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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<th>General</th>
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<tr>
<td>centimeter cm</td>
<td>Alaska Department of Fish and Game ADF&amp;G</td>
<td>fork length FL</td>
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<tr>
<td>deciliter dL</td>
<td>Alaska Administrative Code AAC</td>
<td>mideye-to-fork MEF</td>
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<td>gram g</td>
<td>all commonly accepted abbreviations e.g., Mr., Mrs., Jr., etc.</td>
<td>mideye-to-tail-fork METF</td>
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<td>hectare ha</td>
<td>all commonly accepted professional titles e.g., Dr., Ph.D., R.N., etc.</td>
<td>standard length SL</td>
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<td>kilogram kg</td>
<td>@</td>
<td>total length TL</td>
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<tr>
<td>kilometer km</td>
<td>compass directions: east E north N south S west W</td>
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<td>liter L</td>
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<tr>
<td>meter m</td>
<td>corporate suffixes: Company Corp. Corporation Inc. Ltd. D.C. Corp. Inc. Ltd. et al. etc.</td>
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<td>milliliter mL</td>
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<td>millimeter mm</td>
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| Weights and measures (English) | | |
| cubic feet per second ft³/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 pH | | |
| (negative log of)     | | |
| parts per million ppm| | |
| parts per thousand ppt| | |
| volts V              | | |
| watts W              | | |
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by
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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, 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 km² (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.

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 (LLOOP) of all inspected fish to prevent double sampling. These fish were closely examined for presence of a tag, an LUOP, an LLOOP, 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:

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

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 \( \left\{ \hat{M}_i^*, \hat{C}_i^*, \hat{R}_i^* \right\} \) 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:

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

(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).

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

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:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i}$$

(3)

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

(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

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

(5)

and

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

(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

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}}$$

(7)

and

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

(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 $\sum_{jk} \hat{p}_{jk} = 1$. 

8
**Expansion Factor**

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

\[
\hat{\pi}_i = \frac{\hat{N}_i}{C_i}
\]

\( i \) being 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 (\( \bar{\pi} \)) and its estimated variance are

\[
\bar{\pi} = \frac{1}{k} \sum_{i=1}^{k} \hat{\pi}_i
\]

\[
\text{var}(\bar{\pi}) = \frac{1}{(k-1)} \sum_{i=1}^{k} (\hat{\pi}_i - \bar{\pi})^2
\]

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

\[
\hat{N}_i = \bar{\pi} C_i
\]

\[
\text{var}(\hat{N}_i) = C_i^2 \text{var}(\bar{\pi})
\]

**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):

\[
f(w_i) = \frac{d_i}{d}
\]

where: \( f(w_i) \) 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:

\[
\bar{w} = \sum_{i=1}^{l} w_i f(w_i)
\]

with

\[
\text{var}(\bar{w}) = \sum_{i=1}^{l} (w_i - \bar{w})^2 f(w_i)
\]

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

\[
z = \sum_{i=1}^{d} \left( \frac{w_i - \bar{w}}{\text{var}(\bar{w})} \right)^3 f(w_i)
\]

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

\[
g = \sum_{i=1}^{d} \left( \frac{w_i - \bar{w}}{\text{var}(\bar{w})} \right)^4 f(w_i)
\]

**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
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 ($\chi^2 = 7.64$, df = 1, $P < .01$) but not medium fish ($\chi^2 = 1.15$, df = 1, $P = 0.28$). However, the recapture rates were similar for large males and females during event 2 ($\chi^2 = 0.30$, 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>
<thead>
<tr>
<th>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).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length (MEF)</strong></td>
</tr>
<tr>
<td>0–400 mm</td>
</tr>
<tr>
<td>Released in event 1 with marks (M)</td>
</tr>
<tr>
<td>Inspected at:</td>
</tr>
<tr>
<td>1. Upriver a</td>
</tr>
<tr>
<td>Inspected (C)b</td>
</tr>
<tr>
<td>Recaptured (R)</td>
</tr>
<tr>
<td>Recaptured/captured</td>
</tr>
<tr>
<td>2. Downriver c</td>
</tr>
<tr>
<td>Inspected (C)d</td>
</tr>
<tr>
<td>Recaptured (R)</td>
</tr>
<tr>
<td>Recaptured/captured</td>
</tr>
<tr>
<td>Total Inspected</td>
</tr>
<tr>
<td>Inspected (C)</td>
</tr>
<tr>
<td>Recaptured (R)</td>
</tr>
<tr>
<td>Recaptured/captured</td>
</tr>
</tbody>
</table>

a Includes Boundary and Crippler 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.
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.

<table>
<thead>
<tr>
<th>Marking dates</th>
<th>Number marked</th>
<th>Estimated fraction recovered</th>
<th>Recovery location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Downriver&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Upriver&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>6/11 to 7/10</td>
<td>271</td>
<td>0.192</td>
<td>38</td>
</tr>
<tr>
<td>7/11 to 8/16</td>
<td>230</td>
<td>0.222</td>
<td>45</td>
</tr>
<tr>
<td>Total/proportion</td>
<td>501</td>
<td>0.206</td>
<td>83</td>
</tr>
<tr>
<td>Number inspected</td>
<td>657</td>
<td></td>
<td>179</td>
</tr>
<tr>
<td>Fraction marked</td>
<td></td>
<td>0.126</td>
<td>0.112</td>
</tr>
</tbody>
</table>

**LARGE CHINOOK SALMON**

**MEDIUM CHINOOK SALMON**

<table>
<thead>
<tr>
<th>Marking dates</th>
<th>Number marked</th>
<th>Estimated fraction recovered</th>
<th>Recovery location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/11 to 7/10</td>
<td>73</td>
<td>0.151</td>
<td>10</td>
</tr>
<tr>
<td>7/11 to 8/16</td>
<td>116</td>
<td>0.164</td>
<td>12</td>
</tr>
<tr>
<td>Total/proportion</td>
<td>189</td>
<td>0.159</td>
<td>22</td>
</tr>
<tr>
<td>Number inspected</td>
<td>227</td>
<td></td>
<td>117</td>
</tr>
<tr>
<td>Fraction marked</td>
<td></td>
<td>0.097</td>
<td>0.068</td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes Clear, Gene’s Lake, Kerr, and Lake creeks and the Eulachon River.

<sup>b</sup> 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).

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey count</td>
<td>636</td>
<td>840</td>
<td>680</td>
<td>1,341</td>
<td>2,019</td>
<td>897</td>
<td>1,121</td>
<td>1,008</td>
<td>1,068</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$n_2$</td>
<td>16 78</td>
<td>15 79</td>
<td>13 50</td>
<td>8 69</td>
<td>3 74</td>
<td>9 66</td>
<td>2 114</td>
<td>30 105</td>
<td>12 79</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$n_1$</td>
<td>75 307</td>
<td>87 466</td>
<td>125 380</td>
<td>128 570</td>
<td>71 778</td>
<td>148 725</td>
<td>52 646</td>
<td>189 501</td>
<td>109 547</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$n_2$</td>
<td>156 761</td>
<td>217 707</td>
<td>251 523</td>
<td>158 719</td>
<td>74 1,014</td>
<td>109 644</td>
<td>124 985</td>
<td>344 836</td>
<td>179 774</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mark-recapture (M-R) estimate</td>
<td>701 2,970</td>
<td>1,198 4,132</td>
<td>2,267 3,914</td>
<td>2,278 5,872</td>
<td>769 10,541</td>
<td>1,638 6,988</td>
<td>698 5,546</td>
<td>2,114 3,963</td>
<td>1,458 5,491</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE (M-R)</td>
<td>158</td>
<td>277</td>
<td>290</td>
<td>413</td>
<td>602</td>
<td>490</td>
<td>968</td>
<td>644</td>
<td>124</td>
<td>1,181</td>
<td>690</td>
<td>805</td>
<td>80</td>
<td>433</td>
<td>339</td>
<td>325</td>
<td>406</td>
<td>571</td>
</tr>
<tr>
<td>Survey count/(M-R) (%)</td>
<td>21.4</td>
<td>20.3</td>
<td>17.4</td>
<td>22.8</td>
<td>19.2</td>
<td>12.8</td>
<td>20.2</td>
<td>25.4</td>
<td>19.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV (M-R) (%)</td>
<td>22.5</td>
<td>9.3</td>
<td>24.2</td>
<td>10.0</td>
<td>26.6</td>
<td>12.5</td>
<td>42.5</td>
<td>11.0</td>
<td>16.1</td>
<td>11.2</td>
<td>42.1</td>
<td>11.5</td>
<td>11.5</td>
<td>7.8</td>
<td>16.0</td>
<td>8.2</td>
<td>25.2</td>
<td>10.2</td>
</tr>
<tr>
<td>95% RP M-R estimate (%)</td>
<td>44.2</td>
<td>18.3</td>
<td>47.4</td>
<td>19.6</td>
<td>52.0</td>
<td>24.5</td>
<td>83.3</td>
<td>21.5</td>
<td>31.6</td>
<td>22.0</td>
<td>82.6</td>
<td>22.6</td>
<td>22.5</td>
<td>15.3</td>
<td>31.4</td>
<td>16.1</td>
<td>4.9</td>
<td>3.93</td>
</tr>
<tr>
<td>Expansion factor (EF) a</td>
<td>4.67</td>
<td>4.92</td>
<td>5.76</td>
<td>4.38</td>
<td>5.22</td>
<td>7.79</td>
<td>4.95</td>
<td>3.93</td>
<td>4.83</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE (EF) a</td>
<td>0.44</td>
<td>0.49</td>
<td>0.72</td>
<td>0.48</td>
<td>0.58</td>
<td>0.90</td>
<td>0.39</td>
<td>0.32</td>
<td>0.59</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>CV (EF) a</td>
<td>9</td>
<td>10</td>
<td>13</td>
<td>11</td>
<td>12</td>
<td>8</td>
<td>8</td>
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<tr>
<td>95% RP (EF) a</td>
<td>18</td>
<td>20</td>
<td>25</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>15</td>
<td>16</td>
<td>24</td>
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<tr>
<td>M-R lower 95% C.I.</td>
<td>489</td>
<td>2,499</td>
<td>815</td>
<td>3,433</td>
<td>1,506</td>
<td>3,110</td>
<td>1,358</td>
<td>4,848</td>
<td>557</td>
<td>8,705</td>
<td>1,017</td>
<td>5,775</td>
<td>557</td>
<td>4,814</td>
<td>1,602</td>
<td>3,406</td>
<td>988</td>
<td>4,574</td>
</tr>
<tr>
<td>M-R upper 95% C.I.</td>
<td>1,109</td>
<td>3,636</td>
<td>1,903</td>
<td>4,974</td>
<td>3,811</td>
<td>5,071</td>
<td>5,042</td>
<td>7,347</td>
<td>1,068</td>
<td>13,253</td>
<td>3,331</td>
<td>8,845</td>
<td>1,068</td>
<td>6,530</td>
<td>2,907</td>
<td>4,684</td>
<td>2,530</td>
<td>6,793</td>
</tr>
<tr>
<td>Estimated bias (%)</td>
<td>2.3</td>
<td>0.1</td>
<td>3.0</td>
<td>0.6</td>
<td>3.4</td>
<td>1.5</td>
<td>9.6</td>
<td>1.1</td>
<td>1.5</td>
<td>0.9</td>
<td>7.5</td>
<td>0.6</td>
<td>0.4</td>
<td>0.03</td>
<td>1.4</td>
<td>0.5</td>
<td>3.6</td>
<td>0.7</td>
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</table>

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.

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

<table>
<thead>
<tr>
<th>Brood year and age class</th>
<th>2001</th>
<th>2000</th>
<th>1999</th>
<th>1998</th>
<th>1997</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

**PANEL A: AGE COMPOSITION OF MEDIUM CHINOOK SALMON**

<table>
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<tr>
<th>Sexes</th>
<th>Sample size</th>
<th>( \hat{P}_{ijk} \times 100 )</th>
<th>( \hat{N}_{ijk} \times 100 )</th>
<th>SE(( \hat{P}_{ijk} ))</th>
<th>SE(( \hat{N}_{ijk} ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>12</td>
<td>3.6</td>
<td>75</td>
<td>1.0</td>
<td>24</td>
</tr>
<tr>
<td>Females</td>
<td>2</td>
<td>0.6</td>
<td>13</td>
<td>0.4</td>
<td>9</td>
</tr>
<tr>
<td>Sexes combined</td>
<td>12</td>
<td>3.6</td>
<td>75</td>
<td>1.0</td>
<td>24</td>
</tr>
</tbody>
</table>

**PANEL B: COMPOSITION OF LARGE CHINOOK SALMON**

<table>
<thead>
<tr>
<th>Sexes</th>
<th>Sample size</th>
<th>( \hat{P}_{ijk} \times 100 )</th>
<th>( \hat{N}_{ijk} \times 100 )</th>
<th>SE(( \hat{P}_{ijk} ))</th>
<th>SE(( \hat{N}_{ijk} ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>193</td>
<td>23.6</td>
<td>934</td>
<td>1.5</td>
<td>96</td>
</tr>
<tr>
<td>Females</td>
<td>3</td>
<td>0.4</td>
<td>15</td>
<td>0.2</td>
<td>8</td>
</tr>
<tr>
<td>Sexes combined</td>
<td>196</td>
<td>23.9</td>
<td>948</td>
<td>1.5</td>
<td>98</td>
</tr>
</tbody>
</table>

-continued-
Table 5.—Page 2 of 2.

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<th>Brood year and age class</th>
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<th>1999</th>
<th>1998</th>
<th>1997</th>
<th>Total</th>
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<td></td>
<td>1.1</td>
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<td>1.3</td>
<td>1.4</td>
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<td>PANEL C: AGE COMPOSITION OF MEDIUM AND LARGE CHINOOK SALMON</td>
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<td></td>
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</tr>
<tr>
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<td>186</td>
<td>108</td>
<td>813</td>
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<tr>
<td>$\hat{p}_{jk} \times 100$</td>
<td>1.2</td>
<td>47.9</td>
<td>15.0</td>
<td>8.6</td>
<td>72.7</td>
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<tr>
<td>SE($\hat{p}_{jk} \times 100$</td>
<td>0.4</td>
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<td>1.3</td>
<td>0.9</td>
<td>2.0</td>
<td></td>
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<tr>
<td>$\hat{N}_{jk}$</td>
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<td>2,909</td>
<td>912</td>
<td>523</td>
<td>4,419</td>
<td></td>
</tr>
<tr>
<td>SE($\hat{N}_{jk}$</td>
<td>24</td>
<td>332</td>
<td>93</td>
<td>63</td>
<td>393</td>
<td></td>
</tr>
<tr>
<td>Females Sample size</td>
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<td>78</td>
<td>255</td>
<td>4</td>
<td>342</td>
<td></td>
</tr>
<tr>
<td>$\hat{p}_{jk} \times 100$</td>
<td>0.4</td>
<td>6.2</td>
<td>20.3</td>
<td>0.3</td>
<td>27.3</td>
<td></td>
</tr>
<tr>
<td>SE($\hat{p}_{jk} \times 100$</td>
<td>0.2</td>
<td>0.8</td>
<td>1.7</td>
<td>0.2</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>$\hat{N}_{jk}$</td>
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<td>377</td>
<td>1,234</td>
<td>19</td>
<td>1,658</td>
<td></td>
</tr>
<tr>
<td>SE($\hat{N}_{jk}$</td>
<td>12</td>
<td>51</td>
<td>120</td>
<td>10</td>
<td>151</td>
<td></td>
</tr>
<tr>
<td>Sexes Sample size</td>
<td>12</td>
<td>512</td>
<td>264</td>
<td>363</td>
<td>4</td>
<td>1,155</td>
</tr>
<tr>
<td>$\hat{p}_{j} \times 100$</td>
<td>1.2</td>
<td>48.3</td>
<td>21.2</td>
<td>28.9</td>
<td>0.3</td>
<td>100.0</td>
</tr>
<tr>
<td>SE($\hat{p}_{j} \times 100$</td>
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<td>3.1</td>
<td>1.6</td>
<td>2.1</td>
<td>0.2</td>
<td></td>
</tr>
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<td>1,289</td>
<td>1,756</td>
<td>19</td>
<td>6,077</td>
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<tr>
<td>SE($\hat{N}_{j}$</td>
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<td>334</td>
<td>122</td>
<td>160</td>
<td>10</td>
<td>470</td>
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Table 6.—Estimated average length (MEF in mm) by age, sex and sampling event of Chinook salmon sampled in the Unuk River in 2004.

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<th></th>
<th>Brood year and age class</th>
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<th>2000</th>
<th>1999</th>
<th>1998</th>
<th>1997</th>
<th>Total</th>
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<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
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<td><strong>PANEL A: EVENT 1, LOWER UNUK RIVER SET GILLNET</strong></td>
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<td></td>
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</tr>
<tr>
<td>Males</td>
<td>Sample size</td>
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<td>72</td>
<td>54</td>
<td>444</td>
<td>695</td>
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<td>Avg. length</td>
<td>445</td>
<td>647</td>
<td>756</td>
<td>903</td>
<td>695</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>28</td>
<td>39</td>
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<td>66</td>
<td>99</td>
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<tr>
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<td>Avg. length</td>
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<td>838</td>
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<td>209</td>
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<td>691</td>
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<td>445</td>
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<td>773</td>
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<td>Avg. length</td>
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<td>62</td>
<td>73</td>
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<td>255</td>
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<td>Avg. length</td>
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<td>48</td>
<td>58</td>
<td>55</td>
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<td>7</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Spaghetti tag no.</th>
<th>Release date/time</th>
<th>Recapture date/time</th>
<th>Sulking period</th>
<th>Day</th>
<th>Hour</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>8044</td>
<td>07/20/04 09:15</td>
<td>07/20/04 10:00</td>
<td>0 days, 0 hours, and 45 minutes</td>
<td>0</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>8046</td>
<td>07/20/04 13:09</td>
<td>07/20/04 17:07</td>
<td>0 days, 3 hours, and 58 minutes</td>
<td>0</td>
<td>3</td>
<td>58</td>
</tr>
<tr>
<td>8050</td>
<td>06/21/04 06:20</td>
<td>07/01/04 14:39</td>
<td>10 days, 8 hours, and 19 minutes</td>
<td>10</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>8052</td>
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<td>07/12/04 16:05</td>
<td>20 days, 23 hours, and 48 minutes</td>
<td>20</td>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>8059</td>
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<td>06/30/04 17:30</td>
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<td>2</td>
<td>4</td>
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<tr>
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<td>2 days, 0 hours, and 58 minutes</td>
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<td>0</td>
<td>58</td>
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<tr>
<td>8072</td>
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<td>6 days, 20 hours, and 57 minutes</td>
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<td>20</td>
<td>57</td>
</tr>
<tr>
<td>8153</td>
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<td>3</td>
</tr>
<tr>
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<td>14 days, 7 hours, and 30 minutes</td>
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<td>7</td>
<td>30</td>
</tr>
<tr>
<td>8205</td>
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<td>5 days, 3 hours, and 45 minutes</td>
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<td>3</td>
<td>45</td>
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<tr>
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<td>54</td>
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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.

ACKNOWLEDGMENTS

We thank Amy Holm for her assistance with project planning, expediting equipment, and data entry. We thank Nicole Zeiser, Roger Hayward, Chris S’gro, Roger Wagner, Chris Stack, and Micah Sanguinetti of ADF&G for operating the gillnets used to capture and tag fish in the lower Unuk River and for their efforts in capturing tagged and untagged fish on the spawning grounds; Dave Magnus and Christie Hendrich of ADF&G and volunteer Tim Baldy for their help with the spawning grounds sampling; Keith Pahlke and John Der Hovanisian for performing the aerial counts of spawning abundance and for logistical assistance; Ed Jones for logistical assistance; and David Bernard for his biometric support on the 2004 operational plan and this report. We thank float plane pilots Jeff Carlin and Dave Doyon, helicopter pilot Eric Eichner, and tugboat captain Stretch Chatham for their logistical support; the ADF&G creel and port sampling staffs for their diligence in recovering CWT’d Chinook salmon; Cathy Robinson, Ron Josephson, Detlef Buettner, Anna Sharp, and the rest of the CFMD Tag Lab in Juneau for dissecting and decoding heads and providing sampling supplies and data on CWT recoveries; Sue Millard for determining the ages on adult Chinook salmon scales; and Judy Shuler for preparation of the final manuscript.

REFERENCES CITED

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


REFERENCES CITED (Continued)


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

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1992 Brood year total 16,612 16,431

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1993 Brood year total 23,774 23,753

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1994 Brood year total 47,848 47,662

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1995 Brood year total 51,730 51,694

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1996 Brood year total 79,890 79,026

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1997 Brood year total 42,007 41,836

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1998 Brood year total 30,013 29,994

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1999 Brood year total 48,565 48,486

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2000 Brood year total 56,486 56,343

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**2001 Brood year total**  
66,540  66,383

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<th>Number tagged</th>
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<td>3/29–4/10/04</td>
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**2002 Brood year total**  
58,227  58,894

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**2003 Brood year total**  
27,186  27,129
Appendix A3.–Detection of size-selectivity in sampling and its effects on estimation of size composition.

<table>
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<tr>
<th>Case I:</th>
<th>&quot;Accept&quot; $H_0$</th>
<th>There is no size-selectivity during either sampling event.</th>
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<tbody>
<tr>
<td>Case II:</td>
<td>&quot;Accept&quot; $H_0$</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td></td>
<td>Reject $H_0$</td>
<td>There is no size-selectivity during the second sampling event but there is during the first.</td>
</tr>
<tr>
<td>Case III:</td>
<td>Reject $H_0$</td>
<td>&quot;Accept&quot; $H_0$</td>
</tr>
<tr>
<td></td>
<td>&quot;Accept&quot; $H_0$</td>
<td>There is size-selectivity during both sampling events.</td>
</tr>
<tr>
<td>Case IV:</td>
<td>&quot;Accept&quot; $H_0$</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td></td>
<td>Reject $H_0$</td>
<td>There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.</td>
</tr>
</tbody>
</table>

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.

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<th>Year examined</th>
<th>Number examined</th>
<th>Adipose clips</th>
<th>Number sacrificed</th>
<th>Fall</th>
<th>Spring</th>
<th>Total</th>
<th>Valid</th>
<th>Percent adipose</th>
<th>Valid Event</th>
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<td>3.0%</td>
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<table>
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<th>Number examined</th>
<th>Adipose clips</th>
<th>Number sacrificed</th>
<th>Number of valid tags</th>
<th>Percent adipose Valid</th>
<th>Marked fraction (θ)</th>
<th>Event</th>
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<td>9.7% 9.7%</td>
<td>1&amp;2</td>
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<td>12 9 21 100.0%</td>
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<td>1&amp;2</td>
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<td>1.3</td>
<td>2003</td>
<td>1,112</td>
<td>117</td>
<td>28</td>
<td>11 17 28 100.0%</td>
<td>10.5% 10.5%</td>
<td>1&amp;2</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>2.2</td>
<td>2003</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1998</td>
<td>1.4</td>
<td>2004</td>
<td>527</td>
<td>50</td>
<td>1</td>
<td>1 1 1 100.0%</td>
<td>9.5% 9.5%</td>
<td>1&amp;2</td>
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</tr>
<tr>
<td>1998 Brood year total</td>
<td></td>
<td></td>
<td>2,091</td>
<td>196</td>
<td>53</td>
<td>24 29 53 100.0%</td>
<td>9.4% 9.4%</td>
<td>1&amp;2</td>
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<tr>
<td>1999</td>
<td>0.2</td>
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<td></td>
<td></td>
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<td></td>
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<td>1999</td>
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<td>2003</td>
<td>147</td>
<td>15</td>
<td>13</td>
<td>7 5 12 92.3%</td>
<td>10.2% 9.4%</td>
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<tr>
<td>1999</td>
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<td>2004</td>
<td>381</td>
<td>47</td>
<td>3</td>
<td>2 1 3 100.0%</td>
<td>12.3% 12.3%</td>
<td>1&amp;2</td>
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<tr>
<td>1999 Brood year total</td>
<td></td>
<td></td>
<td>532</td>
<td>62</td>
<td>16</td>
<td>9 6 15 93.8%</td>
<td>11.7% 10.9%</td>
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<td>2003</td>
<td>72</td>
<td>4</td>
<td>4</td>
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<td>2000</td>
<td>1.2</td>
<td>2004</td>
<td>787</td>
<td>61</td>
<td>51</td>
<td>29 21 50 98.0%</td>
<td>7.8% 7.6%</td>
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<td>2000 Brood year total</td>
<td></td>
<td></td>
<td>859</td>
<td>65</td>
<td>55</td>
<td>31 23 54 98.2%</td>
<td>7.6% 7.4%</td>
<td>1&amp;2</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>1.1</td>
<td>2004</td>
<td>34</td>
<td>7</td>
<td>7</td>
<td>5 2 7 100.0%</td>
<td>20.6% 20.6%</td>
<td>1&amp;2</td>
<td></td>
</tr>
<tr>
<td>2001 Brood year total</td>
<td></td>
<td></td>
<td>34</td>
<td>7</td>
<td>7</td>
<td>5 2 7 100.0%</td>
<td>20.6% 20.6%</td>
<td>1&amp;2</td>
<td></td>
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### Appendix A5—Estimated annual escapement of Chinook salmon in the Unuk River by age class and sex, 1997–2004.

<table>
<thead>
<tr>
<th>Year</th>
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<th>Male</th>
<th>Female</th>
<th>Total</th>
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<td></td>
<td>1.1</td>
<td>1.2</td>
<td>2.2</td>
<td>1.3</td>
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<tr>
<td>1997</td>
<td>%</td>
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<td></td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>46</td>
<td>881</td>
<td>5</td>
<td>724</td>
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<tr>
<td>Female</td>
<td>5</td>
<td>526</td>
<td>1,102</td>
<td>46</td>
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<tr>
<td>Total</td>
<td>46</td>
<td>886</td>
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<td>1,425</td>
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<tr>
<td>%</td>
<td>1.3</td>
<td>24.1</td>
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<tr>
<td>Estimated escapement</td>
<td>%</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>232</td>
<td>1,299</td>
<td>6</td>
<td>1,392</td>
</tr>
<tr>
<td>Female</td>
<td>1,172</td>
<td>870</td>
<td>29</td>
<td>2,071</td>
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<tr>
<td>Total</td>
<td>232</td>
<td>1,299</td>
<td>6</td>
<td>2,564</td>
</tr>
<tr>
<td>%</td>
<td>4.4</td>
<td>24.4</td>
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<tr>
<td>1998</td>
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</tr>
<tr>
<td>Male</td>
<td>211</td>
<td>2,189</td>
<td>1,134</td>
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<tr>
<td>Female</td>
<td>26</td>
<td>914</td>
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<td>211</td>
<td>2,216</td>
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<tr>
<td>%</td>
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<td>35.4</td>
<td>18.3</td>
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</tr>
<tr>
<td>Estimated escapement</td>
<td>%</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>2,444</td>
<td>2,312</td>
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<tr>
<td>Female</td>
<td>47</td>
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<td>1,128</td>
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<td>9</td>
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<td>3,948</td>
<td>1,645</td>
</tr>
<tr>
<td>%</td>
<td>0.1</td>
<td>30.6</td>
<td>48.4</td>
<td>20.2</td>
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<tr>
<td>2000</td>
<td>%</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>83</td>
<td>936</td>
<td>3,680</td>
<td>894</td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>3,243</td>
<td>2,443</td>
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</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>946</td>
<td>6,923</td>
<td>3,337</td>
</tr>
<tr>
<td>%</td>
<td>0.7</td>
<td>8.3</td>
<td>32.5</td>
<td>7.9</td>
</tr>
<tr>
<td>Estimated escapement</td>
<td>%</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>2,437</td>
<td>1,675</td>
<td>1,146</td>
<td>22</td>
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<td>Female</td>
<td>48</td>
<td>1,212</td>
<td>2,042</td>
<td>33</td>
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<tr>
<td>Total</td>
<td>2,485</td>
<td>2,887</td>
<td>3,188</td>
<td>55</td>
</tr>
<tr>
<td>%</td>
<td>28.8</td>
<td>33.5</td>
<td>37.0</td>
<td>6.0</td>
</tr>
<tr>
<td>2001</td>
<td>%</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>192</td>
<td>580</td>
<td>6</td>
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<tr>
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<td>0</td>
<td>1,195</td>
<td>1,027</td>
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<tr>
<td>Total</td>
<td>192</td>
<td>592</td>
<td>6</td>
<td>3,930</td>
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<tr>
<td>%</td>
<td>3.1</td>
<td>9.5</td>
<td>0.1</td>
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<tr>
<td>2002</td>
<td>%</td>
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</tr>
<tr>
<td>Male</td>
<td>75</td>
<td>2,909</td>
<td>912</td>
<td>523</td>
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<tr>
<td>Female</td>
<td>27</td>
<td>377</td>
<td>1,234</td>
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<tr>
<td>Total</td>
<td>75</td>
<td>2,936</td>
<td>1,289</td>
<td>1,756</td>
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<tr>
<td>%</td>
<td>1.2</td>
<td>48.3</td>
<td>21.2</td>
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-continued-
### Appendix A5—Page 2 of 2.

<table>
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<th>1.2</th>
<th>2.2</th>
<th>1.3</th>
<th>0.4</th>
<th>1.4</th>
<th>1.5</th>
<th>2.4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-2004 Male</td>
<td>%</td>
<td>1.5</td>
<td>24.6</td>
<td>0.0</td>
<td>25.1</td>
<td>0.0</td>
<td>8.4</td>
<td>0.2</td>
<td></td>
<td>59.9</td>
</tr>
<tr>
<td>Estimated Female</td>
<td>%</td>
<td>0.3</td>
<td>0.0</td>
<td>19.6</td>
<td>0.0</td>
<td>19.9</td>
<td>0.4</td>
<td>0.0</td>
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<td>40.1</td>
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<td>%</td>
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<td>24.9</td>
<td>0.0</td>
<td>44.7</td>
<td>0.0</td>
<td>28.3</td>
<td>0.6</td>
<td>0.0</td>
<td>100.0</td>
</tr>
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<table>
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<th>Year</th>
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<th>1.2</th>
<th>2.2</th>
<th>1.3</th>
<th>0.4</th>
<th>1.4</th>
<th>1.5</th>
<th>2.4</th>
<th>Total</th>
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</thead>
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<td>Male</td>
<td>106</td>
<td>1,709</td>
<td>1</td>
<td>1,746</td>
<td>1</td>
<td>583</td>
<td>13</td>
<td></td>
<td></td>
<td>4,159</td>
</tr>
<tr>
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<td>22</td>
<td>1,359</td>
<td>1</td>
<td>1,380</td>
<td>26</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>2,790</td>
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<td>106</td>
<td>1,731</td>
<td>2</td>
<td>3,105</td>
<td>1</td>
<td>1,963</td>
<td>39</td>
<td>1</td>
<td></td>
<td>6,949</td>
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</table>

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<th>1.2</th>
<th>2.2</th>
<th>1.3</th>
<th>0.4</th>
<th>1.4</th>
<th>1.5</th>
<th>2.4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>1997-2004%</td>
<td>1.5</td>
<td>24.6</td>
<td>0.0</td>
<td>25.1</td>
<td>0.0</td>
<td>8.4</td>
<td>0.2</td>
<td></td>
<td>59.9</td>
</tr>
<tr>
<td>Estimated Female</td>
<td>mean %</td>
<td>0.3</td>
<td>0.0</td>
<td>19.6</td>
<td>0.0</td>
<td>19.9</td>
<td>0.4</td>
<td>0.0</td>
<td></td>
<td>40.1</td>
</tr>
<tr>
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<td>%</td>
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<td>24.9</td>
<td>0.0</td>
<td>44.7</td>
<td>0.0</td>
<td>28.3</td>
<td>0.6</td>
<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
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).

### PANEL A: ESTIMATED MEAN DATE OF MIGRATION AT SN1

<table>
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<tr>
<th>Year</th>
<th>Eulachon Creek</th>
<th>Clear Creek</th>
<th>Lake Creek</th>
<th>Kerr Creek</th>
<th>Genes Creek</th>
<th>Cripple Creek</th>
<th>Boundary Creek</th>
<th>Tributaries combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>10-Jul</td>
<td>14-Jul</td>
<td>11-Jul</td>
<td>11-Jul</td>
<td>8-Jul</td>
<td>10-Jul</td>
<td>8-Jul</td>
<td>10-Jul</td>
</tr>
<tr>
<td>1998</td>
<td>3-Jul</td>
<td>10-Jul</td>
<td>5-Jul</td>
<td>21-Jun</td>
<td>29-Jun</td>
<td>4-Jul</td>
<td>3-Jul</td>
<td>3-Jul</td>
</tr>
<tr>
<td>1997</td>
<td>7-Jul</td>
<td>11-Jul</td>
<td>6-Jul</td>
<td>7-Jul</td>
<td>6-Jul</td>
<td>9-Jul</td>
<td>8-Jul</td>
<td>8-Jul</td>
</tr>
</tbody>
</table>

97–03 Mean 11-Jul 15-Jul 11-Jul 8-Jul 12-Jul 11-Jul 12-Jul 11-Jul

### PANEL B: STANDARD DEVIATION (in days)

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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>13</td>
<td>10</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>.14</td>
<td>.59</td>
<td>-0.48</td>
<td>-0.24</td>
<td>-0.10</td>
<td>1.36</td>
<td>0.50</td>
<td>-0.66</td>
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### PANEL C: SKEWNESS ESTIMATION

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</thead>
<tbody>
<tr>
<td></td>
<td>3.38</td>
<td>4.34</td>
<td>3.75</td>
<td>3.59</td>
<td>2.48</td>
<td>5.41</td>
<td>4.68</td>
<td>4.46</td>
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<tr>
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<td>2.64</td>
<td>1.00</td>
<td>1.23</td>
<td>1.49</td>
<td>2.48</td>
<td>1.82</td>
<td>1.00</td>
<td>2.27</td>
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### PANEL D: KURTOSIS ESTIMATION * 

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17</td>
<td>3.70</td>
<td>3.57</td>
<td>3.02</td>
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<td>3.76</td>
<td>3.80</td>
<td>3.23</td>
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<td>10</td>
<td>2.29</td>
<td>2.35</td>
<td>2.78</td>
<td>2.05</td>
<td>1.52</td>
<td>1.52</td>
<td>1.52</td>
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<tr>
<td></td>
<td>27</td>
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<td>3.25</td>
<td>3.78</td>
<td>1.39</td>
<td>4.18</td>
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### PANEL E: NUMBER OF FISH MARKED AT SN1 AND RECAPTURED ON TRIBUTARIES

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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>690</td>
<td>703</td>
<td>873</td>
<td>853</td>
<td>697</td>
<td>504</td>
<td>550</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>13</td>
<td>2</td>
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</table>

* 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.

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<th>2000</th>
<th>1999</th>
<th>1999</th>
<th>1997</th>
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<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
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**Panel A: Event 2 Samples by Location**

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<th>Females</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Boundary Creek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>62.5</td>
<td>2</td>
</tr>
<tr>
<td>Females</td>
<td>1</td>
<td>12.5</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>62.5</td>
<td>3</td>
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**PANEL C: ALL TRIBUTARIES COMBINED**

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**Spawning grounds Large-sized**

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**PANEL D: EVENT 1, LOWER UNUK RIVER SET GILLNET SAMPLES**

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