium-sized chinook salmon marked early and late in the experiment were equally likely to be recaptured (χ^2 = 0.06, df = 1, P = 0.81), and their recapture rate did not vary by sampling location (upriver versus down river) (χ^2 = 2.22, df = 1, P = 0.14). Estimated statistical bias from 1000 bootstrap samples was marginal (7.5%), and the 95% confidence interval was 1,017 to 3,331. Estimated abundance of all fish >400 mm MEF ($\hat{N} = \hat{N}_{med} + \hat{N}_{\lg}$) for 2002 is 8,626 (SE = 1,060).

ESTIMATES OF AGE AND SEX COMPOSITION

Age-1.2, age-1.3 and age-1.4 chinook salmon dominated the age compositions of fish >400 mm MEF sampled during event 2 on the spawning grounds (Appendix A3, Figure 8). Age-1.2 fish were 29% (SE = 5.9%), age-1.3 fish 34% (SE = 3.1%), and age-1.4 fish 37% (SE = 3.5%) of the escapement of medium and large fish; 61% (SE = 3.5%) of these were males (Table 5). Compared to the average estimated age composition of chinook salmon sampled during event 2 from 1997 through 2001, the 2002 spawning grounds sample was composed of approximately 12% more age-1.4 fish, 11% fewer age-1.3 fish, and only 14% of the five year average of age-1.1 chinook salmon (Appendix A4). There were an estimated 3,346 (SE = 408) spawning females in 2002 (Table 5).

Estimated average lengths by age and sex were similar between events 1 and 2 in 2002 (Table 6). The average length of age-1.4 fish, regardless of gender, was larger than those sampled from 1997 to 2001 (Appendix A5). Although the proportion of medium to large-sized fish was greater in event 1 than event 2, the set gillnets in event 1 caught significantly fewer fish under approxi-

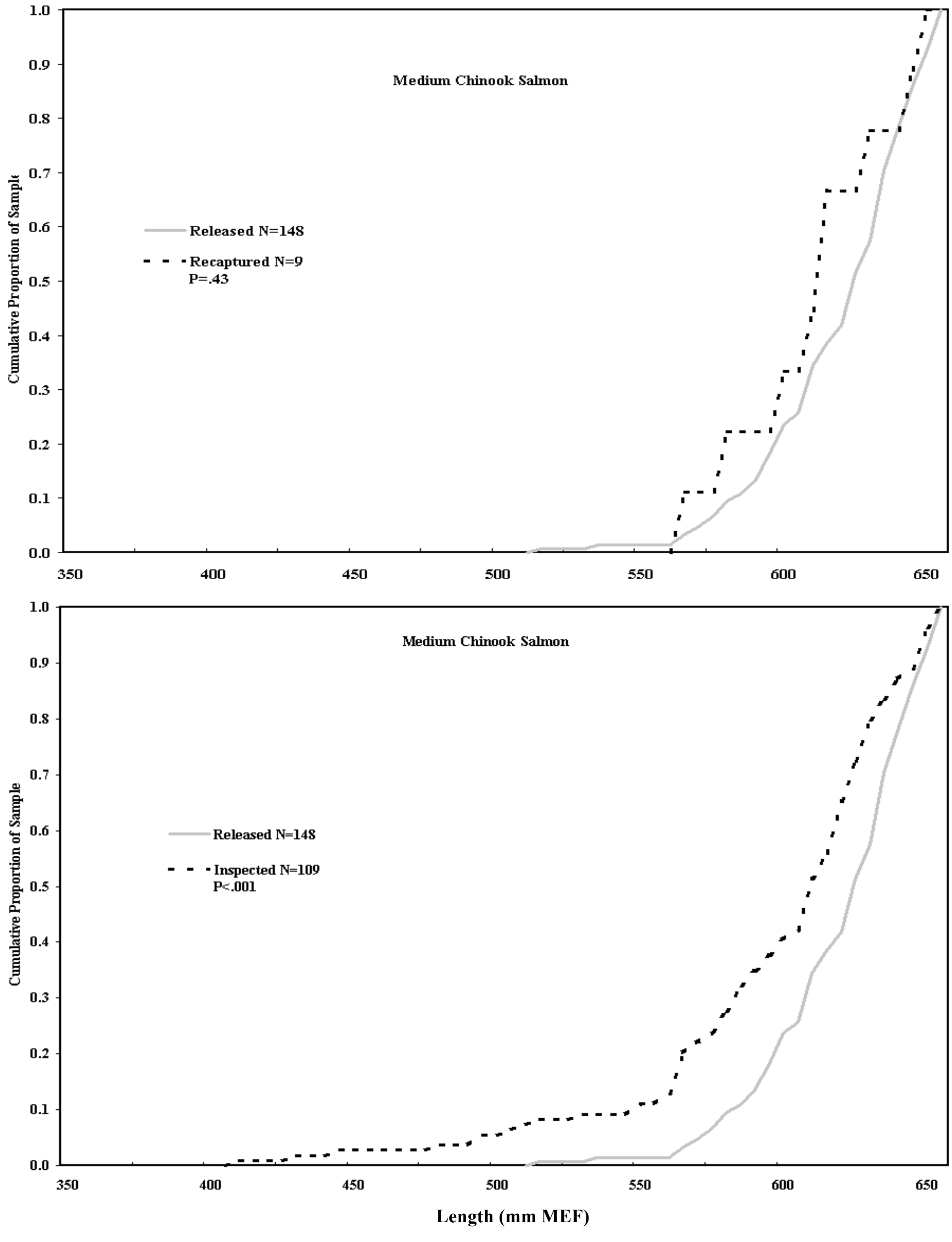

Figure 5.–Cumulative relative frequencies of medium chinook salmon (401–659 mm MEF) marked in the lower Unuk River in 2002 compared with those inspected and recaptured on the spawning grounds.

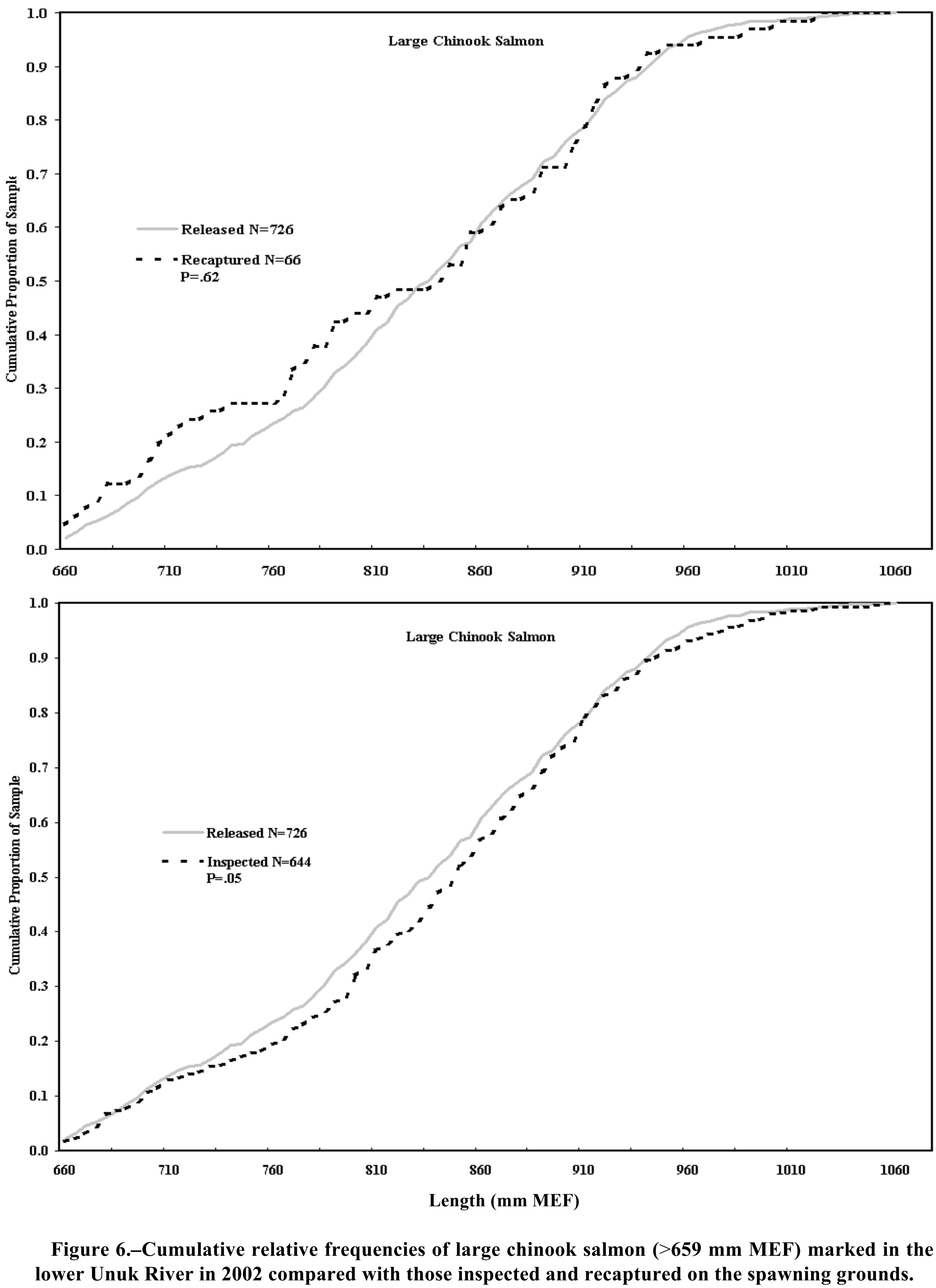

Figure 6.–Cumulative relative frequencies of large chinook salmon (>659 mm MEF) marked in the lower Unuk River in 2002 compared with those inspected and recaptured on the spawning grounds.

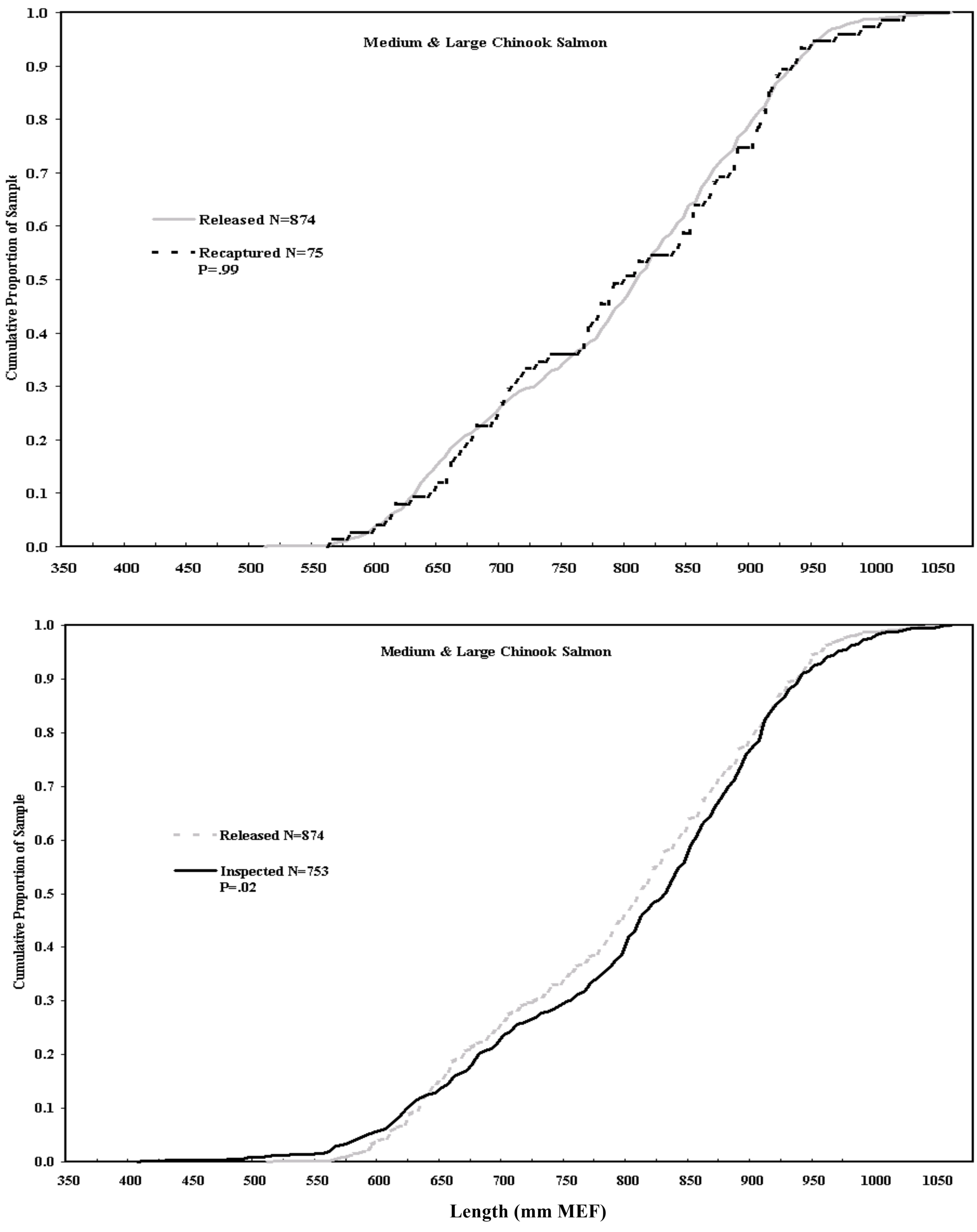

Figure 7.–Cumulative relative frequencies of medium and large chinook salmon combined (>400 mm MEF) marked in the lower Unuk River in 2002 compared with those inspected and recaptured on the spawning grounds.

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, 2002. 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 7/17	412	0.073	21	9	30
7/18 to 8/11	313	0.086	15	12	27
Total/proportion	725	0.079	36	21	57
Number inspected			404	240	644
Fraction marked			0.089	0.088	0.089
MEDIUM CHINOOK SALMON					
6/11 to 7/17	95	0.053	3	2	5
7/18 to 8/11	53	0.038	1	1	2
Total/proportion	148	0.047	4	3	7
Number inspected			70	39	109
Fraction marked			0.057	0.077	0.064

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

[b] Includes Boundary and Cripple creeks.

mately 620 mm MEF (Figure 6). Similarly, the age and length composition data indicate that the set gillnets used in event 1 also do not capture as great a proportion of the largest fish in the run as compared to event 2 (Table 5, Table 6). In general, the length data gathered in event 2 during spawning grounds sampling is most appropriate for length composition analysis, since using a multitude of gear types to gather samples has been shown to reduce bias in age, sex, and length sampling for chinook salmon (Jones and McPherson 1999).

EXPANSION FACTOR

Of the estimated 6,988 large chinook salmon immigrating in 2002 to the Unuk River, 897 (13%) were counted during peak survey counts. This percentage is lower than that of previous years, which ranged from 15% in 1994 to 23% in 2000 (Table 4). Using the 1997–2001 mark recapture estimates and peak survey counts; the mean expansion factor would therefore be 5.0 (SD = 0.53). The expansion factor for 1994 is not included because of the low relative precision of that estimate (54%) as compared to those from 1997 to 2001 (range of 18% in 1997 to 24% in 1999). The expansion factor for 2002 is also not included because of the relatively poor quality of the survey counts compared to those from previous years.

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). In 2002, 53 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 four days with a maximum period of over 25 days and a minimum of 35 minutes (Table 7). This rate does not appear to vary by length or age; however, a noticeable trend exists when examined by marking date. The "sulk" rate appears to be higher for fish marked earlier versus later in the project, and averaged 12.3 days for fish released in June, 2.9 days for fish released from 1-15 July, and 1.4 days for fish released 16-31 July (Figure 9). The degree to which a fish has completed the physiological

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 (1994, 1997–2002).**

	1994		1997		1998		1999		2000		2001		2002		Average 1997–2002	
	Medium	**Large**	**Medium**	**Large**	**Medium**	**Large**	**Medium**	**Large**	**Medium**	**Large**	**Medium**	**Large**	**Medium**	**Large**	**Medium**	**Large**
Survey count		711		636		840		680		1,341		2,019		897		1,069
m_2	0	10	16	78	15	79	13	50	8	69	3	74	9	66	11	69
n_1	15	161	75	307	87	466	125	380	128	570	71	778	148	725	106	538
n_2	38	313	156	761	217	707	251	523	158	719	74	1,014	109	644	161	728
Mark-recapture (M–R) estimate		4,623	701	2,970	1,198	4,132	2,267	3,914	2,278	5,872	769	10,541	1,638	6,988	1,475	5,736
SE (M–R)		1,266	158	277	290	413	602	490	968	644	124	1,181	690	805	472	635
Survey count/(M–R) (%)		15.4		21.4		20.3		17.4		22.8		19.2		12.8		18.5
CV (M–R) (%)		27.4	22.5	9.3	24.2	10.0	26.6	12.5	42.5	11.0	16.1	11.2	42.1	11.5	30.3	11.2
95% RP M–R estimate (%)		53.7	44.2	18.3	47.4	19.6	52.0	24.5	83.3	21.5	31.6	22.0	82.6	22.6	59.4	22.0
Expansion factor (EF) [a]		6.50		4.67		4.92		5.76		4.38		5.22		7.79		5.0
SD (EF) [a]		1.78		0.44		0.49		0.72		0.48		0.58		0.90		0.53
CV (EF) (%) [a]		27		9		10		13		11		11		12		11
95% RP (EF) (%) [a]		54		18		20		25		21		21		23		21
M–R lower 95% C.I.		2,992	489	2,499	815	3,433	1,506	3,110	1,358	4,848	557	8,705	1,017	5,775	957	4,728
M–R upper 95% C.I.		9,425	1,109	3,636	1,903	4,974	3,811	5,071	5,042	7,347	1,068	13,253	3,331	8,845	2,711	7,188
Estimated bias (%)			2.3	0.1	3.0	0.6	3.4	1.5	9.6	1.1	1.6	0.9	7.5	0.6	5.0	0.9

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

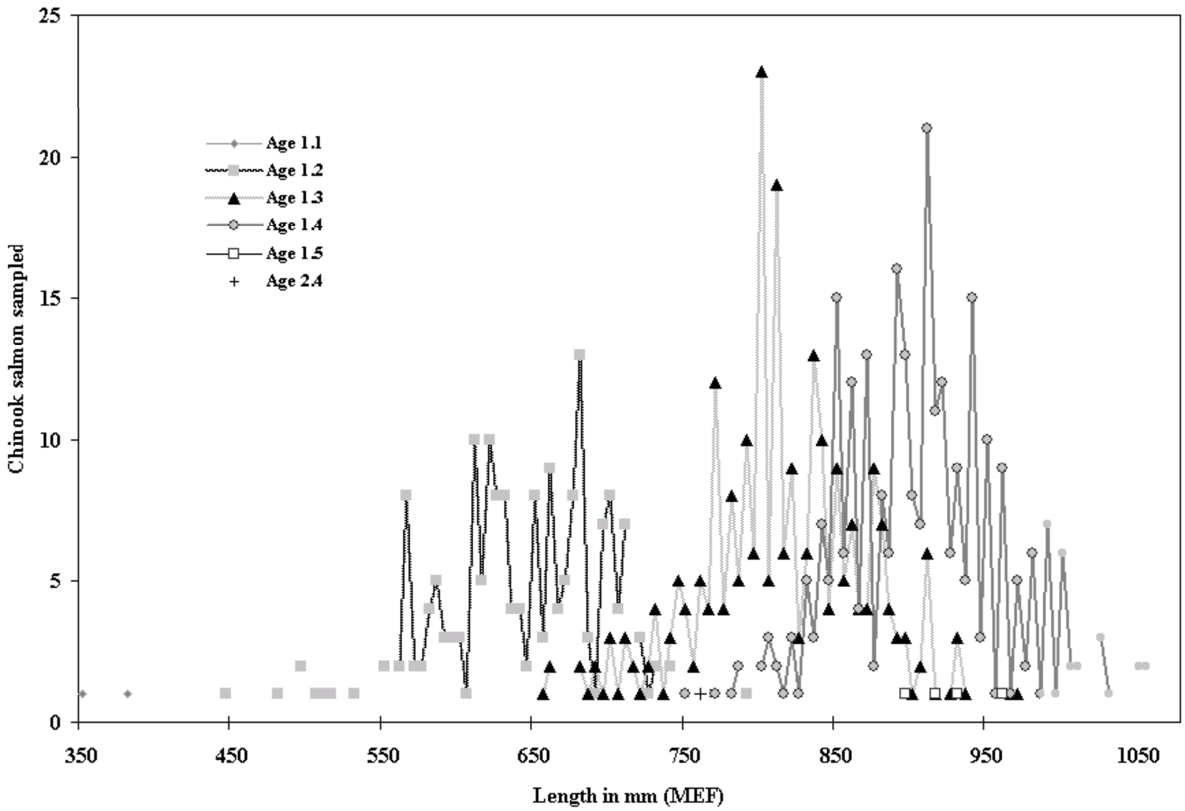

Figure 8.–Numbers of chinook salmon sampled by length and age at all seven tributary spawning sites sampled on the Unuk River in 2002.

changes necessary for changing from a marine to fresh water habitat and the time available between release and spawning events are likely to be prime factors determining sulk time. This phenomenon has been observed in other studies (Milligan et al. 1984; Johnson et al. 1992; Johnson 1993; Bendock and Alexandersdottir 1993; Eiler et al. *In prep*) and is consistent with results obtained during previous chinook salmon mark-recapture experiments on the Unuk River (Jones et al. 1998; Jones and McPherson 1999, 2000, 2002, Weller and McPherson 2003). Whereas this persistent behavior is largely handling-induced, no handling-induced behavior is involved with the phenomenon (Bernard et al. 1999).

Loss of primary tags was higher than in previous years. Of the 75 recaptures seen in event 2, 11 of these fish (15%) were missing their primary tag. The average rate of primary tag loss from 1997-2001 was 8% with a range of 3% observed in 1997 to 14% in 2000. This was likely a result of either applying too much pressure on the crimping tool, which can burn the monofilament leader and decrease its strength, or not enough pressure on the crimping tool resulting in an inadequate crimp. Of the 75 recaptured fish, 66 were large-sized with ten missing primary tags (15%) and nine were medium-sized with one missing primary tag (11%). In all cases, secondary marks were clearly visible on recaptured fish, once fish were in hand whether the tag was present or not.

Gillnets were selective toward bigger, medium-sized fish in 2002. This occurred in 1997 and 2000 when the age-1.1 fish were smaller than average, as was the case again this year. This year only two age-1.1 fish were captured during the mark-recapture study, both on the spawning grounds, and both small-sized fish. The small size of these two fish precluded their inclusion in the abundance estimate, however, and the estimated

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 2002 as determined from spawning grounds samples.**

		Brood year and age class						
		1999	1998	1997	1996	1995	1995	
		1.1	1.2	1.3	1.4	1.5	2.4	**Total**
PANEL A: AGE COMPOSITION OF MEDIUM CHINOOK SALMON								
Males	Sample size		104	1				105
	$\hat{p}_{ijk} \times 100$		98.1	0.9				99.1
	$SE(\hat{p}_{ijk}) \times 100$		1.3	0.9				0.9
	$\hat{N}_{ijk}$		1,607	15				1,623
	$SE(\hat{N}_{ijk})$		677	15				684
Females	Sample size		1					1
	$\hat{p}_{ijk} \times 100$		0.9					0.9
	$SE(\hat{p}_{ijk}) \times 100$		0.9					0.9
	$\hat{N}_{ijk}$		15					15
	$SE(\hat{N}_{ijk})$		15					15
Sexes combined	Sample size		105	1				106
	$\hat{p}_{ij} \times 100$		99.1	0.9				100.0
	$SE(\hat{p}_{ij}) \times 100$		0.9	0.9				
	$\hat{N}_{ij}$		1,623	15				1,638
	$SE(\hat{N}_{ij})$		684	15				690
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON								
Males	Sample size		76	152	105	2		335
	$\hat{p}_{ijk} \times 100$		11.9	23.8	16.4	0.3		52.3
	$SE(\hat{p}_{ijk}) \times 100$		1.3	1.7	1.5	0.2		2.0
	$\hat{N}_{ijk}$		830	1,660	1,146	22		3,658
	$SE(\hat{N}_{ijk})$		130	224	167	16		443
Females	Sample size		3	111	187	3	1	305
	$\hat{p}_{ijk} \times 100$		0.5	17.3	29.2	0.5	0.2	47.7
	$SE(\hat{p}_{ijk}) \times 100$		0.3	1.5	1.8	0.3	0.2	2.0
	$\hat{N}_{ijk}$		33	1,212	2,042	33	11	3,330
	$SE(\hat{N}_{ijk})$		19	174	266	19	11	407

-continued-

Table 5.–(Page 2 of 2).

		Brood year and age class						
		1999	1998	1997	1996	1995	1995	
		1.1	1.2	1.3	1.4	1.5	2.4	**Total**
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON (continued)								
Sexes combined	Sample size		79	263	292	5	1	640
	$\hat{p}_{ij} \times 100$		12.3	41.1	45.6	0.8	0.2	100
	$SE(\hat{p}_{ij}) \times 100$		1.3	1.9	2.0	0.3	0.2	
	$\hat{N}_{ij}$		863	2,872	3,188	55	11	6,988
	$SE(\hat{N}_{ij})$		134	357	392	25	11	805
PANEL C: AGE COMPOSITION OF MEDIUM AND LARGE CHINOOK SALMON								
Males	Sample size		180	153	105	2		440
	$\hat{p}_{ik} \times 100$		28.3	19.4	13.3	0.3		61.2
	$SE(\hat{p}_{ik}) \times 100$		4.1	1.7	1.4	0.2		2.7
	$\hat{N}_{jk}$		2,437	1,675	1,146	22		5,280
	$SE(\hat{N}_{jk})$		690	225	167	16		815
Females	Sample size		4	111	187	3	1	306
	$\hat{p}_{ik} \times 100$		0.6	14.1	23.7	0.4	0.1	38.8
	$SE(\hat{p}_{ik}) \times 100$		0.3	1.5	2.0	0.2	0.1	2.7
	$\hat{N}_{jk}$		48	1,212	2,042	33	11	3,346
	$SE(\hat{N}_{jk})$		25	174	266	19	11	408
Sexes combined	Sample size		184	264	292	5	1	746
	$\hat{p}_{j} \times 100$		28.8	33.5	37.0	0.6	0.1	100
	$SE(\hat{p}_{j}) \times 100$		4.1	2.4	2.6	0.3	0.1	
	$\hat{N}_{j}$		2,485	2,887	3,188	55	11	8,626
	$SE(\hat{N}_{j})$		697	358	392	25	11	1,060

Table 6.–Estimated average length (mm MEF) **by age, sex and sampling event of chinook salmon sampled in the Unuk River in 2002.**

		Brood year and age class									
		1999	1999	1998	1997	1997	1997	1996	1995	1995	
		0.2	1.1	1.2	0.4	1.3	2.2	1.4	1.5	2.4	**Total**
PANEL A: EVENT 1, LOWER UNUK RIVER SET GILLNET											
Males	Sample size	1		239	1	195	1	73	1		511
	Avg. length	570		649	905	790	670	919	940		742
	SD			45		64		67			113
	SE			3		5		8			5
Females	Sample size			8		158		203			369
	Avg. length			636		819		906			863
	SD			44		47		46			71
	SE			16		4		3			4
Sexes combined	Sample size	1		247	1	353	1	276	1		880
	Avg. length	570		649	905	803	670	909	940		793
	SD			45		59		52			114
	SE			3		3		3			4
PANEL B: EVENT 2, SPAWNING GROUNDS											
Males	Sample size		2	180		153		105	2		442
	Avg. length		368	639		802		921	928		763
	SD		18	56		65		66	46		132
	SE		13	4		5		6	33		6
Females	Sample size			4		111		187	3	1	306
	Avg. length			671		826		895	955	760	867
	SD			49		42		47	57		61
	SE			25		4		3	33		3
Sexes combined	Sample size		2	184		264		292	5	1	748
	Avg. length		368	640		812		904	944	760	805
	SD		18	56		58		56	49		120
	SE		13	4		4		3	22		4

Table 7.–Chinook salmon released and recaptured during event 1 in the lower Unuk River in 2002 and the elapsed time between release and recapture.

Tag no.	Release date and time	Recapture date/time	Sulking period	Day	Hr	Min
4124	06/18/02 15:45	07/07/02 16:30	19 days, 0 hours, and 45 minutes	19	0	45
4126	06/19/02 10:40	07/04/02 09:00	14 days, 22 hours, and 20 minutes	14	22	20
4131	06/19/02 17:50	06/28/02 10:40	8 days, 16 hours, and 50 minutes	8	16	50
4150	06/22/02 17:31	07/08/02 16:15	15 days, 22 hours, and 44 minutes	15	22	44
4152	06/22/02 17:53	07/07/02 12:55	14 days, 19 hours, and 2 minutes	14	19	2
5013	06/27/02 10:08	07/06/02 07:02	8 days, 20 hours, and 54 minutes	8	20	54
5014	06/27/02 10:30	07/03/02 17:25	6 days, 6 hours, and 55 minutes	6	6	55
5019	06/27/02 17:40	07/22/02 17:43	25 days, 0 hours, and 3 minutes	25	0	3
5030	06/29/02 07:00	07/06/02 13:30	7 days, 6 hours, and 30 minutes	7	6	30
5033	06/30/02 11:45	07/02/02 11:30	1 day, 23 hours, and 45 minutes	1	23	45
5044	07/01/02 15:25	07/07/02 07:55	5 days, 16 hours, and 30 minutes	5	16	30
5047	07/01/02 18:04	07/16/02 19:10	15 days, 1 hour, and 6 minutes	15	1	6
5014	07/03/02 17:25	07/07/02 12:50	3 days, 19 hours, and 25 minutes	3	19	25
5065	07/06/02 06:30	07/06/02 10:50	0 days, 4 hours, and 20 minutes		4	20
5082	07/07/02 06:50	07/11/02 07:31	4 days, 0 hours, and 41 minutes	4	0	41
4124	07/07/02 16:30	07/08/02 10:40	0 days, 18 hours, and 10 minutes		18	10
5115	07/08/02 10:33	07/09/02 08:06	0 days, 21 hours, and 33 minutes		21	33
5149	07/08/02 18:05	07/09/02 12:45	0 days, 18 hours, and 40 minutes		18	40
5156	07/09/02 08:05	07/09/02 10:15	0 days, 2 hours, and 10 minutes		2	10
5168	07/09/02 14:35	07/15/02 16:30	6 days, 1 hour, and 55 minutes	6	1	55
6821	07/11/02 12:07	07/12/02 10:59	0 days, 22 hours, and 52 minutes		22	52
6847	07/12/02 10:58	07/15/02 09:50	2 days, 22 hours, and 52 minutes	2	22	52
6861	07/13/02 06:42	07/13/02 18:20	0 days, 11 hours, and 38 minutes		11	38
6865	07/13/02 07:00	07/17/02 16:00	4 days, 9 hours, and 0 minutes	4	9	0
10410	07/14/02 17:15	07/15/02 15:50	0 days, 22 hours, and 35 minutes		22	35
10412	07/15/02 06:00	07/15/02 10:33	0 days, 4 hours, and 33 minutes		4	33
10423	07/15/02 13:00	07/18/02 13:35	3 days, 0 hours, and 35 minutes	3	0	35
10438	07/15/02 18:20	07/16/02 19:25	1 day, 1 hour, and 5 minutes	1	1	5
10447	07/16/02 06:43	07/19/02 06:10	2 days, 23 hours, and 27 minutes	2	23	27
10492	07/16/02 19:00	07/19/02 10:00	2 days, 15 minutes, and 0 minutes	2	15	0
11895	07/17/02 05:35	07/17/02 06:10	0 days, 0 hours, and 35 minutes			35
11913	07/17/02 08:15	07/20/02 14:15	3 days, 6 hours, and 0 minutes	3	6	0
11967	07/17/02 18:23	07/18/02 11:45	0 days, 17 hours, and 22 minutes		17	22
2045	07/19/02 12:36	07/19/02 19:05	0 days, 6 hours, and 29 minutes		6	29
2049	07/19/02 13:20	07/25/02 16:40	6 days, 3 hours, and 20 minutes	6	3	20
2056	07/19/02 16:53	07/20/02 14:41	0 days, 21 hours, and 48 minutes		21	48
2073	07/20/02 05:32	07/20/02 06:25	0 days, 0 hours, and 53 minutes			53
2087	07/20/02 07:40	07/20/02 10:20	0 days, 2 hours, and 40 minutes		2	40
2099	07/20/02 10:53	07/22/02 15:35	2 days, 4 hours, and 2 minutes	2	4	42
2136	07/22/02 09:56	07/22/02 10:50	0 days, 0 hours, and 54 minutes			54
2148	07/22/02 13:46	07/22/02 15:30	0 days, 1 hour, and 44 minutes		1	44
2173	07/23/02 07:50	07/24/02 14:45	1 day, 6 hours, and 55 minutes	1	6	55
2203	07/24/02 11:55	07/27/02 06:25	2 days, 6 hours, and 30 minutes	2	6	30
2237	07/27/02 07:20	07/28/02 18:01	1 day, 10 hours, and 41 minutes	1	10	41
2241	07/27/02 10:35	07/30/02 06:26	2 days, 19 hours, and 51 minutes	2	19	51
2246	07/28/02 07:03	07/29/02 11:48	1 day, 4 hours, and 45 minutes	1	4	45
2247	07/28/02 07:26	07/28/02 16:07	0 days, 8 hours, and 41 minutes		8	41
2249	07/28/02 09:00	07/29/02 08:35	0 days, 23 hours, and 35 minutes		23	35
2250	07/28/02 09:25	07/31/02 09:40	3 days, 0 hours, and 15 minutes	3	0	15
2237	07/28/02 18:01	07/30/02 13:00	1 day, 19 hours, and 1 minute	1	19	1
2269	07/29/02 07:36	07/30/02 06:40	0 days, 23 hours, and 4 minutes		23	4
2269	07/30/02 06:40	07/30/02 15:12	0 days, 8 hours, and 32 minutes		8	32
2250	07/31/02 09:40	07/31/02 10:39	0 days, 0 hours, and 59 minutes			59

Average = 4 days, 0 hours, 57 minutes; maximum = 25 days, 0 hours, 3 minutes; minimum = 0 days, 0 hours, 35 minutes.

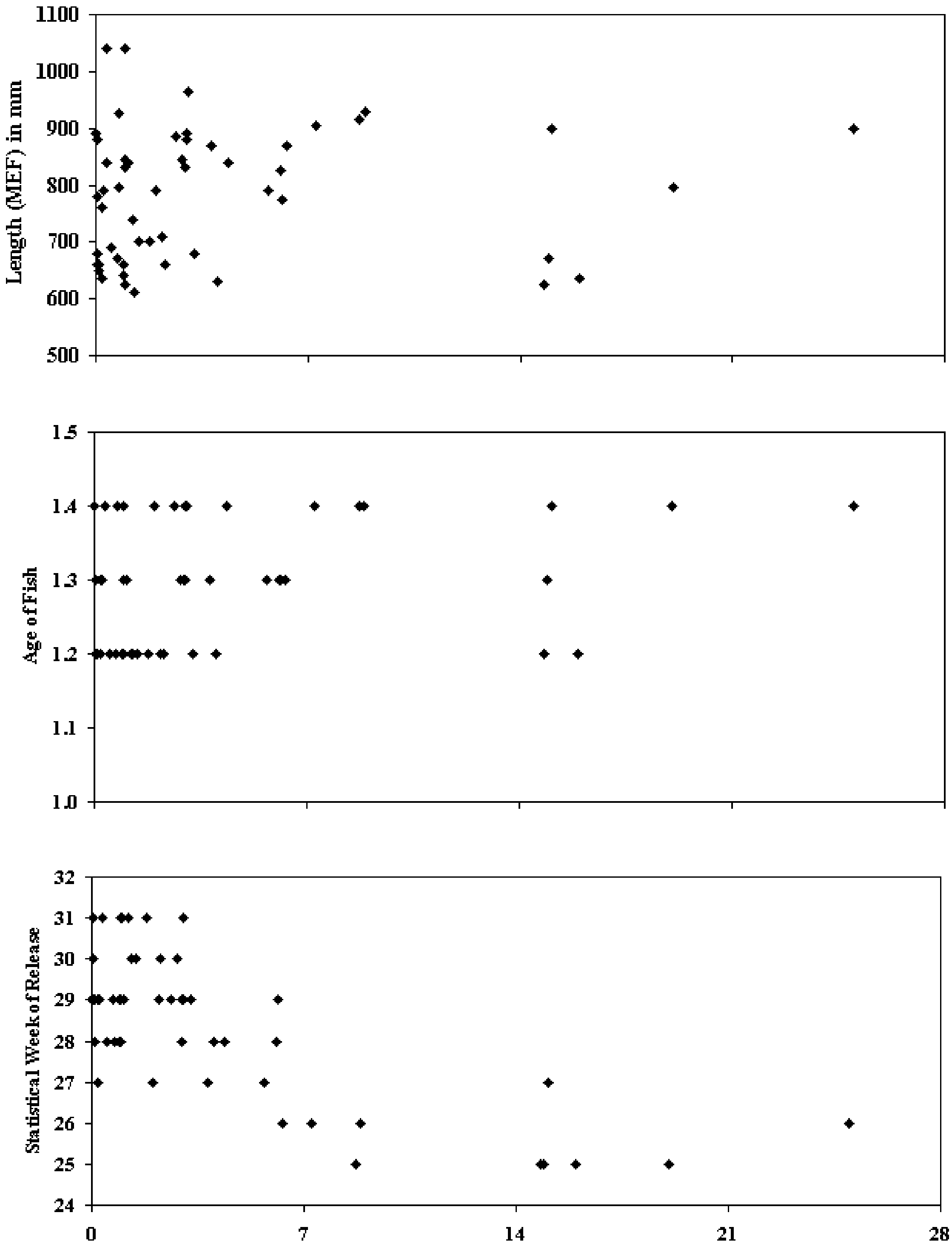

Figure 9.–The elapsed time between release and recapture of chinook salmon caught multiple times in the lower Unuk River set gillnets in 2002 by date of release, fish length, and age of fish.

contribution of age-1.1 fish to the 2002 escapement was zero for the first time in the seven years of this study. The average size of age-1.2 fish captured at the set gillnets was 10 mm (MEF) greater than those caught during spawning grounds sampling. The results of the K-S test for medium-sized fish captured on the spawning grounds versus those marked at the set gillnet clearly illustrate that the set gillnets were relatively ineffective at capturing small medium-sized fish.

By using a variety of sampling techniques such as rod and reel snagging, lure fishing, gillnets, dipnets, and carcass sampling on the spawning grounds, we were again successful in avoiding size and sex-selective sampling, even under difficult conditions. McPherson et al. (1997) found that using a variety of gear types reduced bias in age, sex, and length composition estimates. The proportion of spawning ground samples collected by spear and carcass sampling in 2002 was much lower than in previous years of this study (Table 8). Persistently high water levels during the month of August caused carcasses and post-spawning fish in weakened condition to be quickly flushed out of spawning tributaries and thus unavailable for sampling.

As in previous years, the estimated abundance of large fish was considerably greater than corresponding estimates obtained from the peak survey counts. Observer bias resulting in underestimation of 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; Jones et al. 1998; Jones and McPherson 1999, 2000, 2002) and of salmon in general (Jones 1995). This year, about 13% (897) of the estimated 6,988 large fish immigrating to the Unuk River were counted in the peak survey count. This percentage is the lowest obtained in the seven years of this study (Table 4) (Pahlke et al. 1996; Jones et al. 1998; Jones and McPherson 1999, 2000, 2002; Weller and McPherson 2003). Aerial and foot surveys yielded relatively low counts, primarily because of poor survey conditions (high water), similar to those encountered during 1994 surveys (Pahlke et al. 1996). In addition, foot surveys of Cripple Creek where historically the largest number of fish have been counted, were delayed past the time of peak spawning because of logistical and personnel problems in addition to high water.

Table 8.–Proportions of Unuk River chinook salmon sampled, by gear type, on the spawning grounds, 1997–2002.

	1997	1998	1999	2000	2001	2002
Carcass	0.06	0.07	0.12	0.01	0.12	0.01
Dipnet	0.07	0.05				0.01
Lure	0.01		0.06	0.03		0.05
Gillnet	0.09	0.61	0.05			0.23
Snag	0.65	0.25	0.47	0.75	0.75	0.64
Spear	0.12	0.02	0.30	0.20	0.12	
Other						0.07

This study is one part of a program to estimate run size, exploitation rate, harvest distribution, marine survival, and other population parameters for Unuk River stock. Between 3% and 13% of the smolt have been tagged each year with CWTs since the fall of 1993 (1992 brood year, Appendices A1, A6). Analysis of these data is proceeding, and a manuscript describing production for the 1993 to 1997 brood years is in progress. Preliminary results suggest production of fingerlings has ranged between 255,000 to 759,000 with juvenile overwinter survival ranging from 34% to 81%. The estimated number of smolt emigrating from the Unuk River has ranged from 197,000 to 492,000 and preliminary marine harvest estimates suggest that an average of 1,323 chinook salmon were harvested annually from 1998 to 2002.

The estimated number of age-1.4 fish in the overall escapement (3,188) was greater than that seen in five of the six previous years of the mark-recapture study (Pahlke et al 1996; Appendix A4) and only slightly less than the estimated 3,307 age-1.4 fish observed in 2002. Abundance of the 1996 brood year was high across ages, contributing an estimated 211 age-1.1, 2,491 age-1.2, and 6,778 age-1.3 fish to the 1999–2001 escapements respectively, each representing the largest contribution by age class observed during this study (1994, 1997–2002)

(Pahlke et al 1996; Appendix A4). Preliminary results indicate that of the 1992–1998 brood years, the 1996 brood year produced the largest estimated fingerling population (759,000; 7-year average equals 529,000) and largest estimated smolt population (492,000; 7-year average equals 337,000), and experienced slightly below average overwinter survival (65% as opposed to the 7-year average of 67%).

CONCLUSION AND RECOMMENDATIONS

Because this project will continue through 2003, 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. Fish should continue to be captured at SN1, because this site 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. This year, an unusually high number of fish lost their primary tags (15%). This was likely the result of poor crimping during the tagging procedure, and effort should be made to ensure that crimps are applied correctly. We recommend that surveys (particularly on Cripple Creek) continue in a manner similar to those in the past and that observers attempt to maintain consistency in counting efficiency from year to year. Further, we recommend that more effort be applied to foot surveys to increase the probability of performing a survey during the period of peak abundance. Finally, the age, sex, and length composition estimates from previous years of study have been relatively unbiased, which can be primarily attributed to using several types of capture gear during sampling on the spawning grounds. We will continue this practice in future years.

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APPENDIX A

Appendix A1.–Numbers of Unuk River chinook salmon fall fry and spring smolt captured and tagged with coded-wire tags, 1992 brood year to present.

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**
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 Brood year total					54,697	**54,546**

Appendix A2.–Detection of size-selectivity in sampling and its effects on estimation of size composition.

Results of hypothesis tests (K-S and χ^2) on lengths of fish MARKED during event 1 and RECAPTURED during event 2	Results of hypothesis tests (K-S) on lengths of fish CAPTURED during event 1 and CAPTURED during the event 2
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

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

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

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

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

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

Appendix A3.–Numbers by sex and age for chinook salmon sampled on the Unuk River spawning grounds in 2002 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									
				1999	1999	1998	1997	1997	1997	1996	1995	1995	
Location	**Size**	**Sex**		0.2	1.1	1.2	0.4	1.3	2.2	1.4	1.5	2.4	**Total**
PANEL A: EVENT 2 SAMPLES BY LOCATION													
		Males	#			6		3		1			10
			%			37.5		18.8		6.3			62.5
Boundary Creek	Medium- and large-	Females	#					3		3			6
	sized		%					18.8		18.8			37.5
		Total	#			6		6		4			16
			%			37.5		37.5		25.0			100
		Males	#			14		26		16	1		57
			%			15.4		28.6		17.6	1.1		62.6
Clear Creek	Medium- and large-	Females	#			2		11		21			34
	sized		%			2.2		12.1		23.1			37.4
		Total	#			16		37		37	1		91
			%			17.6		40.7		40.7	1.1		100
		Males	#			72		61		17			150
			%			27.7		23.5		6.5			57.7
Cripple Creek [a]	Medium- and large-	Females	#					51		58		1	110
	sized		%					19.6		22.3		0.4	42.3
		Total	#			72		112		75		1	260
			%			27.7		43.1		28.8		0.4	100
		Males	#			13		7		9			29
			%			20.0		10.8		13.9			44.6
Eulachon	Medium- and large-	Females	#					12		23	1		36
	sized		%					18.5		35.4	1.5		55.4
		Total	#			13		19		32	1		65
			%			20.0		29.2		49.2	1.5		100
		Males	#		2	65		33		40			140
			%		0.9	27.9		14.2		17.2			60.1
Gene's Lake Creek [b]	Medium- and large-	Females	#			2		28		63			93
	sized		%			0.9		12.0		27.0			39.9
		Total	#		2	67		61		103			233
			%		0.9	28.8		26.2		44.2			100
		Males	#			3		10		13			26
			%			7.0		23.3		30.2			60.5
Lake Creek [c]	Medium- and large-	Females	#					3		13	1		17
	sized		%					7.0		30.2	2.3		39.5
		Total	#			3		13		26	1		43
			%			7.0		30.2		60.5	2.3		100

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				Brood year and age class									
				1999	1999	1998	1997	1997	1997	1996	1995	1995	
Gear type	**Size**	**Sex**		0.2	1.1	1.2	0.4	1.3	2.2	1.4	1.5	2.4	**Total**
PANEL B: EVENT 2 SAMPLES BY GEAR [d]													
		Males	#			2		2		1			5
			%			18.2		18.2		9.1			45.5
Carcass	Medium- and large-sized	Females	#					3		3			6
			%					27.3		27.3			54.5
		Total	#			2		5		4			11
			%			18.2		45.5		36.4			100
		Males	#			1		2		1			4
			%			25.0		50.0		25.0			100
Dipnet	Medium- and large-sized	Females	#										
			%										
		Total	#			1		2		1			4
			%			25.0		50.0		25.0			100
		Males	n			7		9		6			22
			%			20.6		26.5		17.6			64.7
Rod and reel lure	Medium- and large-sized	Females	#			1		3		8			12
			%			2.9		8.8		23.5			35.3
		Total	#			8		12		14			34
			%			23.5		35.3		41.2			100
		Males	#		2	117		106		59	1		285
			%		0.4	24.5		22.2		12.4	0.2		59.7
Rod and reel snag	Medium- and large-sized	Females	#			1		70		117	3	1	192
			%			0.2		14.7		24.5	0.6	0.2	40.3
		Total	#		2	118		176		176	4	1	477
			%		0.4	24.7		36.9		36.9	0.8	0.2	100
		Males	#			43		25		31			99
			%			25.1		14.6		18.1			57.9
Gillnet	Medium- and large-sized	Females	#			1		25		46			72
			%			0.6		14.6		26.9			42.1
		Total	#			44		50		77			171
			%			25.7		29.2		45.0			100
		Males	#			10		9		7	1		27
			%			19.6		17.6		13.7	2.0		52.9
Other/unknown	Medium- and large-sized	Females	#			7		4		13			24
			%			13.7		7.8		25.5			47.1
		Total	#			17		13		20	1		51
			%			33.3		25.5		39.2	2.0		100

-continued-

Appendix A3.–(Page 3 of 3).

				Brood year and age class									
				1999	1999	1998	1997	1997	1997	1996	1995	1995	
Location	**Size**	**Sex**		0.2	1.1	1.2	0.4	1.3	2.2	1.4	1.5	2.4	**Total**
PANEL C: EVENT 2 ALL TRIBUTARIES COMBINED													
	Medium-sized	Males	#			104		1					105
			%			98.1		0.9					99.1
		Females	#			1							1
			%			0.9							0.9
		Total	#			105		1					106
			%			99.1		0.9					100
Spawning grounds [e]	Large-sized	Males	#			77		151		105	2		335
			%			12.0		23.4		16.4	0.3		52.3
		Females	#			3		111		187	3	1	305
			%			0.5		27.3		29.2	0.5	0.2	47.7
		Total	#			80		262		292	5	1	640
			%			12.5		40.9		45.6	0.8	0.2	100
	Medium- and large-sized	Males	#			181		152		105	2		440
			%			24.3		20.4		14.1	0.3		59.0
		Females	#			4		111		187	3	1	306
			%			0.5		14.9		25.1	0.4	0.1	41.0
		Total	#			185		263		292	5	1	746
			%			24.8		35.3		39.1	0.7	0.1	100
PANEL D: EVENT 1 LOWER UNUK RIVER SET GILLNET SAMPLES													
	Medium-sized	Males	#	1		145		5					151
			%	0.6		92.9		3.2					96.8
		Females	#			5							5
			%			3.2							3.2
		Total	#	1		150		5					156
			%	0.6		96.2		3.2					100
Setnet 1 (SN1)	Large-sized	Males	#			94	1	190	1	73	1		360
			%			13.0	0.1	26.2	0.1	10.1	0.1		49.7
		Females	#			3		158		203			364
			%			0.4		21.8		28.0			50.3
		Total	#			97	1	348	1	276	1		724
			%			13.4	0.1	48.1	0.1	38.1	0.1		100
	Medium- and large-sized	Males	#	1		239	1	195	1	73	1		511
			%	0.1		27.2	0.1	22.2	0.1	8.3	0.1		58.1
		Females	#			8		158		203			369
			%			0.9		18.0		23.1			41.9
		Total	#	1		247	1	353	1	276	1		880
			%	0.1		28.1	0.1	40.1	0.1	31.4	0.1		100

[a] Excludes 2 male and 1 female chinook salmon sampled at Cripple Creek of unknown age.

[b] Excludes 2 Genes Lake male chinook salmon of unknown age, 1 female of unknown length, and 1 chinook of unknown gender.

[c] Excludes 1 Lake Creek male chinook salmon of unknown age.

[d] No ages available for 4 snagged male and 1 snagged female chinook salmon, 1 male captured by gillnet, and 1 female captured using rod and reel lure gear. Excludes 1 snagged female chinook of unknown length and 1 chinook of unrecorded gender.

[e] Includes 2 age-1.1 small-sized chinook salmon; excludes 2 chinook salmon of unknown length and 7 of unknown age.

Appendix A4.–Estimated annual escapement of chinook salmon in the Unuk River by age class and sex, 1997–2002.

		AGE CLASS							
Year		1.1	1.2	2.2	1.3	1.4	1.5	2.4	Total
	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		59.6
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	29.4	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	97	1,698	2	1,820	616	15		4,247
1997–2002	%	1.3	23.5	0.0	25.2	8.5	0.2		58.8
average	Female		23		1,450	1,463	26	11	2,973
annual	%		0.3		20.1	20.3	0.4	0.2	41.2
estimated	Total	97	1,720	2	3,270	2,080	41	11	7,221
escapement	%	1.3	23.8	0.0	45.3	28.8	0.6	0.2	100.0

Appendix A5.–Estimated average length (mm MEF) by age, sex, and sampling event of chinook salmon sampled in the Unuk River, 1997–2002.

Age	Sex		Year 1997[a]	1998[b]	1999	2000	2001	2002[c]	Average
			PANEL A: EVENT 1 LOWER UNUK RIVER SET GILLNET SAMPLES						
Age-1.1	Males	#		5	3		10		3
		Avg. length		447	493		402		430
		SD		20	28		23		41
		SE		9	16		7		24
	Females	#	--------------------- none ---------------------------						
	Total	#		5	3		10		3
		Avg. length		447	493		402		430
		SD		20	28		23		41
		SE		9	16		7		24
Age-1.2	Males	#	85	103	178	275	96	239	163
		Avg. length	636	621	640	655	633	649	643
		SD	46	46	42	42	49	45	110
		SE	5	4	3	3	5	3	9
	Females	#	1	2	1	11	6	8	5
		Avg. length	675	695	710	654	683	636	661
		SD		49		35	15	44	76
		SE		35		11	6	16	35
	Total	#	86	105	179	286	102	247	168
		Avg. length	637	622	641	655	636	649	644
		SD	46	46	42	42	50	45	111
		SE	5	5	3	2	5	3	9
Age-1.3	Males	#	76	192	99	213	296	195	179
		Avg. length	776	800	772	785	813	790	794
		SD	71	68	48	60	60	64	153
		SE	8	5	5	4	3	5	11
	Females	#	61	158	62	141	267	158	141
		Avg. length	802	815	792	815	825	819	816
		SD	53	44	45	42	44	47	113
		SE	7	3	6	4	3	4	9
	Total	#	137	350	161	354	563	353	320
		Avg. length	788	806	780	797	818	803	804
		SD	65	59	48	55	53	59	139
		SE	6	3	4	3	2	3	8
Age-1.4	Males	#	28	47	48	39	83	73	53
		Avg. length	926	914	886	910	901	919	908
		SD	48	74	54	42	64	67	145
		SE	9	11	8	7	7	8	20
	Females	#	81	92	82	50	125	203	106
		Avg. length	889	896	876	877	897	906	894
		SD	38	45	56	40	50	46	113
		SE	4	5	6	6	5	3	11
	Total	#	109	139	130	89	208	276	159
		Avg. length	898	902	880	892	899	909	899
		SD	44	57	55	44	56	52	126
		SE	4	5	5	5	4	3	10
Age-1.5	Males	#	2				2	1	1
		Avg. length	913				1,000	940	953
		SD	4				7		8
		SE	3				5		9
	Females	#	4	3		3	1		2
		Avg. length	906	913		980	890		927
		SD	38	35		35			62
		SE	19	20		20			46
	Total	#	6	3		3	3	1	3
		Avg. length	908	913		980	963	940	935
		SD	29	35		35	64		86
		SE	12	20		20	37		53

-continued-

Appendix A5.–(Page 2 of 2).

Age	Sex		Year						
			1997[a]	1998[b]	1999	2000	2001	2002[c]	Average
PANEL B: EVENT 2 SPAWNING GROUNDS SAMPLES									
Age-1.1	Males	#	51	40	24	10	20	2	25
		Avg. length	363	433	434	370	395	368	399
		SD	39	24	24	30	26	18	68
		SE	5	4	5	10	6	13	14
	Females	#	---------------------- none ----------------------------						
	Total	#	51	40	24	10	20	2	25
		Avg. length	363	433	434	370	395	368	399
		SD	39	24	24	30	26	18	68
		SE	5	4	5	10	6	13	14
Age-1.2	Males	#	193	218	249	260	90	180	198
		Avg. length	622	616	619	642	624	639	627
		SD	60	54	49	50	53	56	132
	SE	SE	4	4	3	3	6	4	9
	Females	#	1		3	5	1	4	2
		Avg. length	665		772	726	675	671	712
		SD			13	38		49	63
		SE			7	17		25	41
	Total	#	194	218	252	265	91	184	201
		Avg. length	622	616	620	644	624	640	628
		SD	60	54	50	51	53	56	133
		SE	4	4	3	3	6	4	9
Age-1.3	Males	#	157	234	129	246	353	153	212
		Avg. length	777	801	765	789	811	802	795
		SD	58	59	50	64	56	65	144
		SE	5	4	4	4	3	5	10
	Females	#	114	200	104	174	312	111	169
		Avg. length	811	821	793	816	826	826	818
		SD	42	44	39	42	38	42	101
		SE	4	3	4	3	2	4	8
	Total	#	271	434	233	420	665	264	381
		Avg. length	791	810	778	800	818	812	805
		SD	55	54	48	57	49	58	131
		SE	3	3	3	3	2	4	7
Age-1.4	Males	#	70	56	56	55	87	105	72
		Avg. length	887	918	878	910	901	921	904
		SD	79	61	66	60	66	66	163
		SE	9	8	9	8	7	6	19
	Females	#	239	148	136	120	235	187	178
		Avg. length	890	899	874	884	886	895	889
		SD	46	43	55	46	44	47	115
		SE	3	4	5	4	3	3	9
	Total	#	309	204	192	175	322	292	249
		Avg. length	889	904	875	892	890	904	893
		SD	55	49	58	52	51	56	131
		SE	3	3	4	4	3	3	8
Age-1.5	Males	#	3	1	1	2	2	2	2
		Avg. length	962	1,070	1,105	938	915	928	966
		SD	71			124	113	46	188
		SE	41			88	80	33	139
	Females	#	10	5	1	4		3	4
		Avg. length	944	855	880	975		955	929
		SD	33	45		36		57	88
		SE	10	20		18		33	45
	Total	#	13	6	2	6	2	5	6
		Avg. length	948	891	993	963	915	944	941
		SD	41	97	159	65	113	49	236
		SE	11	39	113	27	80	22	99

[a] Excludes one event 1 age-2.4 female chinook salmon and one event 2 age-2.2 male.

[b] Excludes one event 2 age-2.2 male chinook salmon.

[c] Excludes one event 1 age-0.2 male chinook salmon, one event 1 age-2.2 male fish, and one event 2 age-2.4 female.

Appendix A6.–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.

Brood	Age	Year	Number	Adipose	Number	Number of valid tags				Percent	Marked fraction (θ)	
year	class	examined	examined	clips	sacrificed	Fall	Spring	Total	Valid	adipose	Valid	Event
1992	1.2	1996	33	0								1&2
1992	1.3	1997	485	14	11	10	1	11	100.0%	2.9%	2.9%	1&2
1992	2.2	1997	1	0								1&2
1992	1.4	1998	346	16	8	4	4	8	100.0%	4.6%	4.6%	1&2
1992	1.5	1999	2	0								1&2
1992 Brood year total			867	30	19	14	5	19	100.0%	3.5%	3.5%	1&2
1993	1.1	1996	4	1	1	1	0	1	100.0%	25.0%	25.0%	1&2
1993	1.2	1997	309	40	35	28	3	31	88.6%	12.9%	11.5%	1&2
1993	1.3	1998	787	62	43	35	8	43	100.0%	7.9%	7.9%	1&2
1993	2.2	1998	1	0								1&2
1993	1.4	1999	346	37	17	13	4	17	100.0%	10.7%	10.7%	1&2
1993	1.5	2000	9	0								1&2
1993 Brood year total			1,456	140	96	77	15	92	95.8%	9.6%	9.2%	1&2
1994	1.1	1997	60	4	4	2	2	4	100.0%	6.7%	6.7%	1&2
1994	1.2	1998	331	30	25	14	11	25	100.0%	9.1%	9.1%	1&2
1994	2.1	1998	1	0								1&2
1994	1.3	1999	433	45	12	7	5	12	100.0%	10.4%	10.4%	1&2
1994	1.4	2000	264	13	7	3	3	6	85.7%	4.9%	4.2%	1&2
1994	1.5	2001	5	0								1&2
1994 Brood year total			1,094	92	48	26	21	47	97.9%	8.4%	8.2%	1&2
1995	1.1	1998	77	15	13	13	0	13	100.0%	19.5%	19.5%	1&2
1995	1.2	1999	483	63	46	30	16	46	100.0%	13.0%	13.0%	1&2
1995	1.3	2000	772	74	19	10	7	17	89.5%	9.6%	8.6%	1&2
1995	1.4	2001	530	53	19	12	7	19	100.0%	10.0%	10.0%	1&2
1995	1.5	2002	6	1	1	1	0	1	100.0%	16.7%	16.7%	1&2
1995	2.4	2002	1	0								1&2
1995 Brood year total			1,869	206	98	66	30	96	98.0%	11.0%	10.8%	1&2
1996	0.1	1998	1	0								1&2
1996	1.1	1999	59	7	5	4	1	5	100.0%	11.9%	11.9%	1&2
1996	1.2	2000	553	72	49	33	14	47	95.9%	13.0%	12.5%	1&2
1996	1.3	2001	1,231	143	43	27	11	38	88.4%	11.6%	10.3%	1&2
1996	1.4	2002	571	58	15	11	4	15	100.0%	10.2%	10.2%	1&2
1996 Brood year total			2,415	280	112	75	30	105	93.8%	11.6%	10.9%	1&2
1997	1.1	2000	11	1	1	0	1	1	100.0%	9.1%	9.1%	1&2
1997	1.2	2001	194	26	23	12	5	17	73.9%	13.4%	9.9%	1&2
1997	0.4	2002	1	0								1&2
1997	1.3	2002	618	61	7	4	3	7	100.0%	9.9%	9.9%	1&2
1997	2.2	2002	1	0								1&2
1997 Brood year total			825	88	31	16	9	25	80.6%	10.7%	8.6%	1&2
1998	1.1	2001	30	3	3	0	3	3	100.0%	10.0%	10.0%	1&2
1998	1.2	2002	436	26	21	12	9	21	100.0%	6.0%	6.0%	1&2
1998 Brood year total			466	29	24	12	12	24	100.0%	6.2%	6.2%	1&2
1999	0.2	2002	1	0								1&2
1999	1.1	2002	2	0								1&2
1999 Brood year total			3	0						0.0%		1&2

Appendix A7.–Names of computer files containing data, statistics, and interim calculations concerning the estimated spawning abundance of chinook salmon in the Unuk River, 2002.

File name	Description
02unuk41a_sm.xls	Spreadsheet containing all the mark-recapture data with various pivot table results, Tables 1 and 4- 8, Figures 5-9, Appendices A1, A3, and A4, abundance estimates, bootstrap results, and chi-squared analyses.
02unuk41b.xls	Spreadsheet containing Table 9 and Appendices A5 and A6.
02unuk41c.xls	Spreadsheet containing Tables 2 and 3.
MR4FATE.BAS	Program used for bootstrapping abundance estimates to estimate variance and bias, for both medium and large size groups, in flat ASCII format.