Fishery Data Series No. 12-04

Production of Unuk River Chinook Salmon through 2008 from the 1992–2005 Broods

by

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and

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February 2012

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

Two-event mark-recapture experiments were used to estimate the abundance of Chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Unuk River in 2007 and 2008. Biological data were collected during both events. Each apparently healthy fish was marked with a numbered solid-core spaghetti tag sewn through its back and 2 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 to estimate the fraction of the population that had been marked.

Abundance of large Chinook salmon (≥660 mm MEF) was estimated to be 5, 668 (SE = 446) in 2007 and 3,104 (SE = 357) in 2008. The estimates were made from 577 marked and 114 recaptured fish out of 1,127 examined upstream in 2007, and 557 marked and 54 recaptured fish out of 242 examined upstream in 2008. Using indirect methods, abundance of fish <660 mm MEF was estimated to be 961 (SE = 106) in 2007 and 875 (SE = 146) in 2008.

As part of a stock assessment program that began in fall 1993 (1992 brood year), coded wire tags (CWTs) were implanted in juvenile Chinook salmon on the Unuk River each fall and spring from 2005 to 2008. Harvest, harvest distribution, incidental harvest mortality, and total fishing mortality were estimated for the 1992–2005 brood year returns through 2008. Estimates of spawning abundance derived from the inriver mark-recapture studies (1994 and 1997–2008), escapement age-sex-length data (1995–2008), and CWT study results were used to estimate total production, marine survival, and exploitation rates for the 1992–2005 broods, through 2008.

The adipose fins of CWT fish were also excised as the first event in a two-event mark recapture study in order to estimate smolt abundance for the 1992–2005 broods. Smolt abundance and CWT release and recovery information were used to estimate fingerling abundance and the overwinter survival rate of fingerling Chinook salmon from the 1992–2005 broods.

Key words: abundance, Chinook salmon, Unuk River, mark-recapture, spaghetti tag, axillary appendage, coded wire tags, harvest, harvest distribution, incidental mortality, fishing mortality, marine survival, exploitation rates, production, overwinter survival, fingerlings, smolt

INTRODUCTION

The Unuk River is 1 of 11 escapement indicator streams for Chinook salmon *Oncorhynchus tshawytscha* in Southeast Alaska (SEAK; Pahlke 1997). This system traverses the Misty Fjords National Monument and flows into Behm Canal, a narrow saltwater passage north and east of Ketchikan (Figure 1). The Unuk River is the largest Chinook salmon producer in Behm Canal. Peak single-day aerial and foot survey counts of “large” Chinook salmon ≥660 mm MEF have been used as an index of escapement for the Unuk River. From 1979 to 1989, the index is roughly dome shaped, with peak values occurring in 1984 (1,837 fish) and 1986 (2,126 fish; Pahlke 1997); the survey count averaged 1,347 during this period. From 1990 to 2000 the index values declined, averaging only 849 fish, or 63% of the previous 11-year period. Survey counts increased from 2001to 2006 (Weller and Evans 2009), averaging 1,152 fish, with a peak count of 2,019 fish in 2001.

Low Unuk River survey counts in the early 1990s coincided with similar declines in the three other Behm Canal indicator stocks, the Chickamin, Blossom, and Keta River stocks (Pahlke, 1996; Figure 1), and prompted concern over the health of the Chinook salmon population in Behm Canal. In 1992, the Alaska Department of Fish and Game (ADF&G), Division of Sport Fish began a research program on the Unuk River. Goals of the program were to estimate overwinter survival of fingerlings, production and marine survival of smolts, escapement and harvest of adults, total production, exploitation rates, and ultimately to estimate a biological escapement goal (BEG) for this stock. These goals are being accomplished with inriver mark-recapture experiments on adult and juvenile Chinook salmon, and with marine catch sampling programs.

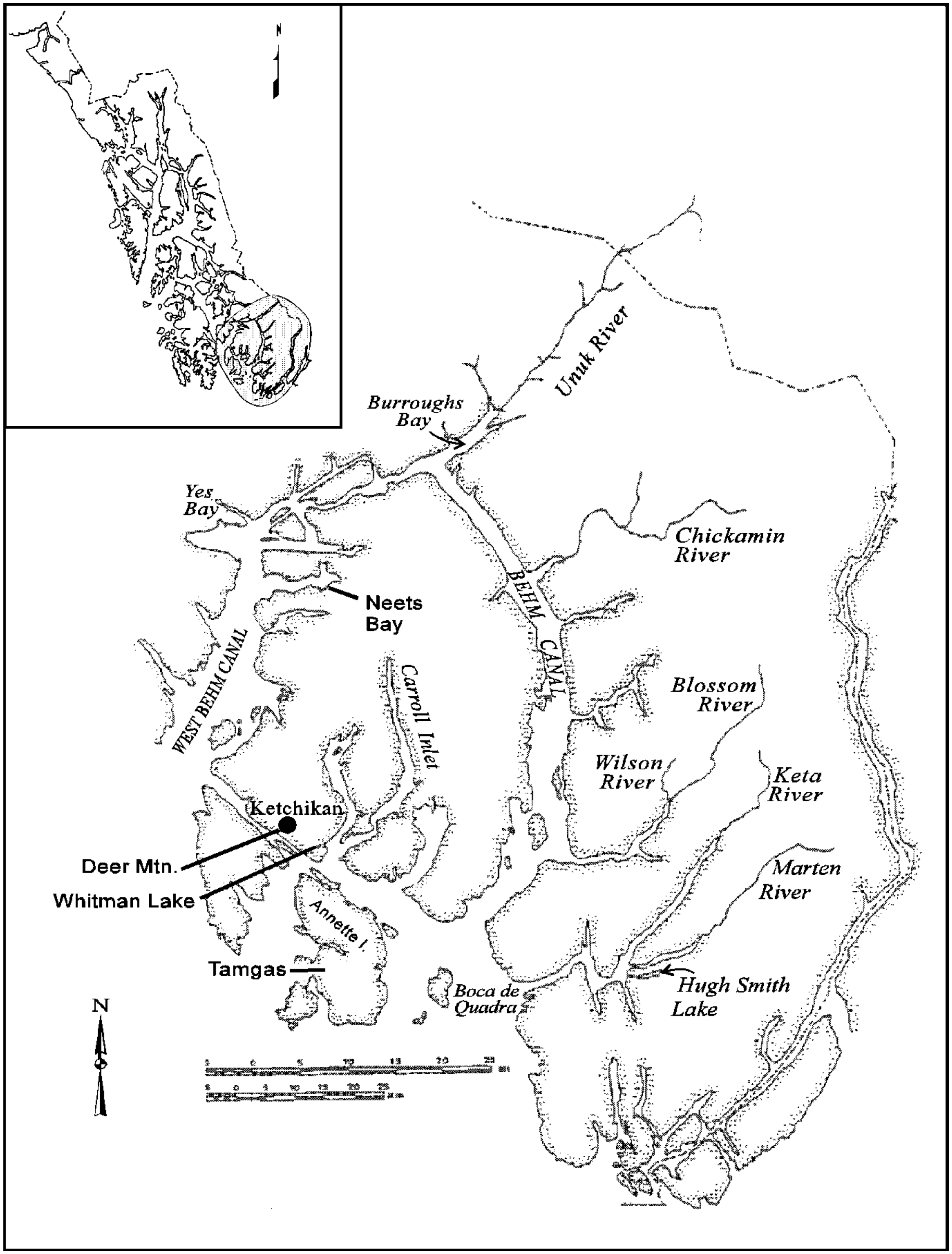

Figure 1.–Behm Canal area in Southeast Alaska and the location of selected Chinook salmon systems and hatcheries.

A BEG for the Unuk River of 650–1,400 large fish counted in surveys, or an actual escapement of about 3,000–7,000 large fish, was established in 1997 (McPherson and Carlile 1997). Only large fish are counted in 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 are generally fish 3-ocean age (age-.3) or older. Nearly all females in the spawning population are classified as large. 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 6 tributaries: Cripple, Gene's Lake, Kerr, Clear, and Lake creeks, plus the Eulachon River (Pahlke 1997; Figure 2).

Mark-recapture and radio telemetry studies were conducted in 1994 (Pahlke 1996). Mark-recapture studies have also been conducted annually from 1997 through 2006 (Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002; Weller and McPherson 2003a-b, 2004, 2006a-b; Weller and Evans 2009). The radio telemetry study indicated that 83% (SE = 9%) of all spawning occurred in the six tributaries surveyed. The 1997–2006 mark-recapture experiments estimated that an average of 5,431 large Chinook salmon entered the river during those years and ranged from 2,970 (1997) to 10,541 (2001; Weller and Evans 2009). Indices during those years averaged 1,041 large Chinook salmon, or 19.6% of the mark-recapture estimates, and ranged from 636 (1997) to 2,019 (2001). The highest recorded index of 2,126 large fish occurred in 1986 (Pahlke 1997). From 1977 to 2006, average peak survey counts in the six index tributaries of the Unuk River were distributed as follows: Cripple Creek (405 fish, 37%), Gene's Lake Creek (370 fish, 33%), Eulachon River (158 fish, 14%), Clear Creek (103 fish, 9%), Kerr Creek (39 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 2009, 2010).

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 estimated that commercial and sport harvest rates on the Unuk River Chinook salmon stock (age-1.1–1.5) ranged from 14% to 24%; however, the precision of the harvest estimates was low, as was confidence in the expansion factor used to estimate escapements (McPherson and Carlile 1997; Pahlke et al. 1996).

Starting in 1993, young-of-the-year (YOY) fingerlings were tagged with CWTs (Hendrich et al. 2008). From 1993 through 2004, 428,672 Chinook (fall) fingerlings were tagged, with an annual average of 35,719 and a range of 13,789 (1993) to 61,905 (1997). Tagging of smolt commenced in spring 1994, and 119,009 smolt were tagged through 2004 with an annual average of 10,819 and a range of 2,642 (1994) to 17,121 (1998).

Based on data collected through 2004, an adult-to-adult spawner-recruit model incorporating a marine survival parameter was used to revise the BEG range to 1,800–3,800 large spawners (Hendrich et al. 2008). In index equivalents this represents a peak survey count of between 375 and 800 large fish, significantly less than the previous BEG range of 650–1,400 large fish counted in surveys (McPherson and Carlile 1997). The dataset used in the BEG estimate of Hendrich at al. (2008) included a longer time series relative to the BEG estimate of 1997, was able to incorporate improved estimates of the age composition of the spawning population, marine survival, incidental mortality, and harvest, and used an expansion factor based on 7 years of mark-recapture data to estimate spawning abundance as opposed to the single year of mark-recapture data available in 1997.

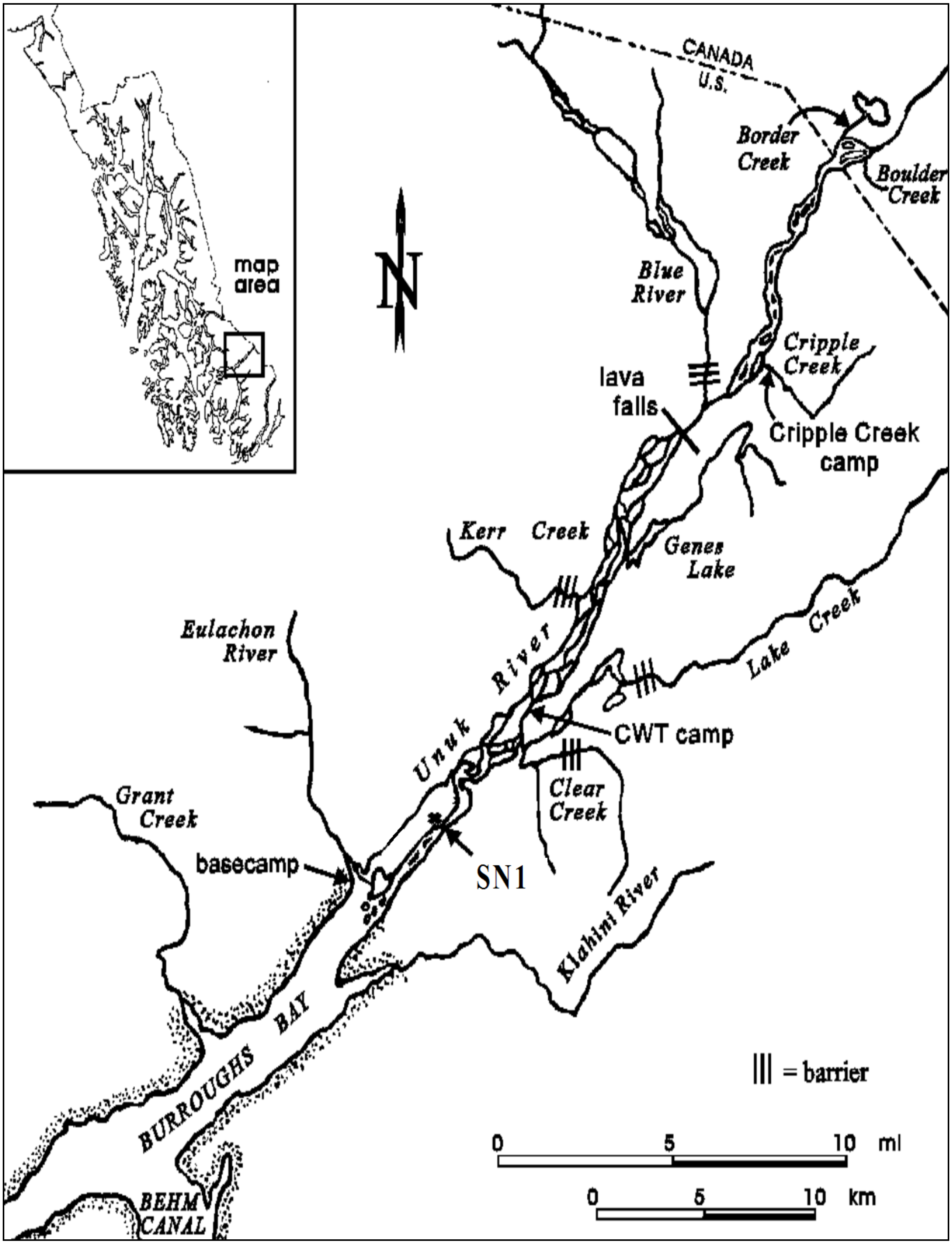

Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to Chinook salmon migration, and location of ADF&G research sites. SN = setnet, CWT = coded wire tag.

The current stock assessment program for adult escapement of Chinook salmon to the Unuk River has 3 primary objectives: (1) to estimate escapement; (2) to estimate age, sex, and length (ASL) distribution in the escapement; and (3) to estimate the fraction of fish possessing CWTs/adipose fin clips by brood year. Meeting this last objective is essential to estimating: a) harvest of this stock (CWTs) in current and future sport and commercial fisheries, and b) smolt abundance (adipose fin clips). Together, harvest and escapement data enable us to estimate total production and exploitation rates, and the combination of production and smolt abundance allows for marine survival estimation.

The objective of this manuscript is to provide the results of the 2007 and 2008 adult mark-recapture studies on the Unuk River. Results of the CWT study from 2005–2008 are also reported, as are revisions and updates to previously published results of the CWT study (Hendrich et al. 2008) from 1992 to 2004.

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 SEAK.

METHODS

ADULT ABUNDANCE

Two-event mark-recapture experiments for closed populations were used to estimate the number of immigrant large Chinook salmon to the Unuk River in 2007 and 2008. 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. We originally planned to also use mark-recapture techniques to estimate the abundance of medium fish, with length class defined as the smallest length of recapture (595 mm MEF to 659 mm MEF in 2007 and 540 mm MEF to 659 mm MEF in 2008); a lack of recaptures in those size classes forced us, however, to estimate fish <660 mm MEF using a combination of ASL data and the estimated abundance of large fish (see below).

Event 1: Sampling in the Lower River

Adult Chinook salmon were captured using set gillnets at the SN (setnet) 1 site (Figure 2) as they immigrated into the lower Unuk River between 11 June and 5 August during 2007, and 11 June and 4 August in 2008. 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. The SN1 site has been used for event 1 fish capture since 1997. This site is located approximately 3 km upstream of saltwater on the south channel, the mainstem of the lower Unuk River, below all known spawning areas except the Eulachon River (Figures 2 and 3).

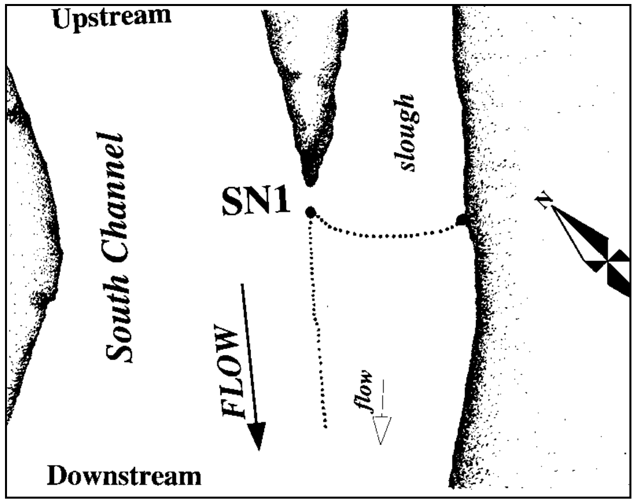

Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River in 2007 and 2008. SN = setnet.

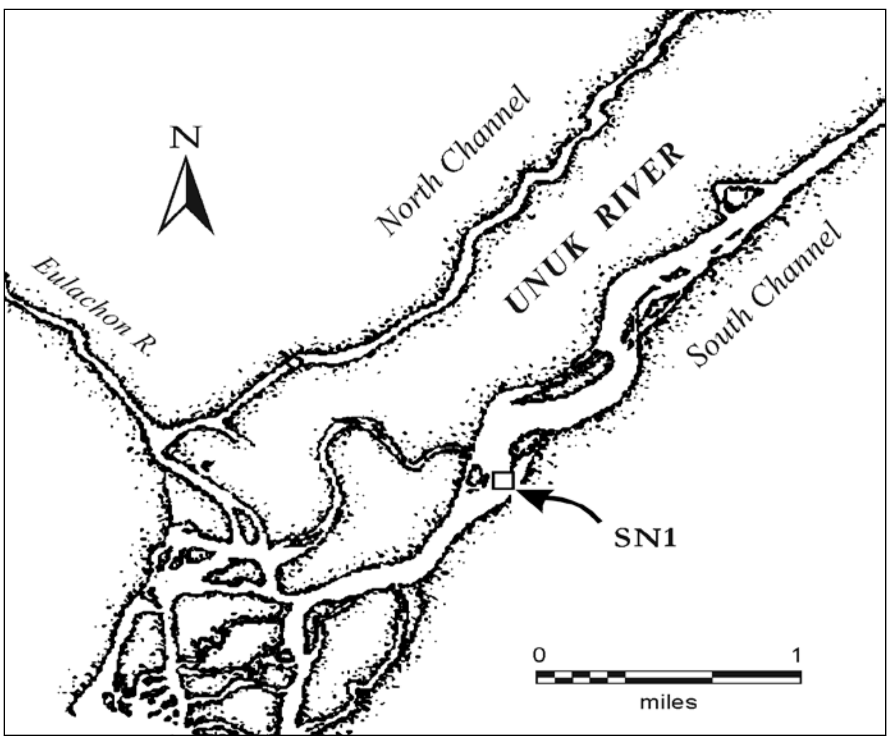

Figure 4.–Net placement used at the set gillnet site (SN1) on the lower Unuk River in 2007 and 2008. SN = setnet.

Back-to-back shifts fished 2 set gillnets at SN1 12 hours per day, 6 days per week. Crew shifts were staggered during the week so that at least 1 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 (Figure 4). 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 for ASL data. Length was measured to the nearest 5 mm MEF, and sex was determined from external, dimorphic characteristics. Five scales were taken about 25 mm apart within the preferred area on the left side of each fish. The preferred area is 2 to 3 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 and <700 mm MEF (jacks) were sacrificed, and their heads were sent to the ADF&G Division of Commercial Fisheries Mark, Tag and Age Laboratory (Tag Lab) for detection and decoding of CWTs.

With the exception of fish <700 mm MEF that were missing an adipose fin (these fish were sacrificed for CWT extraction), all captured fish judged healthy were marked with a uniquely numbered solid-core spaghetti tag sewn through the back, a clip of the left axillary appendage (LAA), and a left upper operculum punch (LUOP) 0.63 cm (0.25 in) in diameter. The axillary clip and operculum punch enabled detection of tag loss. The spaghetti tag consisted of a 5.71 cm (2.25 in) section of laminated Floy tubing shrunk onto a 38 cm (15 in) piece of 80-lb-test monofilament fishing line. The monofilament was sewn through the back just behind the dorsal fin and secured by crimping both ends of the monofilament in a line crimp. The excess monofilament was then trimmed off. Each spaghetti tag was individually numbered and stamped with an ADF&G phone number.

Event 2: Sampling on the Spawning Grounds

Chinook salmon of all sizes were sampled on Boundary Lake Creek (also known as Border Creek); on Clear, Cripple, Gene's Lake, Kerr, and Lake creeks; and on the Eulachon River in 2007 and 2008 (Figure 2). These seven tributaries received an estimated 84% (83% when Boundary Lake Creek is excluded) of the escapement in the telemetry study of Pahlke et al. (1996). Various methods were used to capture fish including rod and reel, 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 (Jones et al. 1998; Jones and McPherson 1999, 2000, 2002; McPherson et al. 1997). A hole was punched into the left lower operculum (LLOP) of all newly inspected fish to prevent double sampling. Inspected fish were closely examined for a tag, an LUOP, an LLOP, an LAA, a missing adipose fin, and were sampled to obtain ASL data by the same techniques used in the lower river. For Chinook salmon missing adipose fins, all fish <700 mm MEF, as well as postspawn fish of all sizes, were sacrificed to retrieve CWTs. Heads so collected were sent to the Tag Lab for dissection and decoding of tags. Foot, boat, or aerial surveys were also conducted on each of the sampled tributaries on at least 1 occasion. Multiple surveys were spaced approximately 1 week apart and when possible, a survey was conducted on the historical peak of observed abundance.

Abundance by Size

Abundance of large ($\hat{N}_L$) fish was estimated separately so that the estimate for $\hat{N}_L$ could be compared to the survey index. $\hat{N}_L$ was estimated using Chapman's modification of the Petersen estimator (Seber 1982):

$$\hat{N}_L = \frac{(M_L+1)(C_L+1)}{(R_L+1)} - 1 \tag{1}$$

$$\mathrm{var}(\hat{N}_L) = \frac{(M_L+1)(C_1+1)(M_L-R_L)(C_L-R_L)}{(R_L+1)^2(R_L+2)} \tag{2}$$

where M_L is the number of large fish sampled and marked during event 1, C_L is the number of large fish inspected for marks during event 2, and R_L is the number of C_L that possessed marks applied during event 1. The general conditions that must hold for $\hat{N}_L$ to be a consistent estimate of abundance are in Seber (1982) and may be cast as follows:

(a) every fish had an equal probability of being marked in the first event, or that every fish had an equal probability of being captured in the second event, or that marked fish mixed completely with unmarked fish;
(b) both recruitment and mortality did not occur between events;
(c) marking did not affect the catchability of a fish;
(d) fish did not lose their marks in the time between the two events;
(e) all marks were reported on recovery in the second event; and,
(f) double sampling did not occur.

Condition (a) may be violated if size- or sex-selective sampling occurs. Kolmogorov-Smirnov (K-S; Conover 1980) two-sample tests were used to test the hypothesis that fish of different lengths were captured with equal probability during both first and second sampling events. These test procedures are described in Appendix A1, as well as corrective measures (stratification) should size-selectivity be found. These measures are designed to minimize bias in estimation of abundance and composition parameters. Tests for gender bias in 2007 were not conducted because of errors detected in gender classification during first event sampling.

Three consistency tests (Appendix A2) described by Seber (1982) and Arnason et al. (1996) were used to test for temporal and/or spatial violations of condition (a). Contingency table analyses were used to test 3 null hypotheses: 1) for all marked fish recovered during event 2, time of marking is independent of when/where recovery occurs; 2) the probability that a fish inspected during event 2 is marked is independent of when/where it was caught during the second event; and 3) the probability that a marked fish is recovered during event 2 is independent of when it was marked. If all three hypotheses were rejected, the "partially" stratified abundance estimator described by Darroch (1961) was necessary to estimate abundance. Failure to reject at least one of these three hypotheses was sufficient to conclude that at least one of the assumptions in condition (a) was satisfied, and a Petersen-type model was appropriate to estimate abundance.

The experiment was assumed closed to recruitment because first event sampling spanned the entire immigration. Marking was assumed to have little effect on behavior of released fish or the catchability of fish on the spawning grounds because only fish in good condition were tagged and released, and because the 1994 radio telemetry study indicated minimal mortality from handling in the marking event for Chinook salmon (Pahlke et al. 1996). The use of multiple marks during event 1, careful inspection of all fish captured during event 2, and additional marking of all fish inspected helped to ensure assumptions (d), (e), and (f) were met.

Confidence intervals for $\hat{N}_L$ were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991). Fish were divided into 4 capture histories (Table 1). A bootstrap sample was built by drawing with replacement a sample of size $\hat{N}_L$ from the empirical distribution defined by the capture histories. A new set of statistics from each bootstrap sample $\{\hat{M}^*_L, \hat{C}^*_L, \hat{R}^*_L\}$ was generated, along with a new estimate for abundance $\hat{N}^*_L$. Ten thousand such bootstrap samples were drawn, creating the empirical distribution $\hat{F}(\hat{N}^*_L)$, which is an estimate of $F(\hat{N}_L)$. Confidence intervals were estimated from $\hat{F}(\hat{N}^*_L)$ with the percentile method (Efron and Tibshirani 1993, Section 13.3).

Table 1.–Capture histories for large (≥660 mm MEF) Chinook salmon in the population spawning in the Unuk River in 2007 and 2008 (notation explained in text).

	Number of large Chinook salmon		
Capture history	2007	2008	Source of statistics
Marked and not captured in tributaries	463	513	$M_i - R_i$
Marked and captured in tributaries	114	54	R_i
Not marked, but captured in tributaries	1,013	251	$C_i - R_i$
Not marked and not captured in tributaries	4,078	2,276	$N_i - M_i - C_i + R_i$

The abundance of fish <660 mm MEF was estimated indirectly by expanding the estimate for large fish by the estimated size composition of the spawning escapement:

$$\hat{N}_{<660} = \hat{N}_L\left(\frac{1}{\hat{\phi}} - 1\right) \tag{3}$$

where $\hat{N}_{<660}$ is the estimated spawning escapement of fish <660 mm MEF, and $\hat{\phi}$ is the estimated fraction of large fish in the spawning population Chinook salmon (McPherson et al. 1997).

The variance of the estimate for the abundance of small fish was estimated:

$$\operatorname{var}(\hat{N}_{<660}) = \operatorname{var}(\hat{N}_L)\left[\frac{1}{\hat{\phi}} - 1\right]^2 + \hat{N}_L^{\,2}\operatorname{var}\left(\frac{1}{\hat{\phi}}\right) - \operatorname{var}\left(\frac{1}{\hat{\phi}}\right)\operatorname{var}(\hat{N}_L) \tag{4}$$

where

$$\operatorname{var}\left(\frac{1}{\hat{\phi}}\right) \approx \left(\frac{1}{\hat{\phi}}\right)^4 \frac{\hat{\phi}(1-\hat{\phi})}{n-1} \tag{5}$$

and *n* is the number of fish of all sizes sampled in event 2. Confidence intervals were derived via simulation, where for each bootstrap realization of the abundance of large fish, a binomial random variable was drawn (~binomial (trials = number of fish inspected on the spawning grounds, probability $=\hat{\phi}$)) and a simulated $\hat{\phi}$ produced. A simulated $\hat{\mathrm{N}}_{<660}$ was calculated and confidence intervals derived as for the abundance of large fish, above.

The abundance of all fish was estimated as:

$$\hat{N}_{All} = \hat{N}_{<660} + \hat{N}_L \tag{6}$$

with variance estimated as:

$$\operatorname{var}(\hat{N}_{All}) = \hat{N}_L^2\operatorname{var}\left[\frac{1}{\hat{\phi}}\right] + \operatorname{var}(\hat{N}_L)\left(\frac{1}{\hat{\phi}}\right)^2 - \operatorname{var}\left(\frac{1}{\hat{\phi}}\right)\operatorname{var}(\hat{N}_L) \tag{7}$$

EXPANSION FACTOR

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

$$\hat{\pi}_i = \hat{N}_{Li} / C_i \tag{8}$$

and

$$\operatorname{var}(\hat{\pi}_i) = \operatorname{var}(\hat{N}_i) / C_i^2 \tag{9}$$

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

The expansion factor for a year in which no mark-recapture experiment is anticipated is the mean of the $\hat{\pi}_i$ over the k years for which mark recapture experiments are available (11 for the Unuk River at present, from 1997 to 2007; 2008 is not included because of incomplete survey counts):

$$\bar{\pi} = \sum_{i=1}^{k} \hat{\pi}_i \;/\; k \tag{10}$$

The variance associated with use of $\bar{\pi}$ in a prediction, var (π_p), is described in Appendix A3.

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

$$\hat{N}_p = \overline{\pi}\ C_p \tag{11}$$

$$\mathrm{var}(\hat{N}_p) = C_p^2\ \mathrm{var}(\pi_p) \tag{12}$$

MIGRATORY TIMING

The mean date of migration for Unuk River stocks (Boundary Creek, Clear Creek, Cripple Creek, Genes Lake Creek, Kerr Creek, Lake Creek or the Eulachon River) passing the SN1 site was calculated as:

$$\bar{d}_w = \frac{\sum_{i=1}^{n_w} d_{wi}}{n_w} \tag{13}$$

where n_w is the number of marked fish recovered at location w, and d_{wi} is the day the i^{th} fish was marked at the SN1 gillnet site, with variance estimated as:

$$\mathrm{var}(\bar{d}_w) = \frac{\sum_{i=1}^{n_w} (d_{wi} - \bar{d})^2}{(n_w - 1)n_w} \tag{14}$$

AGE AND SEX COMPOSITION

The proportion of the spawning population composed of a given age or sex within a size class c was estimated as a binomial variable:

$$\hat{p}_{gc} = \frac{n_{gc}}{n_c} \tag{15}$$

$$\mathrm{var}(\hat{p}_{gc}) = \frac{\hat{p}_{gc}(1 - \hat{p}_{gc})}{n_c - 1} \tag{16}$$

where n_c is the number of Chinook salmon of size class c in the sample that are successfully aged or sexed, and n_{gc} is the subset of n_c that belongs to group g. Information gathered during event 1 in 2007 was not used to estimate age or sex composition as some gender mis-identification was found to have occurred at SN1. Samples gathered at each spawning tributary in 2007 were pooled together because no differences in age composition were apparent among tributaries sampled. In 2008, fish <660 mm MEF gathered at each spawning tributary were pooled together, but for large fish, only samples from event 1 were used because of event 2 gender bias. Estimated abundance of age/sex group g across size classes is:

$$\hat{N}_g = \sum_c \hat{p}_{gc} \hat{N}_c \tag{17}$$

Because the $\hat{N}_c$ in Eq 17 are correlated ($\hat{N}_{<660}$ is estimated from $\hat{N}_L$ by Eq 3), the $\mathrm{var}\left(\hat{N}_g\right)$ was estimated by simulation.

The estimated proportion of the spawning population in age/sex group g across the large or small population classes is:

$$\hat{p}_g = \frac{\hat{N}_g}{\hat{N}_{ALL}} \tag{18}$$

The $\text{var}(\hat{p}_g)$ was also estimated through simulation.

Standard sample summary statistics were used to calculate estimates of mean length-at-age and its variance (Cochran 1977).

SMOLT ABUNDANCE AND OVERWINTER SURVIVAL

Juvenile Chinook Salmon Capture, Tagging, and Sampling

Chinook salmon from the Unuk River are almost all (>99%; Hendrich et al 2008) from a single freshwater age, overwintering 1 year as fingerlings and emigrating as age-1 smolt. Nearly all Chinook salmon fingerlings tagged in the fall of year $j+1$, and smolt tagged in the spring of year $j+2$ are thus from brood year j. G-40 minnow traps, baited with salmon roe, were fished daily for 24 h/d in the mainstem of the Unuk River, between approximately river km 3 and 19 (Figure 1), each spring and fall from 2005 to 2008. Minnow traps were checked daily, at which time juvenile Chinook salmon were removed from the minnow traps, counted, and subsequently transported to holding pens at camp. Chinook salmon were then separated from other species by using a combination of external morphological characteristics (Jones III et al. 1999). All live Chinook salmon were tranquilized in a water solution of tricain methane-sulfonate (MS 222) buffered with sodium bicarbonate. To alleviate stress, the anesthetic solution was kept near ambient river temperature by frequent water changes, and numbers of smolt tranquilized at any one time was limited (approximately 100). All smolt ≥50 mm FL not missing adipose fins were tagged following procedures described in Koerner (1977) and their adipose fins were excised. All captured smolt missing an adipose fin were subsequently passed through a magnetic tag detector to test for the presence of a CWT. Unique codes were used each spring and fall. Codes were ordered in spools of approximately 5,000, 10,000, or 20,000 tags, and spools were only changed when depleted or when the seasonal tagging period ended.

All tagged fish were held overnight. A random subsample of 50–100 fish was checked each morning for tag retention. The daily estimate of fish tagged and released (valid tagged) equaled the number tagged, minus the number of overnight mortalities, multiplied by the proportion estimated to have retained their tags. The number of fish tagged, the number that died in the holding pen, and the estimated number of fish that had shed their tags were compiled and recorded on ADF&G CWT Tagging Summary and Release Information Forms. These forms were submitted to the Tag Lab in Juneau after each field season.

Each year a minimum of 188 fingerlings and 138 smolt were systematically measured to the nearest 1 mm FL and weighed to the nearest 0.1 g. Standard sample summary statistics were used to calculate estimates of mean length and weight and associated variances (Cochran 1977).

Smolt Abundance

Experience has shown that estimates of the proportion of adults from a given brood year with adipose fin clips does not change appreciably over return years, and thus recovery data were pooled over the i years (maximum = 5) in which fish from brood year j return. Smolt abundance ($\hat{N}_{smolt,j}$) from brood year j was estimated using a version of the Chapman-modified Petersen formula.

$$\hat{N}_{smolt,j} = \frac{(\hat{M}_j + 1)(n_{\bullet j} + 1)}{(a_{\bullet j} + 1)} - 1 \quad (19)$$

where

$n_{\bullet j}$ = $\sum_{i=1}^{L} n_{ij}$ where n_{ij} is the number of adults examined in year i from brood year j for missing adipose fins;

L = number of years over which fish from a given brood return (maximum = 5).

$a_{\bullet j}$ = $\sum_{i=1}^{L} a_{ij}$, where a_i is the number of adipose fin clips observed in n_{ij}; and

$\hat{M}_j$ = estimated number of outmigrating smolt originating from brood year j that bore an adipose fin clip; these fish may be from either the fall (f; year $j+1$) or spring (s; year $j+2$) tagging programs. $\hat{M}_j$ is the sum of the estimated number of fingerlings with adipose fin clips from brood year j surviving to the spring ($\hat{M}_{f\rightarrow s,j}$) and the number of smolt with adipose fin clips from brood year j ($M_{s,j}$), where:

$$\hat{M}_{f\rightarrow s,j} = M_{f,j}\hat{S}_j \quad (20)$$

and

$M_{f,j}$ = number of fingerlings released with adipose fin clips in the fall of year j+1; and

$\hat{S}_j$ = estimated proportion of $M_{f,j}$ that survived to the spring of $j+2$ (overwinter survival) (see Weller and McPherson 2003a, Appendix A7), where:

$$\hat{S}_j = \frac{\hat{M}_{s,valid,j}\, v_{\bullet,f,j}}{\hat{M}_{f,valid,j}\, v_{\bullet,s,j}} \quad (21)$$

and

$\hat{M}_{s,valid,j}$ = estimated number of adipose-finclipped smolt released with valid CWTs in the spring of year j+ 2;

$\hat{M}_{f,valid,j}$ = estimated number of adipose-finclipped fingerlings released with valid CWTs in the fall of year j+1;

$v_{\bullet,f,j}$ = $\sum_{i=1}^{L} v_{i,f,j}$, where $v_{i,f,j}$ is the total number of fish from brood year j implanted with valid CWTs in the fall of year j+1 that were subsequently recovered, regardless of recovery circumstances (for instance recovery location; marine fishery, escapement, etc, or sample type; random, select, or voluntary; see Harvest section below); and

$v_{\bullet,s,j} = \sum_{i=1}^{L} v_{i,s,j}$, where $v_{i,s,j}$ is the total number of fish from brood year j implanted with valid CWTs in the spring of year $j+2$ that were subsequently recovered, regardless of recovery location or sample type.

The variance of the smolt estimate was estimated as:

$$\mathrm{var}\left(\hat{N}_{smolt,j}\right) = \left(n_\bullet + 1\right)^2 \mathrm{var}\left[\left(\hat{M}_{f\to s,j} + M_{s,j} + 1\right)\frac{1}{\left(a_\bullet + 1\right)}\right] \tag{22}$$

where, by Goodman (1960) for independent variables:

$$\begin{aligned}\mathrm{var}\left[\left(\hat{M}_{f\to s,j} + M_{s,j} + 1\right)\frac{1}{\left(a_{\bullet,j} + 1\right)}\right] &= \left(M_{s,j} + \hat{M}_{f\to s,j} + 1\right)^2 \mathrm{var}\left[\frac{1}{a_{\bullet,j}+1}\right] + \left[\frac{1}{a_{\bullet,j}+1}\right]^2 \mathrm{var}\left(\hat{M}_{f\to s,j}\right) \\ &- \mathrm{var}\left[\frac{1}{a_{\bullet,j}+1}\right]\mathrm{var}\left(\hat{M}_{f\to s,j}\right)\end{aligned} \tag{23}$$

and $\mathrm{var}\left(\hat{M}_{f\to s,j}\right)$ is obtained as described in Weller and McPherson (2003a Appendix A7). According to the delta method:

$$\mathrm{var}\left[\frac{1}{a_\bullet + 1}\right] = \left[\frac{1}{a_{\bullet,j}+1}\right]^4 n_{\bullet,j}\hat{p}_a\left(1-\hat{p}_a\right) \tag{24}$$

where $\hat{p}_{a,j} = \dfrac{a_{\bullet,j}}{n_{\bullet,j}}$ is the estimated proportion of inspected adults from brood year j with an adipose fin clip.

The two components in Equation 23 are not independent, but a simulation using data from studies on 7 brood years of Unuk River Chinook salmon to establish realistic population parameters showed the correlation to be negligible. The simulation showed the simulated variance of smolt abundance to be almost identical to that provided by the average of the Goodman-derived estimates (Eq 23) over the simulation.

Fingerling abundance $\hat{N}_f$ for brood year j was estimated as:

$$\hat{N}_{f,j} = \hat{N}_{smolt,j}\frac{1}{\hat{S}_j} \tag{25}$$

$$\mathrm{var}(\hat{N}_{f,j}) \approx \hat{N}_{f,j}^2\left|cv^2\left(\hat{N}_{smolt,j}\right) + cv^2\left(\hat{S}_j\right)\right| \tag{26}$$

HARVEST, INCIDENTAL FISHING MORTALITY, TOTAL FISHING MORTALITY, PRODUCTION, AND EXPLOITATION RATE ESTIMATES

Estimation of Fraction of Adults Bearing CWTs

All adult Chinook salmon captured during the 1994 and 1997–2008 mark-recapture studies and during spawning grounds sampling in 1995 and 1996 were sampled for age (scale) data. Scales with regenerated or otherwise unknown freshwater age were assumed to have a freshwater age of 1 (Hendrich et al. 2008). The age of fish with regenerated or otherwise unknown marine-water ages were estimated from their lengths using estimated length-at-age relationships according to methods in Hendrich et al. (2008; Appendix E1).

The fraction of adults from brood year j that possessed a valid Unuk River CWT was estimated as:

$$\hat{\theta}_j = \frac{\sum_{i=1}^{L} a_{ij}\rho_{ij}}{\sum_{i=1}^{L} n_{ij}} \tag{27}$$

where

n_{ij} = number of adults examined in year i from brood year j for adipose fin clips;

a_{ij} = number of adipose fin clips observed in n_{ij};

ρ_{ij} = $\frac{t_{ij}}{a'_{ij}}$, the proportion of sacrificed adults from brood year j in year i that also possess a valid Unuk CWT; where

a'_{ij} = number of heads examined for CWTs from the a_{ij} fish with adipose fin clips;

t_{ij} = number of CWTs found in a'_{ij}; and

L = number of years over which fish from a given brood return (maximum = 5, representing ages 1.1 through 1.5).

The variance of $\hat{\theta}_j$ was estimated using a parametric bootstrap simulation (e.g. Geiger 1990). For each year of recovery i, adipose clips were generated as a^*_{ij} ~ binomial$\left(n_{ij}, \frac{a_{ij}}{n_{ij}}\right)$, and then CWTs were generated as, t^*_{ij} ~ hypergeometric ($m = t_{ij} / a'_{ij} a^*_{ij}$, $n = a^*_{ij} - t_{ij} / a'_{ij} a^*_{ij}$, $k = a'_{ij} / a_{ij} a^*_{ij}$). Notation for hypergeometric parameters follows that of the R language (R Development Core Team 2005). ρ^*_{ij} was then calculated as $t^*_{ij} / (a^*_{ij} a'_{ij} / a_{ij})$, and $\hat{\theta}^*_j$ as:

$$\hat{\theta}^*_j = \frac{\sum_{i=1}^{L} a_i^* \rho_i^*}{\sum_{i=1}^{L} n_i} \tag{28}$$

Many values of $\hat{\theta}^*_j$ were simulated and the variance of $\hat{\theta}_j$ and of $\hat{\theta}_j^{-1}$ were estimated as described in equation (2) for $var(\hat{N}_L)$.

Returning Chinook salmon were/will be inspected for marks (missing adipose fins) and sampled for age (scale) data annually through 2012 (to complete recoveries of fish from brood year 2005) during mark-recapture operations. Each Chinook salmon was/will be examined for presence of the adipose fin, and a fish missing its adipose fin will be noted. Furthermore, heads were/will be removed from all adipose-finclipped Chinook salmon that are dead, post spawn, or <700 mm MEF (jacks) in length, with the resulting heads collected and shipped to the Tag Lab in Juneau for CWT processing. Scales (age) and length data were/will be collected from all adult Chinook salmon sampled to determine the marked rate by brood year.

Harvest

Landed catch (hereafter referred to as harvest) and CWT sampling data from fisheries managed by the State of Alaska were obtained from the Tag Lab database (http://tagotoweb.adfg.state.ak.us). Oliver (1990) and Hubartt et al. (1999) present details of sampling commercial and recreational fisheries in SEAK, respectively. The Regional Mark Processing Center (RMPC; http://www.rmpc.org/), which maintains the coastwide CWT central database (Regional Mark Information System, or RMIS) provided recovery information, harvest numbers, and CWT sampling statistics from fisheries not included in the Tag Lab database.

Fishery strata are defined as a combination of gear and harvest type with specific spatial and temporal characteristics. Commercial fishery harvest types in SEAK of relevance to this study were traditional fisheries, experimental area (troll) fisheries, terminal fisheries, and private non-profit (PNP) hatchery harvests in the Neets Bay terminal area. The traditional and experimental area fisheries are managed by ADF&G to achieve harvest targets (quotas) pursuant to the Pacific Salmon Treaty and as determined by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC). Experimental area fisheries target Alaska hatchery returns of Chinook salmon in SEAK each spring (approximately May through June), although fish other than Alaskan hatchery fish (treaty fish) are also harvested. The proportion of treaty fish harvested in each experimental fishery determines the total catch limit for each fishery; see Lynch and Skannes (2005a, 2006a, 2007a, and 2008a) for further details on these fisheries. Experimental area fisheries are spatially small (subdistrict specific; Figure 5) and harvest by fishery is tallied by statistical week.

The Neets Bay terminal area fishery is a fishery managed jointly by ADF&G and the Southern Southeast Aquaculture Association to harvest returns to the Neets Bay hatchery (Lynch and Skannes 2005b, 2006b, 2007b, 2008b). Harvest is primarily for cost recovery and brood stock, but some common property terminal harvest does occur (Davidson et al. 2008a). This fishery is confined to District 101-95 (Figure 5), harvest is tallied by statistical week, and gear is undefined.

The Hidden Falls terminal area fishery is a fishery managed jointly by ADF&G and the Northern Southeast Aquaculture Association to harvest returns to the Hidden Falls hatchery (Lynch and Skannes 2005b, 2006b, 2007b, 2008b). This fishery is confined to District 112-12 (Figure 5) and is managed for cost recovery, brood stock, common property terminal harvest (Davidson et al. 2008a), and common property experimental area troll harvest (Lynch and Skannes 2007a, 2008a). Harvest is tallied by statistical week, harvest type, and gear.

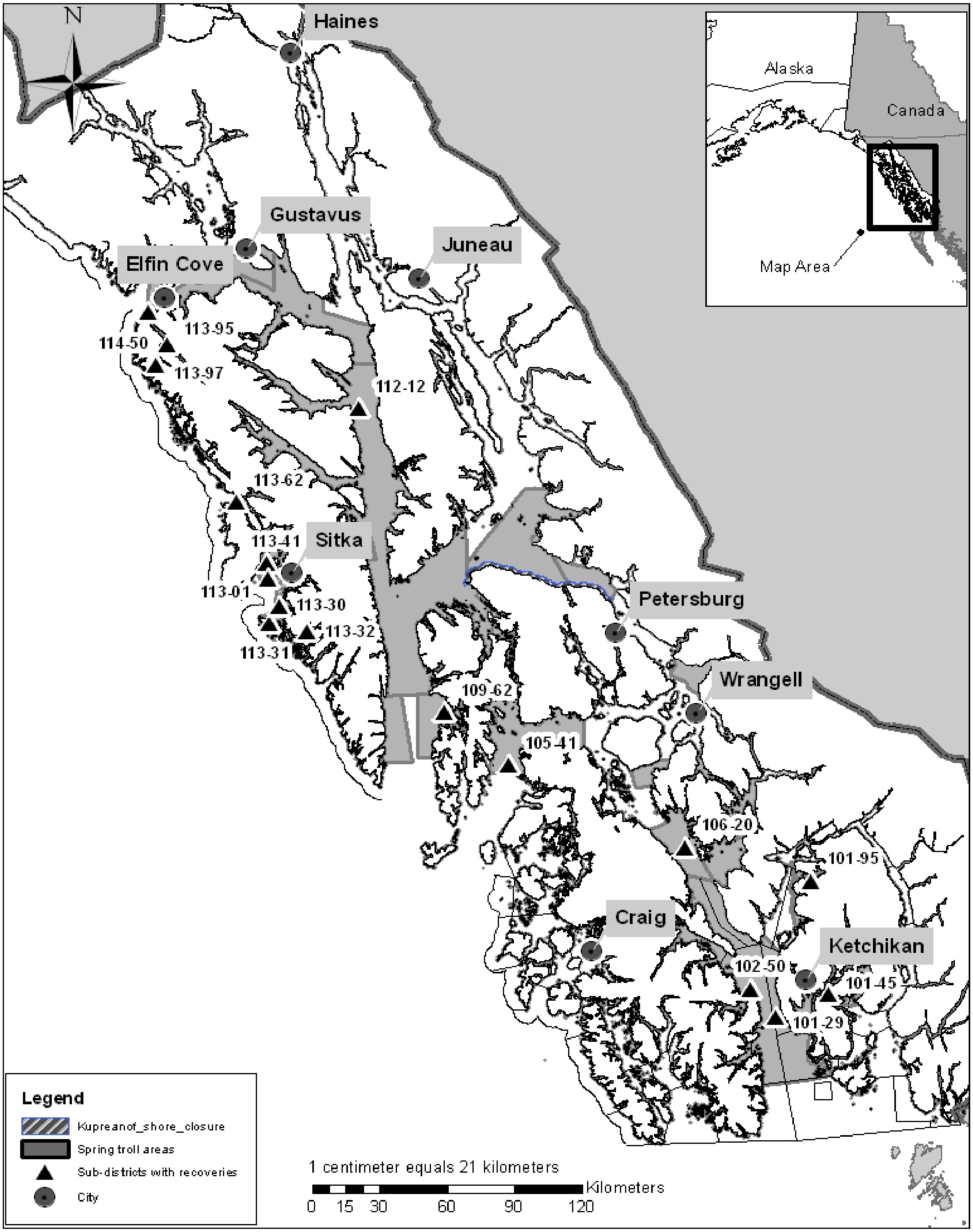

Figure 5.–Southeast Alaska experimental troll fishing areas (district-sub district).

Traditional fisheries are mixed stock interception fisheries; terminal area, aboriginal, experimental area, and test fisheries are not considered traditional fisheries. Harvest from SEAK traditional purse seine (see Davidson et al. 2005a, 2006a, 2007b, 2008a for details on these fisheries), drift gillnet fisheries (see Davidson et al. 2005b, 2006b, 2007a, 2008b for details on these fisheries) are tallied by statistical week and district fished (Figure 6). In SEAK the traditional troll fishery is comprised of winter and summer components. The winter fishery begins 11 October and ends when 45,000 Chinook salmon have been harvested, or on 30 April, whichever occurs first (Lynch and Skannes 2005c, 2007c). The summer troll fishery begins 1 July and ends 20 September, unless the fishery is extended (Lynch and Skannes 2005b, 2006b, 2007b, 2008b). Traditional troll harvests in SEAK are tallied by quadrant and period. A quadrant is a group of combined contiguous districts that divides SEAK into 4 large troll reporting areas (NE, NW, SE, and SW; Figure 7). Period is a group of consecutive statistical weeks. Period 1 starts on 1 January (statistical week 1) and ends when the winter troll fishery closes. Period 2 encompasses the spring, or experimental area, fishery. Period 3 begins when the summer troll fishery opens, generally 1 July, and for traditional Chinook salmon harvest, effectively ends when an inseason assessment of harvest sampling data determines the summer quota of Chinook salmon has been reached and the fishery is closed to Chinook salmon retention (note that the summer troll fishery generally remains open to retention of other salmon species and Period 3 extends throughout this time). If during the summer fishery the entire salmon troll fishery is closed and then reopened, or if Chinook salmon harvest during Period 3 was found to be substantially less than the quota and management reopens the fishery to Chinook retention, an additional period or periods are used to define each additional fishery opening. The final period of each calendar year is from 1 October to 31 December. Note that as Unuk River Chinook salmon have completed spawning by 1 October, harvest contributions of Unuk River Chinook salmon during the final period of a calendar year are accredited to returns of the following calendar year. Canadian troll harvests are tallied by statistical week and management area (Figure 8).

Creel surveys and/or catch sampling of recreational fisheries were randomly conducted in SEAK at marine boat landing sites in Haines, Petersburg, Wrangell, Sitka, Juneau, Craig, Ketchikan, Elfin Cove, and Gustavus during times of peak sport fishing activity, e.g., April through September (Figure 6). Information collected from individual fishers included harvest type, date, and location, number of Chinook salmon inspected for missing adipose fins, and the number of Chinook salmon observed with missing adipose fins. Harvest types relevant to this study were marine boat (MB) and derby fishing in which the sampled fish was entered in a derby (DE). Each sample was classified as either random, select, or voluntary. Creel surveys were used to estimate recreational harvest by fortnight, harvest type, and port of landing (e.g., Wendt and Jaenicke 2011). Recoveries from Canadian recreational fisheries in Northern B.C. are strictly voluntary. CWT sampling information was obtained from a sampling program specifically designed to sample the Cook Inlet early-run marine sport fishery from 1999–2001 (Begich 2007).

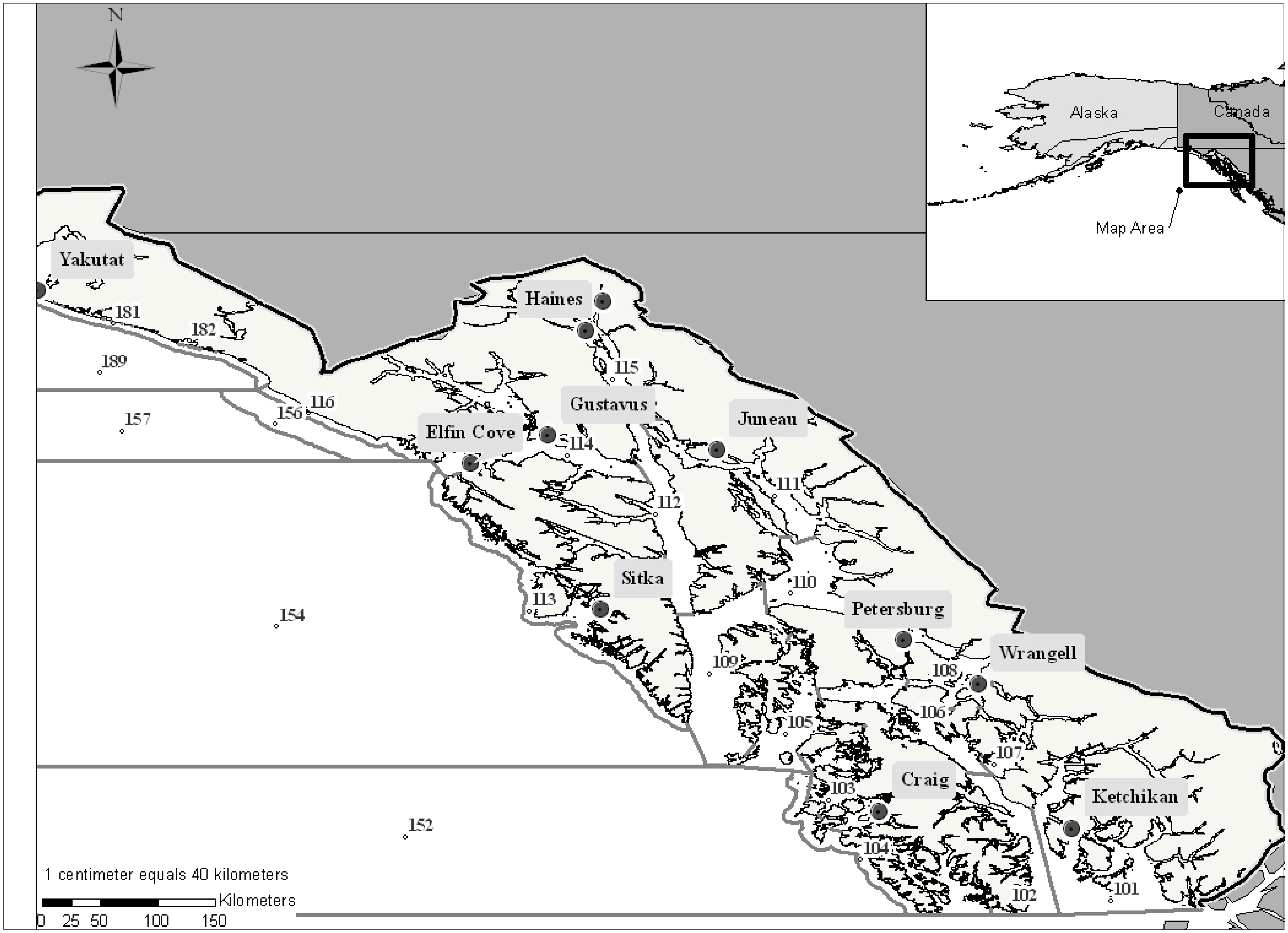

Figure 6.–Southeast Alaska commercial fishing districts and creel census ports.

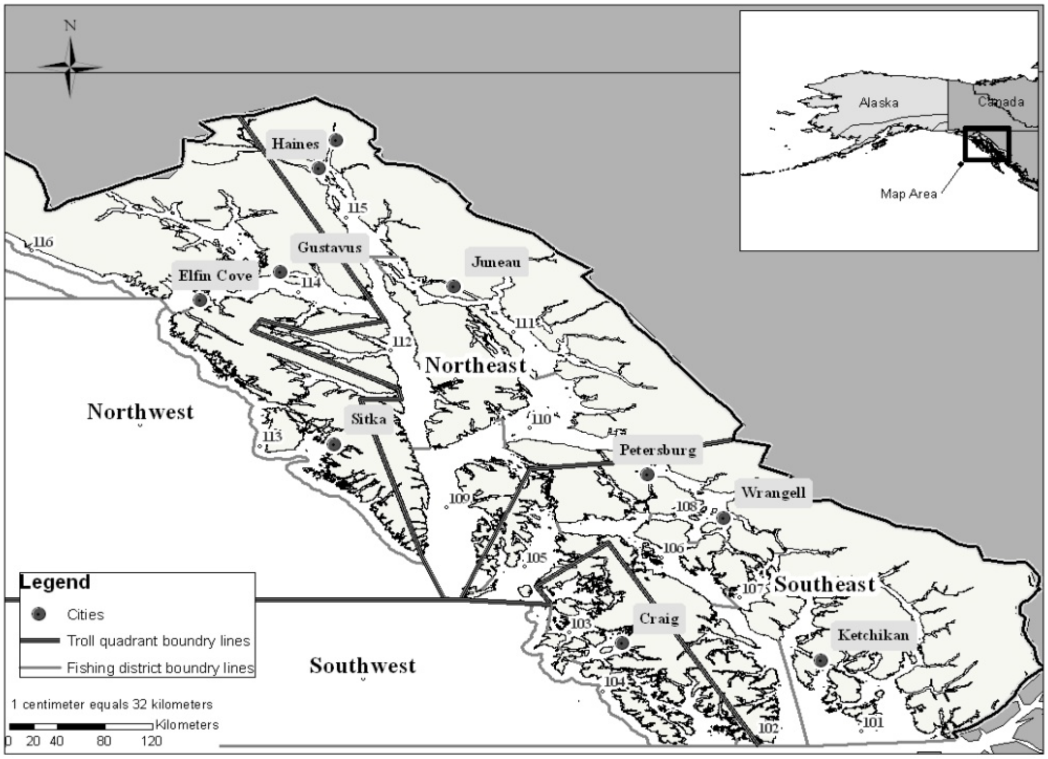

Figure 7.–Southeast Alaska troll fishery quadrants.

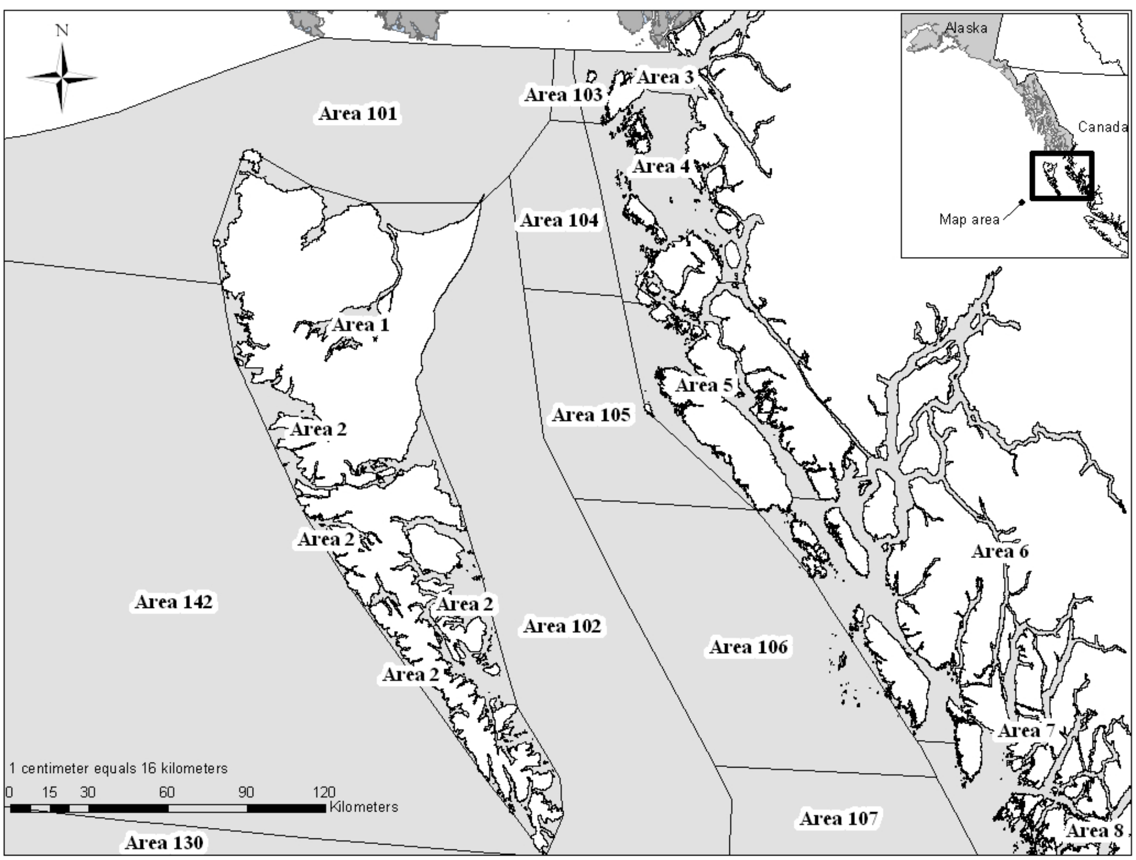

Figure 8.–Northern British Columbia fishery management areas.

Harvest statistics were obtained from the published results in the 1999–2001 Statewide Harvest Survey (SWHS), which included total boat harvest prior to statistical week 25 in the Anchor River, Whiskey Gulch, Deep Creek, and Ninilchik River areas (Howe et al. 2001; Walker et al. 2003; Jennings et al. 2004). CWT sampling information from the Cook Inlet early-run marine sport fishery in 2002 was obtained from the Tag Lab database, and harvest statistics were obtained from the published results in the 2002 SWHS (Kenai Peninsula area, total boat harvest prior to 25 June; Jennings et al. 2006). Aside from voluntary recoveries, sampling of this fishery was terminated after the 2002 season.

The Kodiak recreational fishery and commercial purse seine and set gillnet fisheries were sampled from 1997 to 1999 for Chinook salmon CWTs. Recovery information, sampling statistics, and harvest numbers were obtained from the Tag Lab database.

Chinook salmon by-catch has been sampled for Chinook salmon CWTs in high seas trawl fisheries by the National Marine Fisheries Service throughout the duration of this study. Recovery information, sampling statistics, and harvest numbers were obtained from RMIS.

Random recoveries of Unuk River CWTs from sampled fisheries with known or estimated catch were used to estimate harvest contributions. The contribution r_{uj} of a release group or brood of interest *j* to one fishery stratum *u* is:

$$\hat{r}_{uj} = H_u \left[\frac{m_{uj}}{\lambda_u n_u} \right] \theta_j^{-1}; \qquad \lambda_u = \frac{a'_u t'_u}{a_u t_u} \tag{29}$$

where H_u = total harvest in fishery stratum u, n_u = number of fish inspected (the sample) from fishery stratum *u*, a_u = number of fish in n_u that are missing an adipose fin, a'_u = number of heads from a_u that arrive at the lab, t_u = number of heads from a'_u with CWTs detected, t'_u = number of CWTs from t_u that are dissected from heads and decoded, m_{uj} = number of CWTs with code(s) of interest from n_u, and θ_j = fraction of the brood year *j* tagged with code(s) of interest. Separate strata are used for fish ≥28 in TL(legal size) and fish <28 in TL (sublegal size, jacks) as harvest and sampling data for these size categories are reported separately in Alaska's commercial and recreational fisheries. When H_u and θ_j are known without error, an unbiased estimate of the variance of $\hat{r}_{uj}$ can be calculated as shown by Clark and Bernard (1987). However, in our situation, H_u is estimated with error for sport fisheries, and θ_j is estimated with error on the Unuk River because it is not possible to count or tag all outmigrating smolt. For these reasons, unbiased estimates of the variance of $\hat{r}_{uj}$ were obtained using equations in Table 2 of Bernard and Clark (1996), which show the formulations for large samples.

Select (CWTd fish sampled in a non-random fashion) and voluntary (CWTd fish recovered from other than established sampling programs) recoveries were not used to estimate harvest contributions.

Incidental and Total Fishing Mortality

Estimates of incidental fishing mortality by fishery strata were provided by the northern U.S. co-chair of the PSC CTC (John Carlile, ADF&G, Division of Commercial Fisheries, Juneau, personal communication). Incidental fishing mortality (IM) is mortality caused by the act of fishing but is not part of the actual landed catch and is defined as the difference between reported (or landed) catch and total fishing mortality (FM) in Aggregate Abundance Based Management fisheries (CTC 2005). The CTC of the PSC currently defines 4 categories of incidental mortality: drop-offs, shakers, fish of legal size killed in Chinook salmon non-retention fisheries (CNR legal), and Chinook salmon not of legal size killed in non-retention fisheries (CNR sublegal; CTC 2004).

Drop-off mortality refers to fish that encounter fishing gear, are not successfully landed, but subsequently die as a result of the encounter. The CTC has derived regionally specific drop-off mortality rates for recreational and troll fisheries (CTC 1997). Drop-off mortality in these fisheries is comprised of 2 components: (1) escaped encounters – Chinook salmon that encounter fishing gear, escape prior to being landed, but subsequently die as a result of the encounter; and (2) predation mortality – fish that are lethally injured or removed from gear by predators. The total drop-off mortality rate for the SEAK and British Columbia troll fisheries is estimated to be 0.8% and 1.7%, respectively (CTC 1997). The total drop-off mortality rate for the SEAK and British Columbia recreational fisheries is estimated to be 3.6% (CTC 1997). Drop-off mortality in numbers of fish is then estimated as the relevant drop-off mortality rate times the estimated number of Chinook salmon encounters (the landed catch plus the estimated number of Chinook salmon released) in a fishery. Drop-off mortality is incorporated into legal and sublegal mortality estimation in both retention and CNR fisheries. The algorithm used to estimate drop-off mortality can be found in Appendix 1 of CTC (2004). Purse seine fisheries are considered to have zero drop-off mortality. Because incidental mortality in purse seine and gillnet fisheries are not estimated separately by the CTC, gillnet drop-off mortality is also currently considered to be zero.

Shakers are defined as Chinook salmon that are captured and released because they are either above (extralegal in fisheries with a maximum size limit) or below (sublegal) the legal size limit of a particular fishery (CTC 2004). The shaker mortality rate, the proportion of shakers that subsequently die, is currently only defined for sublegal shakers. Shaker mortality is estimated for each fishery stratum in which a Unuk River CWT was recovered using landed catch, the shaker encounter (legal-sublegal) ratio, and the sublegal shaker mortality rate. The sublegal shaker mortality rate is estimated to be the sum of the drop-off mortality rate (see above) and the mortality rate associated with the release of sublegal fish. The CTC estimates the sublegal release mortality rate to be 25.5% in troll fisheries, 32.2% for fish <33 cm (approximately 13 in) and 12.3% for fish ≥33 cm in recreational fisheries, 72% for purse seine fisheries, and 90% for gillnet fisheries (CTC 1997). However, the current CTC analyses do not separate the net gears into seine and gillnet and therefore must use a combined release mortality rate. The current non-retention mortality rates in use are 90% for legal-sized fish, 90% for sublegal-sized fish and 0% for drop-offs. The shaker encounter ratio for a particular fishery is defined as the ratio of sublegal fish encountered (non-vulnerable population) to legally landed (vulnerable) fish. The product of landed catch, the shaker encounter rate, and the shaker mortality rate provides a nominal estimate of shaker mortality in a given fishery strata. The estimated number of shakers in a stratum is then distributed among the various stocks identified within the fishery stratum, by age, according to their relative estimated abundance in the non-vulnerable population (CTC 2005). Note that it is assumed for any particular stock, the spatial and temporal distribution of sublegal fish of a given age is the same as legal fish of a given age (CTC 2005). Details of the shaker mortality estimation algorithm can be found in CTC (2004), Appendix 1.

During CNR fisheries, both legal-sized and sublegal-sized mortality occurs when Chinook salmon are captured incidental to the target species, but die subsequent to release as a result of the encounter. The estimated number of encounters times a gear mortality rate provides an estimate of CNR mortality for a particular fishery strata and size class. The CTC currently employs 3 separate methods to estimate the number of encounters in CNR fisheries (CTC 2004). The method utilized for a particular fishery depends on the observational data available. The effort/season-length ratio, the external estimate of encounters, and the catchability coefficient methods were used to estimate encounters in the CNR fisheries of relevance to this study. The first method indirectly calculates a CNR encounter rate based on the relative effort or season lengths between the retention and non-retention fisheries and then applies a gear selectivity factor to this rate. The external estimate of encounters method uses the ratio of encounters in a CNR fishery relative to the number of encounters in a retention fishery that immediately pre- or post- cedes the CNR fishery to estimate the number of CNR encounters. The catchability coefficient method is rarely used. It is only used to estimate CNR encounters for a fishery in years for which there was no landed catch. This situation precludes the use of the other two methods, which require landed catch. This method uses stock and age-specific catchability coefficients for both legal- and sublegal-sized fish, in addition to information on the duration of the CNR fishery, to estimate the number of CNR encounters (CTC 2004).

Gear selectivity factors used in the effort/season-length method are an estimate of the relative change in encounter rates between the CNR and retention fisheries resulting from management or fishing actions that reduce Chinook salmon encounters in the CNR fishery. The selectivity factor for legal-sized fish is 0.34 for SEAK troll and net fisheries, 0.20 for Northern British Columbia (NBC) troll, 0.34 for NBC recreational, and 1.0 for NBC net fisheries (Appendix 2 in CTC 2004). The selectivity factor for sublegal encounters is 1.0 for all of the above mentioned fisheries.

For the effort/season-length and the external estimate of encounters methods, CNR encounters of legal-sized fish are estimated as the product of the catch of legal-sized Chinook salmon in the retention fishery and a scalar. For the effort/season-length method, the scalar is the product of the gear selectivity factor and the ratio of the CNR season length to the length of the retention fishery, in days, or the ratio of CNR effort to retention fishery effort, in boat days or angler trips. For the external estimate of encounters method, the scalar is the ratio of the estimated legal CNR encounters to the landed catch in the retention fishery (Appendix 3 in CTC 2004). The stock and age composition of legal-sized fish in the CNR fishery is assumed to be identical to that of the retention fishery for legal-sized fish, and the CNR legal sized mortalities are apportioned accordingly.

Encounters of sublegal-sized fish are estimated in the same manner as the legal-sized fish. However, the sublegal gear selectivity factors are used in place of the legal gear selectivity factors in the effort/season-length method, and the estimated sublegal encounters are used in place of the legal encounters in the external estimate of encounters method. The stock and age composition of the sublegal-sized fish in the CNR fishery is assumed to be identical to that of the shakers in the retention fishery. The consequence of this assumption is that CNR sublegal mortalities are apportioned according to the relative stock abundance in the retention fishery, and within each stock, CNR sublegal mortalities are apportioned according to the relative abundance across all age classes.

The CTC algorithms that generate estimates of incidental mortality do not calculate associated estimates of variance; consequently estimates of incidental mortality by age will not have associated estimates of variance. However, assuming that for brood year j the relative precision of the total estimated fishing mortality $F\hat{M}_j$ (landed catch plus incidental mortality) was equal to that of the total estimated landed catch $\hat{R}_j$, the variance of the estimated incidental mortality $I\hat{M}_j$ can be indirectly estimated as (Hendrich et al. 2008):

$$\mathrm{var}\left(I\hat{M}_j\right) = \left(F\hat{M}_j \frac{\sqrt{\mathrm{var}\left(\hat{R}_j\right)}}{\hat{R}_j}\right)^2 - \mathrm{var}\left(\hat{R}_j\right) \tag{30}$$

Computer program memory limitations resulted in the grouping of some fisheries in the CTC's incidental mortality estimation algorithm. SEAK traditional purse seine and drift gillnet fisheries are one such example. These two fisheries have separate Chinook salmon harvest limits (quotas), management plans, and in the case of the purse seine fishery, size limits. The purse seine fishery has often been subject to periods of non-retention in order to avoid surpassing the annual harvest limit. Since 1995, however, the period of interest in this instance, the drift gillnet fishery, has had no periods of non-retention or size limitations on catch. The CTC algorithm, however, automatically estimates CNR mortality for the drift gillnet fishery during periods of purse seine non-retention. It was not possible to excise the CTC-generated CNR estimates for the drift net fishery from the total incidental mortality estimates used herein, nor was it possible to separate incidental mortality by category type.

Production, Exploitation Rate, and Marine Survival Estimation

The total estimated production (total return) of adults $\hat{T}$ from brood year j is:

$$\hat{T}_j = \sum_{i=1}^{L} \hat{N}_{ji} + \sum_{i=1}^{L} \hat{R}_{ji}\left(AEQ_{ji}\right) + \sum_{i=1}^{L} I\hat{M}_{ji}\left(AEQ_{ji}\right) \tag{31}$$

where

$\hat{N}_{ji}$ = estimated spawning abundance in year i from brood year j,

L = number of years over which fish from a given brood return (maximum = 5, representing ages 1.1 through 1.5),

$\hat{R}_{ji}$ = estimate of landed catch (harvest) in year i from brood year j,

$I\hat{M}_{ji}$ = incidental mortality in year i from brood year j, and

AEQ_{ji} = adult equivalent in year i from brood year j.

AEQ_{ji} is the probability that a fish of a given age (year i from brood year j) will return to the Unuk River in the absence of fishing in the current and all future years (Morishima 2004).

AEQs reduce $\hat{R}_{ji}$ and $I\hat{M}_{ji}$ to account for the fact that fish that are harvested and experience incidental mortality were not necessarily returning to the Unuk River that year (feeder fish). Adult equivalents are stock, brood, and age specific. AEQs for the Unuk stock are derived from returns to hatcheries with Unuk River brood stock (McPherson and Carlile 1997) and were provided by the northern U.S. CTC co-chair (John Carlile, ADF&G, Division of Commercial Fisheries, Juneau, personal communication).

The estimated variance of $\hat{T}_j$ was calculated as:

$$\mathrm{var}(\hat{T}_j) = \sum_{i=1}^{L} \mathrm{var}(\hat{N}_{ji}) + \sum_{i=1}^{L} \mathrm{var}(\hat{R}_{ji}) AEQ_{ji}^2 + \mathrm{var}\left[\sum_{i=1}^{L} I\hat{M}_{ji} AEQ_{ji}\right] \tag{32}$$

where $\mathrm{var}\left[\sum_{i=1}^{L} I\hat{M}_{ji} AEQ_{ji}\right]$ was calculated using Eq 32 with terms adjusted for AEQ.

For brood year j, the exploitation rate $\hat{U}_j$ and its associated variance was estimated as:

$$\hat{U}_j = \frac{F\hat{M}_j}{\hat{T}_j} \tag{33}$$

where total production and fishing mortality are expressed in AEQs. An approximation of the variance, incorporating the covariance between $F\hat{M}_j$ and $\hat{T}_j\,(= \mathrm{var}(\hat{R}_j) + \mathrm{var}(\hat{I}_j))$ was calculated via the delta method (Seber 1982, p. 8):

$$\mathrm{var}\left(\hat{U}_j\right) \approx \frac{F\hat{M}_j^{\,2}}{\hat{T}_j^{\,2}} \left[\frac{\mathrm{var}(F\hat{M}_j)}{F\hat{M}_j^{\,2}} + \frac{\mathrm{var}(\hat{T}_j)}{\hat{T}_j^{\,2}} - 2\frac{\mathrm{var}(F\hat{M}_j)}{(F\hat{M}_j)\hat{T}_j} \right] \tag{34}$$

and:

$$\mathrm{var}\left(F\hat{M}_j\right) = \mathrm{var}\left(I\hat{M}_j\right) + \mathrm{var}\left(\hat{R}_j\right) \tag{35}$$

Simulation shows the approximation in Eq 34 to be excellent.

Marine survival $\hat{Q}$ for brood year j was estimated as:

$$\hat{Q}_j = \frac{\hat{T}_j}{\hat{N}_{smolt,j}} \tag{36}$$

$$\mathrm{var}\left(\hat{Q}_j\right) = \left[\frac{\hat{T}_j}{\hat{N}_{smolt,j}}\right]^2 \left[\frac{\mathrm{var}\left(\hat{T}_j\right)}{\hat{T}_j^2} + \frac{\mathrm{var}\left(\hat{N}_{smolt,j}\right)}{\hat{N}^2_{smolt,j}} \right] \tag{37}$$

RESULTS

2007 MARK RECAPTURE STUDY

Event 1: Sampling in the Lower River

Between 12 June and 2 August 2007, 637 Chinook salmon were sampled in the lower river, of which 623 (46 fish <660 mm MEF and 577 large fish) were marked and released (Table 2). Five captured fish died prior to or during the marking process. Fishing effort at the set gillnets was maintained at relatively constant levels, with the exception of 10–17 July when exceptionally high water levels negated attempts to operate the set gillnets, and the period after 27 July when personnel shortages limited effort (Figure 9). The water levels during 10–17 July were judged to be the highest in a decade by the senior staff member on site (Roger Hayward, ADF&G, Division of Sport Fish, Ketchikan, personal communication). A total of 51 fish were missing adipose fins, of which 7 were sacrificed and 2 died prior to or during marking; the rest were marked and released in good condition. Of the 9 heads recovered during event 1, 6 had valid CWTs for this stock and 3 were without CWTs. Among the fish that were missing adipose fins and of those sacrificed, 41% and 78%, respectively, were males. Both fish that died prior to marking were females.

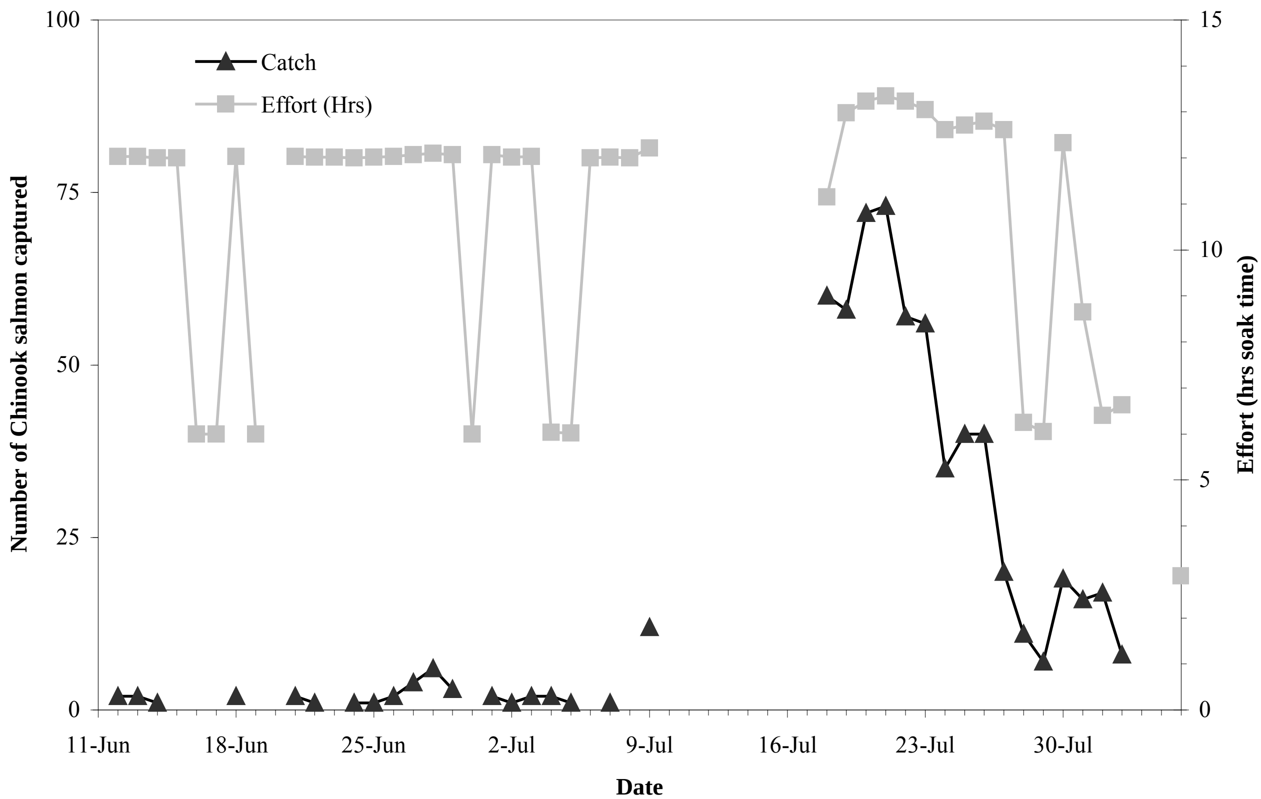

Figure 9.–Effort (in hours of soak time) and catch of Chinook salmon by date at SN1 on the Unuk River, 2007. SN = setnet.

Event 2: Sampling on the Spawning Grounds

During event 2, 1,319 fish were inspected (191 fish <660 mm MEF and 1,127 large fish), of which 123 were recaptured fish (9 <660 mm MEF and 114 large; Table 2). The smallest recaptured fish was 595 mm MEF. No sampled fish had shed their spaghetti tags, but one spaghetti tag number was misrecorded. Adipose fins were missing on 135 fish sampled during event 2, and 40 of these were sacrificed. Of the 40 adipose-clipped fish sacrificed, 33 carried a valid CWT for this stock. Among the fish that were missing adipose fins and of those sacrificed, 61% and 73%, respectively, were males.

Table 2.–Numbers of marked Chinook salmon ≥660 mm MEF (large; PANEL A) and 595–659 mm MEF (PANEL B) released in the lower Unuk River in 2007, and the numbers of marked Chinook salmon ≥660 mm MEF (PANEL C) and 540–659 mm MEF (PANEL D) released in the lower Unuk River in 2008, by marking period, and the number inspected for marks and recaptured at each recovery location.

PANEL A: LARGE (≥660 mm MEF) CHINOOK SALMON IN 2007										
		Recovery location								
Marking dates	Number	Eulachon	Clear	Lake	Kerr	Genes Lake	Cripple	Boundary	Total	Fraction
12 June - 18 July	99		4			4	1		9	0.091
19 July – 25 July	357	3	15	7	4	41	11	2	83	0.232
26 July – 2 August	121	5	1	1	1	9	4		21	0.174
Total/proportion[a]	577	8	20	8	5	54	17	2	114	0.198
Number inspected		58	203	36	30	485	298	17	1,127	
Fraction marked		0.14	0.10	0.22	0.17	0.11	0.06	0.12	0.10	
PANEL B: CHINOOK SALMON <660 mm MEF IN 2007										
		Recovery location								
Marking dates	Number	Eulachon	Clear	Lake	Kerr	Genes Lake	Cripple	Boundary	Total	Fraction
12 June – 18 July	8		1			2			3	0.38
19 July – 25 July	25	1				3	1		5	0.20
26 July – 2 August	13					1			1	0.08
Total/proportion	46	1	1			6	1		9	0.20
Number inspected		4	12	11	1	129	33	1	191	
Fraction marked		0.25	0.08	0.00	0.00	0.05	0.03	0.00	0.05	
PANEL C: LARGE (≥660 mm MEF) CHINOOK SALMON IN 2008										
		Recovery location								
Marking dates	Number	Eulachon	Clear	Lake	Kerr	Genes Lake	Cripple	Boundary	Total	Fraction
17 June – 17 July	172		3	1		3	1		8	0.047
18 July – 24 July	195		9	3		6			18	0.092
25 July – 4 August	190		14	1	2	9			26	0.137
Total/proportion[b]	557		27	5	3	18	1		54	0.097
Number inspected		2	126	24	14	123	16		305	
Fraction marked		0.00	0.21	0.21	0.21	0.15	0.06		0.18	
PANEL D: CHINOOK SALMON <660 mm MEF IN 2008										
		Recovery location								
Marking dates	Number	Eulachon	Clear	Lake	Kerr	Genes Lake	Cripple	Boundary	Total	Fraction
17 June – 17 July	29					1			1	0.03
18 July – 24 July	31		1						1	0.03
25 July – 4 August	32		2			1			3	0.09
Total/proportion	92		3			2			5	0.05
Number inspected			41	4	4	35	2		86	
Fraction marked			0.07	0.00	0.00	0.06	0.00		0.06	

[a] Total recoveries for Cripple Creek include one tagged fish with an unknown (misrecorded) tag number.

[b] Total recoveries for Clear and Kerr creeks each include one tagged fish with an unknown (shed) tag number.

Abundance by Size

Length distributions of large fish that were marked and recaptured were not significantly different ($P = 0.988$, $D = 0.044$; Figure 10; M vs. R in Appendix A1). Likewise, no difference was detected in the length distributions of large fish that were marked and inspected ($P = 0.677$, $D = 0.036$, Figure 11; M vs. C in Appendix A1) or inspected and recaptured ($P = 0.985$, $D = 0.044$, Figure 12; C vs. R in Appendix A1). These results indicate that size selective sampling did not occur during either event for large-sized fish (Case I, Appendix A1).

There was evidence of gender selectivity between sampling events for large fish ($\chi^2 = 15.125$, df = 1, $P < 0.001$ for M vs. C, $\chi^2 = 3.987$, df = 1, $P = 0.046$ for M vs. R, and $\chi^2 = 0.002$, df = 1, $P = 0.963$ for R vs. C). For recaptured large age-1.3 fish, however, of 48 fish identified as females during event 1, 10 (20.8%) were found to be males upon recapture during event 2. Of 47 large age-1.3 fish identified as male during event 1, 3 (6.4%) were subsequently found to be females during event 2. No gender misidentification was identified for fish of other age classes. Based on the observed proportion of gender misidentification during event 1, an estimated 55 large age-1.3 fish were misidentified as female, and 13 fish were misidentified as male. Revising the number of male and female fish marked during event 1 accordingly, contingency table analysis suggests the apparent gender bias was attributed to misidentification of gender during event 1 rather than selectivity during either sampling event ($\chi^2 = 2.109$, df = 1, $P = 0.146$ for M vs. C and $\chi^2 = 0.592$, df = 1, $P = 0.442$ for M vs. R). Because of the gender misidentification problems during event 1, only fish sampled on the spawning grounds were used to estimate the length and sex and age composition of the escapement.

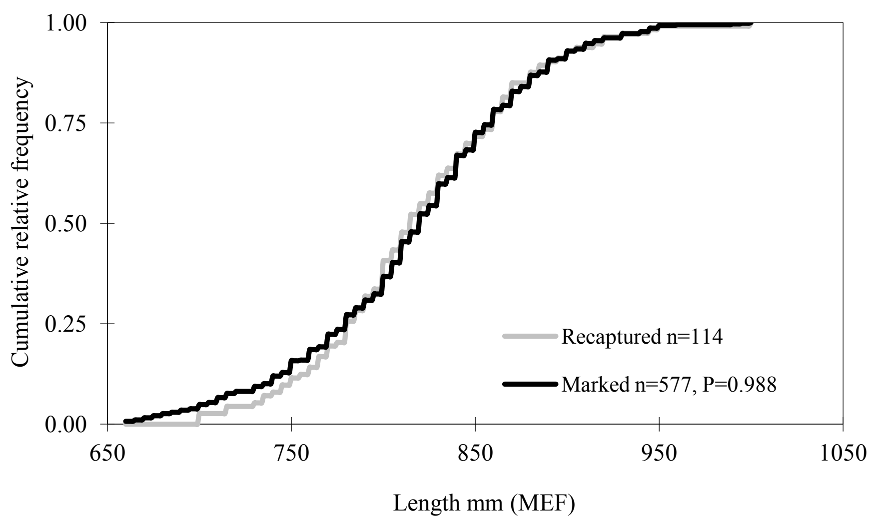

Figure 10.–Cumulative relative frequencies of large Chinook salmon (≥660 mm MEF) marked in the lower Unuk River in 2007 compared with those recaptured on the spawning grounds.

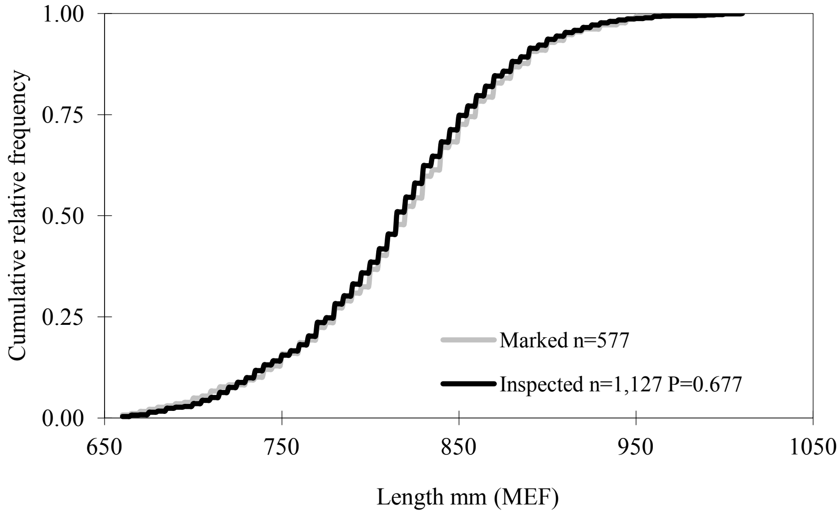

Figure 11.–Cumulative relative frequencies of large Chinook salmon (≥660 mm MEF) marked in the lower Unuk River in 2007 compared with those inspected on the spawning grounds.

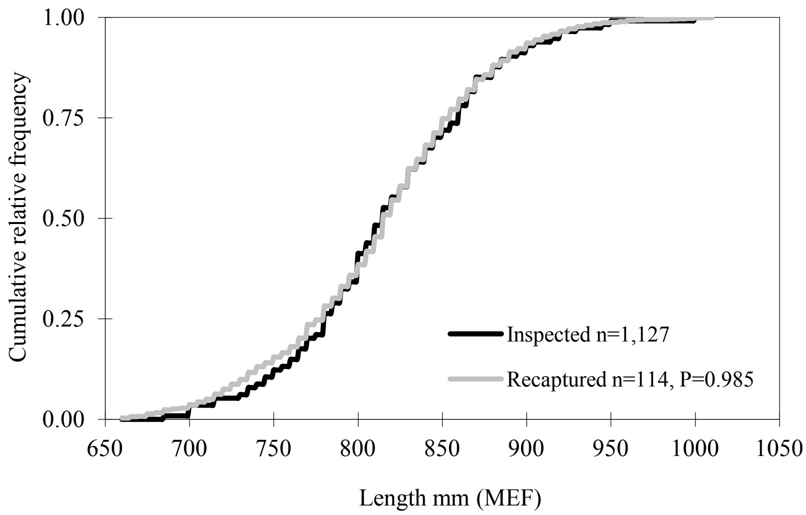

Figure 12.–Cumulative relative frequencies of large Chinook salmon (≥660 mm MEF) inspected on the spawning grounds in 2007 compared with those recaptured on the spawning grounds.

The probability of capturing a large fish during event 2 that was tagged during event 1 was not significantly different if the fish was among the first approximately 50% of fish tagged during event 1 (12 June – 21 July) or not (22 July – 2 August; χ^2 = 0.297, df = 1, P = 0.586; Table 2), satisfying the complete mixing test (Appendix A2).

Results from the diagnostic tests above indicated that the pooled estimator (Eq 1) was appropriate for estimating abundance of large Chinook salmon. Estimated abundance of large fish is 5,668 (M_L = 577; C_L = 1,127; R_L = 114; SE = 446; 95% CI = 4,900 – 6,685), roughly 1,800 fish more than the high end of the BEG range (3,800; Table 3, Figure 13).

Length distributions of fish between 595 mm MEF, the size of the smallest recaptured fish, and 659 mm MEF that were marked and inspected were significantly different (P = 0.027; Figure 14; M vs. C in Appendix A1). No difference was detected in the length distributions of fish 595–659 mm MEF that were marked and recaptured (P = 0.476; Figure 15; M vs. R in Appendix A1) or inspected and recaptured (P = 0.346; Figure 16; C vs. R in Appendix A1). These results indicate that further evaluation was required (Appendix A1) to determine if size-selective sampling occurred. The statistics did not fit any of the A-D scenarios in Appendix A1. We had small sample sizes for all of marked (35), recaptured (9), and inspected (100) fish, making option D the best candidate. P values for the C vs. R test and marked versus recaptured test were large at 0.35 and 0.48, respectively, however. We chose *Case IV* to be conservative. *Case IV* recommends stratification of data for one or both sampling events, which given the sparse number of recaptured fish, was an unsuitable alternative. Consequently, abundance of fish <660 mm MEF was estimated indirectly by expanding the estimate for large fish by the estimated size composition of the spawning escapement (Eq 3; McPherson et al. 1997). Testing of the spawning grounds samples collected in 1994 and 1997–2005 has consistently found no evidence of size or gender selectivity (Pahlke et al. 1996; Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002, Weller and McPherson 2003a-b. 2004, 2006a-b). Estimated abundance of fish <660 mm MEF is 961 (SE = 106), based on 191 fish <660 mm MEF and 1,127 large samples collected on the spawning grounds. Statistical bias of the estimate is 0.7% and the bootstrap-derived 95% confidence interval for the estimated abundance is 770 to 1,199.

Table 3.–Peak survey counts, mark-recapture estimates of abundance, expansion factors, and other statistics for large (≥660 mm MEF) Chinook salmon in the Unuk River (1997–2008 and 1997–2008 average).

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Ave 1997–2008
Survey count	636	840	680	1,341	2,019	897	1,121	1,008	929	940	709	242	947
m2	78	79	50	69	74	66	114	105	101	102	114	54	84
n1	307	466	380	570	778	725	646	501	644	853	577	557	583
n2	761	707	523	719	1,014	644	985	836	749	680	1,127	305	754
Mark-recapture (M-R) est	2,970	4,132	3,914	5,872	10,541	6,988	5,546	3,963	4,742	5,645	5,668	3,104	5,257
SE (M-R)	277	413	490	644	1,181	805	433	325	396	476	446	357	520
Survey count/ (M-R) (%)	21.4	20.3	17.4	22.8	19.2	12.8	20.2	25.4	19.6	16.7	12.5	7.8	18.0
CV (M-R) (%)	9.3	10.0	12.5	11.0	11.2	11.5	7.8	8.2	8.4	8.4	8.0	11.5	9.9
95% RP M-R estimate (%)	18.3	19.6	24.5	21.5	22.0	22.6	15.3	16.1	16.4	16.5	15.4	22.5	19.3
Expansion factor (EF)[a]	4.67	4.92	5.76	4.38	5.22	7.79	4.95	3.93	5.10	6.01	7.99	12.83	5.52
SE (EF)[a]	0.44	0.49	0.72	0.48	0.58	0.90	0.39	0.32	0.43	0.50	0.63	1.48	0.53[b]
CV (EF)[a]	9	10	13	11	11	12	8	8	8	8	17	12	18
95% RP (EF)[a]	18	20	25	21	22	23	15	16	16	16	32	23	35
M-R lower 95% C.I.	2,499	3,433	3,110	4,848	8,705	5,775	4,814	3,406	4,094	4,808	4,900	2,528	4,410
M-R upper 95% C.I.	3,636	4,974	5,071	7,347	13,253	8,845	6,530	4,684	5,579	6,786	6,685	3,991	6,448
Estimated bias (%)	0.1	0.6	1.5	1.1	0.9	0.6	0.03	0.50	0.5	0.5	0.3	1.6	0.7

[a] 1997–2008 average does not include the 2008 EF.

[b] The standard error for prediction ($\sqrt{var(\pi_p)}$ as defined in Eq 15 in Appendix A3) using 1997–2007 data is 1.32. The value is used in Appendix A4 in calculation of SE ($\hat{N}$) for years when there was no mark-recapture estimate.

EXPANSION FACTOR

The peak survey count of large Chinook salmon in the six index streams of the Unuk River was 709 fish in 2007 (Table 3; Appendix A4; Pahlke 2009). Of the estimated 5,668 large Chinook salmon immigrating to the Unuk River in 2007, 12.5% were counted during peak survey counts. This percentage was the lowest on record (Table 3; Pahlke et al 1996), and was attributed in part to our inability to completely survey Genes Lake Creek (high water) and Cripple Creek (high water and obstinate bears) during the peak of spawning. Using the 1997–2007 mark recapture estimates and peak survey counts, the long-term mean expansion factor is 5.52 (Table 3); the SE(mean expansion factor) is 1.30 (Eq 12 in Appendix A3), while SE(prediction), is 1.32 (Eq 15 in Appendix A3). The latter value is required for calculation of variances of predicted escapements for years in which there was no mark-recapture estimate (Appendix A4, column 6).

AGE AND SEX COMPOSITION

There was evidence of gender misidentification during event 1; therefore only event 2 samples were used to estimate the age, sex, and length composition of the spawning population. An estimated 68.2% (SE = 1.3%) of the spawning population of Chinook salmon was comprised of age-1.3 fish (Table 5). Since 1997, only the escapement in 2005 has had a larger proportion of the escapement represented by age-1.3 fish (68.6%: Appendix A6). Age-1.4 fish comprised 15.6% (SE = 1.0%) of the estimated spawning population, the second lowest contribution to the escapement since 1997 (2005, 15.1%; Appendix A6). Age-1.2 fish comprised 12.6% (SE = 0.9%) of the estimated spawning population. Since 1997, the percentage of age-1.2 fish in the spawning population has ranged from 15.1% (2005) to 38.8% (1997), and averaged 27.1% (Appendix A6).

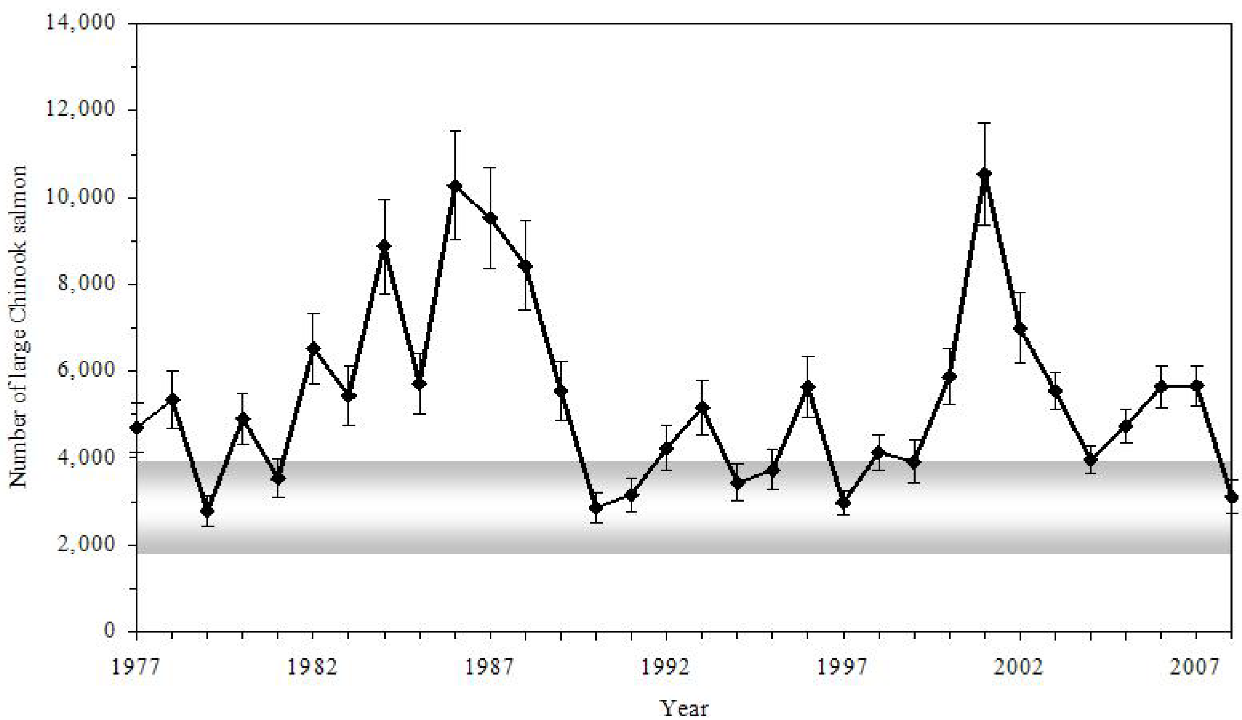

Figure 13.–Preferred estimates of spawning abundance and associated standard errors for large (≥660 mm MEF) Chinook salmon in the Unuk River relative to the biological escapement goal range (1,800–3,800; gray shaded bar), 1977–2008 (see Appendix A4 for numerical values).

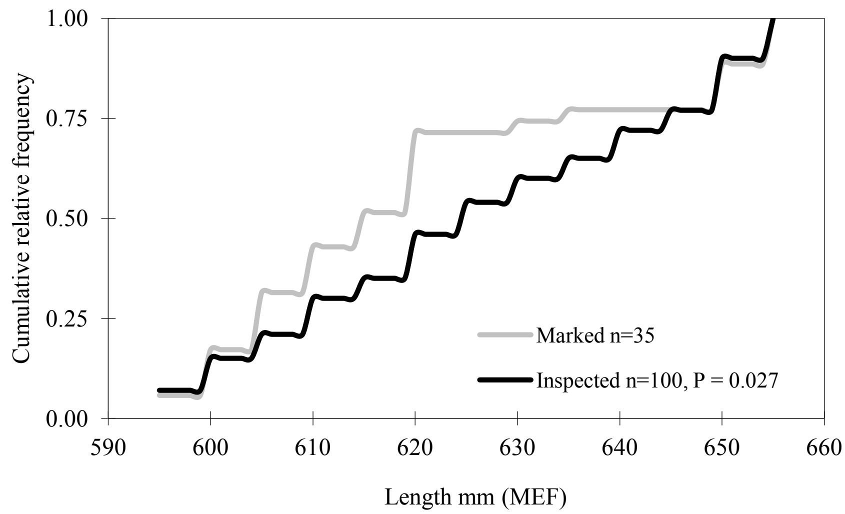

Figure 14.–Cumulative relative frequencies of Chinook salmon 595–659 mm MEF marked in the lower Unuk River in 2007 compared with those inspected on the spawning grounds.

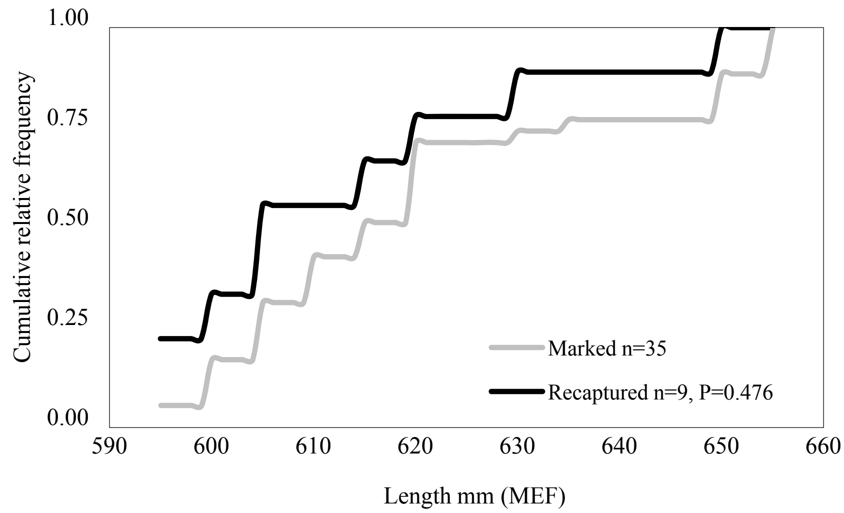

Figure 15.–Cumulative relative frequencies of Chinook salmon 595–659 mm MEF marked in the lower Unuk River in 2007 compared with those recaptured on the spawning grounds.

MIGRATORY TIMING

Migration past SN1 in 2007 was the latest on record (21 July; 1997–2007; Table 4). The mean date of migration past SN1 was estimated to be 22 July for those Chinook salmon marked at the set gillnet site and subsequently recovered on the spawning grounds. This compares to an average date of 11 July from 1997 through 2006. The earliest estimated mean migration date was for fish destined for Clear Creek (21 July). The latest mean migration date was 27 July for the Eulachon River stock.

For fish captured more than once at SN1, an average of 3.75 days elapsed between the time fish were tagged and released and when they were subsequently recaptured at SN1 (sulking behavior; Appendix A5).

Table 4.–Estimated mean date of migration of Chinook salmon stocks past SN1 on the Unuk River from 1997–2008 (Panel A), standard error (Panel B), and sample size (Panel C). SN = setnet.

PANEL A: ESTIMATED MEAN DATE OF MIGRATION AT SN1									
		Tributary							
Year	SN1	Eulachon River	Clear Creek	Lake Creek	Kerr Creek	Genes Lake Creek	Cripple Creek	Boundary Creek	Tributaries combined
1997	7-Jul	12-Jul	6-Jul		7-Jul	6-Jul	9-Jul		8-Jul
1998	3-Jul	10-Jul	5-Jul	21-Jun	29-Jun	2-Jul	4-Jul	3-Jul	3-Jul
1999	12-Jul		11-Jul		14-Jul	11-Jul	13-Jul		12-Jul
2000	11-Jul	15-Jul	11-Jul	10-Jul	14-Jul	13-Jul	15-Jul		13-Jul
2001	15-Jul	21-Jul	16-Jul	4-Jul	17-Jul	15-Jul	10-Jul	9-Jul	13-Jul
2002	15-Jul	19-Jul	11-Jul	22-Jul	20-Jul	17-Jul	17-Jul	26-Jul	17-Jul
2003	12-Jul	14-Jul	13-Jul	13-Jul	14-Jul	9-Jul	6-Jul	8-Jul	11-Jul
2004	9-Jul	18-Jul	8-Jul	10-Jul	9-Jul	7-Jul	9-Jul		9-Jul
2005	8-Jul	10-Jul	8-Jul	3-Jul	10-Jul	11-Jul	6-Jul	9-Jul	8-Jul
2006	9-Jul	14-Jul	11-Jul	5-Jul	3-Jul	9-Jul	11-Jul	12-Jul	10-Jul
2007	21-Jul	27-Jul	21-Jul	23-Jul	22-Jul	22-Jul	23-Jul	23-Jul	22-Jul
2008	19-Jul		22-Jul	20-Jul	29-Jul	21-Jul	13-Jul		22-Jul
1997–2006	10-Jul	15-Jul	10-Jul	8-Jul	11-Jul	10-Jul	10-Jul	11-Jul	11-Jul
PANEL B: STANDARD ERRORS OF THE MEAN DATE OF MIGRATION (in days)									
1997	0.36	3.59	1.54		1.28	1.36	0.73		0.59
1998	0.44	2.50	2.41		1.71	2.24	1.39		0.94
1999	0.43		1.56		4.01	1.92	1.67		1.02
2000	0.48		2.46	5.11	3.56	2.24	1.50		1.11
2001	0.38	3.84	3.46	6.81	0.33	1.67	1.65	6.67	1.15
2002	0.34	4.89	2.13	6.50	2.27	1.29	1.85	6.00	0.95
2003	0.39	5.50	2.10	2.70	1.70	1.28	2.90	7.37	0.87
2004	0.42	3.40	2.38	2.28	3.24	1.28	1.60		0.84
2005	0.32	0.79	1.11	5.07	3.45	0.98	1.02	0.49	0.61
2006	0.35		3.41	1.85		1.19	1.65	5.98	0.86
2007	0.31	0.97	0.86	1.21	1.54	0.47	0.77	2.50	0.34
2008	0.37		1.38	1.45	1.00	2.21			1.07
PANEL C: NUMBER OF FISH MARKED AT SN1 AND RECAPTURED ON TRIBUTARIES									
1997	383	5	20		9	18	38		90
1998	550	2	21	1	13	18	37	1	93
1999	504		13		6	11	29		59
2000	697	1	15	7	6	19	18		66
2001	853	3	13	3	3	15	28	3	68
2002	873	5	5	2	5	25	22	2	66
2003	703	2	22	9	21	37	10	4	105
2004	690	9	17	10	13	53	27		129
2005	714	6	18	4	7	26	46	6	113
2006	1,004	1	9	7	2	54	40	4	117
2007	623	9	21	8	5	60	17	2	122
2008	649		29	5	2	20	1		57

Note: 2000, 2004, and 2008 are leap years.

Table 5.–Estimated age and sex composition of the escapement of small (<660 mm MEF; PANEL A), large (≥660 mm MEF; PANEL B), and combined small- and large-sized (PANEL C) Chinook salmon in the Unuk River in 2007, as determined from spawning grounds samples.

		Brood year and age class									
		2005	2004	2003	2004	2003	2002	2001	2001	2000	
		1.0	1.1	2.1	0.2	1.2	1.3	2.3	1.4	1.5	Total
PANEL A: AGE COMPOSITION OF SMALL CHINOOK SALMON											
Males	Sample size	1	35	1	1	141	9				188
	p_{ijk} x100	0.5	18.6	0.5	0.5	75.0	4.8				100.0
	SE(p_{ijk}) x100	0.5	2.8	0.5	0.5	3.2	1.6				
	N_{ijk}	5	179	5	5	721	46				961
	SE(N_{ijk})	5	34	5	5	85	16				106
Sexes combined	Sample size	1	35	1	1	141	9				188
	p_{ij} x100	0.5	18.6	0.5	0.5	75.0	4.8				100.0
	SE(p_{ij}) x100	0.5	2.8	0.5	0.5	3.2	1.6				
	N_{ij}	5	179	5	5	721	46				961
	SE(N_{ij})	5	34	5	5	85	16				106
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON											
Males	Sample size					23	507	1	64		595
	p_{ijk} x100					2.1	45.4	0.1	5.7		53.3
	SE(p_{ijk}) x100					0.4	1.5	0.1	0.7		1.5
	N_{ijk}					117	2,573	5	325		3,019
	SE(N_{ijk})					26	219	5	47		252
Females	Sample size						375	1	140	6	522
	p_{ijk} x100						33.6	0.1	12.5	0.5	46.7
	SE(p_{ijk}) x100						1.4	0.1	1.0	0.2	1.5
	N_{ijk}						1,903	5	710	30	2,649
	SE(N_{ijk})						170	5	79	13	225
Sexes combined	Sample size					23	882	2	204	6	1,117
	p_{ij} x100					2.1	79.0	0.2	18.3	0.5	100.0
	SE(p_{ij}) x100					0.4	1.2	0.1	1.2	0.2	
	N_{ij}					117	4,476	10	1,035	30	5,668
	SE(N_{ij})					26	359	7	104	13	446
		1.0	1.1	2.1	0.2	1.2	1.3	2.3	1.4	1.5	Total
PANEL C: AGE COMPOSITION OF SMALL AND LARGE CHINOOK SALMON											
Males	Sample size	1	35	1	1	164	516	1	64		783
	p_{ik} x100	0.1	2.7	0.1	0.1	12.6	39.5	0.1	4.9		60.0
	SE(p_{ik}) x100	0.1	0.5	0.1	0.1	0.9	1.4	0.1	0.6		1.4
	N_{jk}	5	179	5	5	837	2,619	5	325		3,980
	SE(N_{jk})	5	34	5	5	94	221	5	47		329
Females	Sample size						375	1	140	6	522
	p_{ik} x100						28.7	0.1	10.7	0.5	40.0
	SE(p_{ik}) x100						1.3	0.1	0.9	0.2	1.4
	N_{jk}						1,903	5	710	30	2,649
	SE(N_{jk})						168	5	78	13	227
Sexes combined	Sample size	1	35	1	1	164	891	2	204	6	1,305
	p_j x100	0.1	2.7	0.1	0.1	12.6	68.2	0.2	15.6	0.5	100.0
	SE(p_j) x100	0.1	0.5	0.1	0.1	0.9	1.3	0.1	1.0	0.2	
	N_j	5	179	5	5	837	4,522	10	1,035	30	6,629
	SE(N_j)	5	34	5	5	95	360	7	104	13	527

An estimated 40% (SE = 1.4%) of the spawning population was female in 2007, similar to the previous 10-year average of 38.8% (Table 5, Appendix A6). There were an estimated 2,649 (SE = 227) spawning females in 2007 (Table 5). Estimated average lengths by age and sex were similar between events 1 and 2 in 2007 (Table 6).

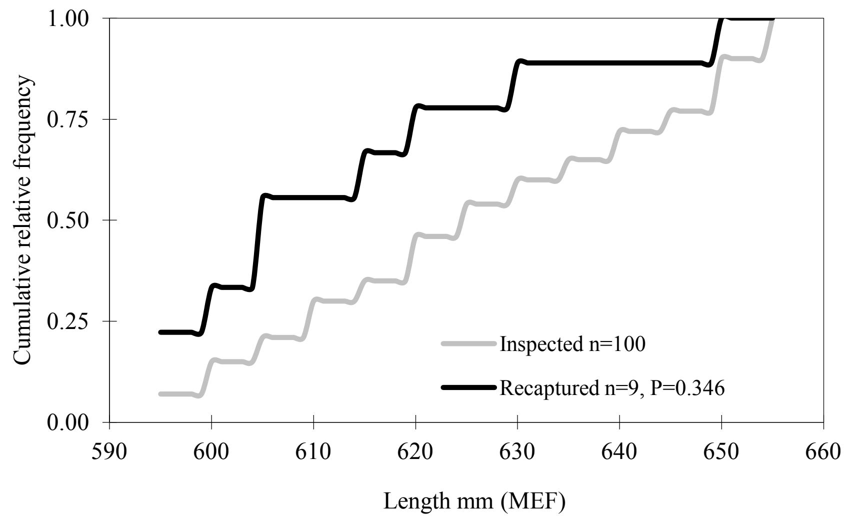

Figure 16.–Cumulative relative frequencies of Chinook salmon 595–659 mm MEF inspected on the spawning grounds in 2007 compared with those recaptured on the spawning grounds.

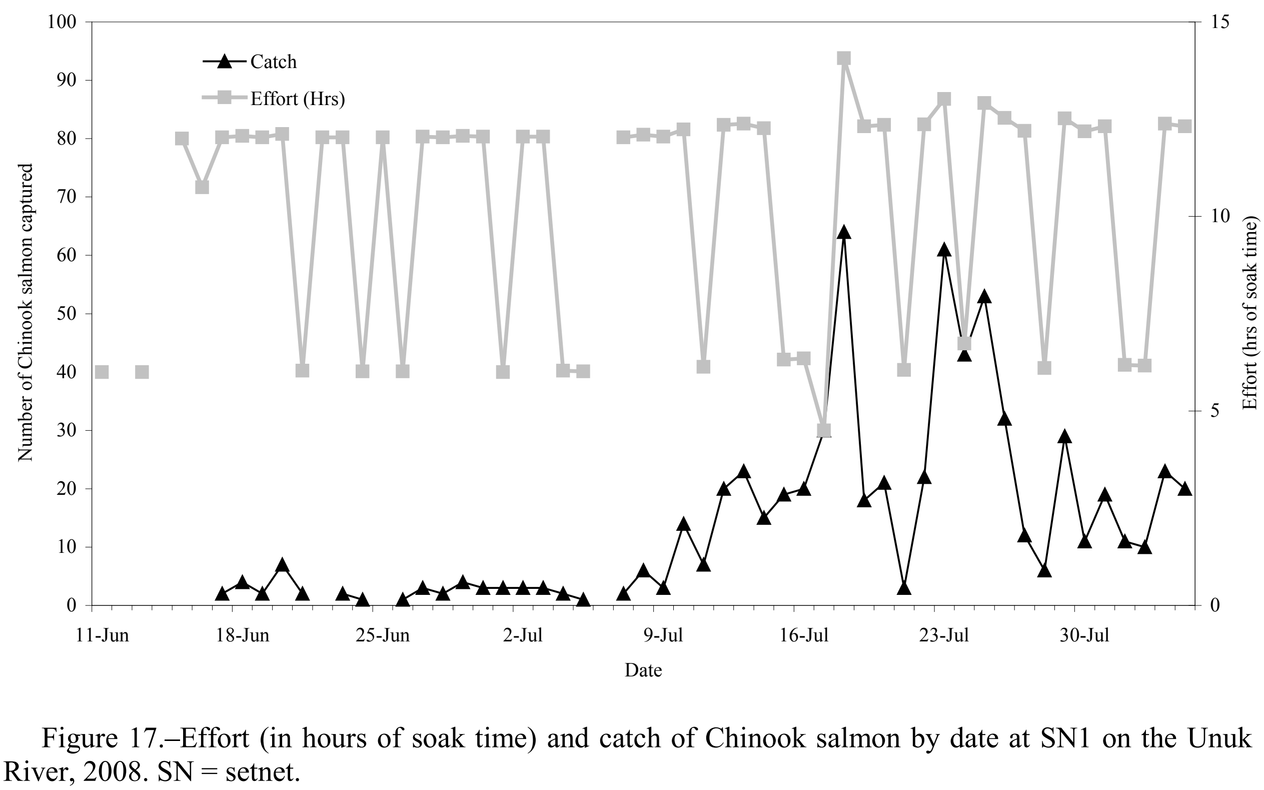

Figure 17.–Effort (in hours of soak time) and catch of Chinook salmon by date at SN1 on the Unuk River, 2008. SN = setnet.

Table 6.–Estimated average length (MEF in mm) by age class, sex, and sampling event of Chinook salmon sampled in the Unuk River in 2007

		Brood year and age class									
		2005 1.0	2004 1.1	2003 2.1	2004 0.2	2003 1.2	2002 1.3	2001 2.3	2001 1.4	2000 1.5	Total
PANEL A: EVENT 1, LOWER UNUK RIVER SET GILLNET											
Males[a]	Sample size		3			64	211		23		307
	Avg. length		400			629	800		867		764
	SD		23			52	65		71		106
	SE		13			7	4		15		6
Females[b]	Sample size						261		60	2	330
	Avg. length						819		877	915	830
	SD						44		42		50
	SE						3		5		3
Sexes combined[c]	Sample size		3			64	472		83	2	637
	Avg. length		400			629	811		874	915	798
	SD		23			52	55		52		88
	SE		13			7	3		6		3
PANEL B: EVENT 2, SPAWNING GROUNDS											
Males[d]	Sample size	1	34	1	1	164	516	1	65		791
	Avg. length	245	391	430	565	610	794	805	873		743
	SD		39			54	60		75		128
	SE		7			4	3		9		5
Females[e]	Sample size						375	1	140	6	527
	Avg. length						815	740	869	862	830
	SD						41		40	39	48
	SE						2		3	16	2
Sexes combined[f]	Sample size	1	34	1	1	164	891	2	205	6	1,318
	Avg. length	245	391	430	565	610	803	773	870	862	778
	SD		39			54	54	46	54	39	112
	SE		7			4	2	33	4	16	3

[a] Male total includes 6 fish of undetermined age.
[b] Female total includes 7 fish of undetermined age.
[c] Total includes 13 fish of undetermined age.
[d] Male total includes 8 fish of undetermined age.
[e] Female total includes 5 fish of undetermined age.
[f] Total includes 13 fish of undetermined age.

2008 MARK RECAPTURE STUDY

Event 1: Sampling in the Lower River

Between 11 June and 4 August 2008, 665 Chinook salmon were sampled in the lower river, of which 649 (92 fish <660 mm MEF and 557 large) were marked and released (Table 2). Seven captured fish died prior to or during the marking process. Fishing effort at the set gillnets was maintained at relatively constant levels through 4 August (Figure 17). Persistent flooding began on 5 August and effectively ended event 1 activities. A total of 52 fish were missing adipose fins, of which 8 were sacrificed and 2 died prior to or during marking; the rest were marked and released in good condition. Of the 10 heads recovered during event 1, 4 had valid CWTs for this stock, 3 heads were purloined by ravens, and three were without CWTs. Among the fish that were missing adipose fins and of those sacrificed, 33% and 80%, respectively, were males. Both adipose-clipped fish that died prior to marking were females, and neither fish was subsequently determined to have had a CWT.

Event 2: Sampling on the Spawning Grounds

During event 2, 391 fish were inspected (86 fish <660 mm MEF and 305 large), of which 59 were recaptured fish (5 <660 mm MEF and 54 large; Table 2). The smallest recaptured fish was 540 mm MEF. Two sampled fish had shed their spaghetti tags. Adipose fins were missing on 51 fish sampled during event 2, and 15 of these were sacrificed. Of the 15 adipose-clipped fish sacrificed, 10 carried a valid CWT for this stock. All five sacrificed fish that did not contain a CWT were determined to be age-1.2 fish. Among the fish that were missing adipose fins and of those sacrificed, 67% and 87%, respectively, were males.

Because of persistent flooding from 5 to 18 August, the effectiveness of escapement sampling at Genes Lake and Clear Creek was seriously degraded. During this period it was also impossible to safely reach other escapement tributaries, impossible to capture fish in other tributaries, or both. This period encompassed the traditional peak spawning dates on the various tributaries of the Unuk River. Cripple Creek, which typically supports 1 of the 2 largest spawning populations in the Unuk River watershed, was first sampled on 20 August and few fish or fish carcasses remained.

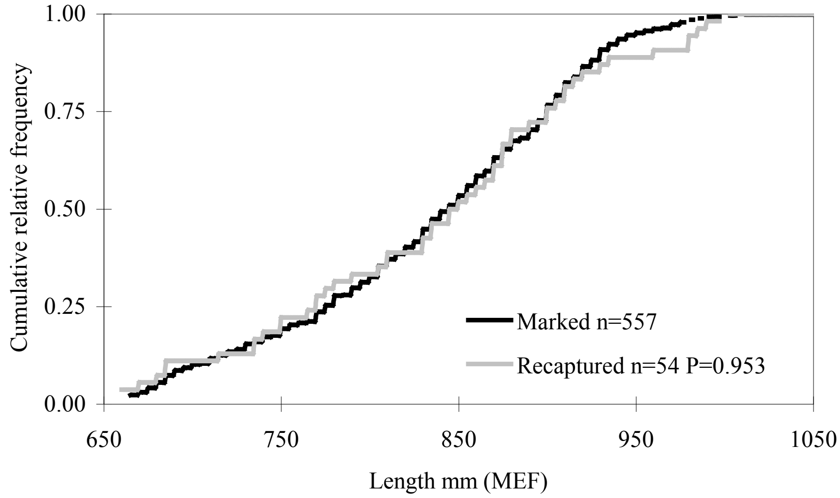

Figure 18.–Cumulative relative frequencies of large Chinook salmon (≥660 mm MEF) marked in the lower Unuk River in 2008 compared with those recaptured on the spawning grounds.

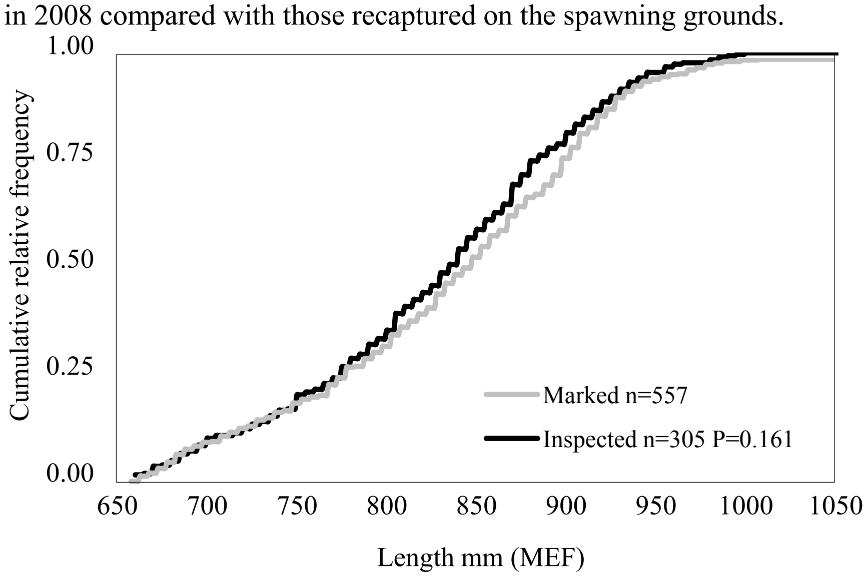

Figure 19.–Cumulative relative frequencies of large Chinook salmon ≥ PP 0() PDUNHGLQWKH ORZHU8QXN5LYHULQ FRPSDUHGZLWKWKRVHLQVSHFWHGRQWKHVSDZQLQJJURXQGV

Abundance by Size

Length distributions of large fish that were marked and recaptured were not significantly different (P = 0.953, D = 0.071; Figure 18; M vs. R in Appendix A1). Likewise, no difference was detected in the length distributions of large fish that were marked and inspected (P = 0.161, D = 0.078, Figure 19; M vs. C in Appendix A1) or inspected and recaptured (P = 0.888, D = 0.081, Figure 20; C vs. R in Appendix A1).

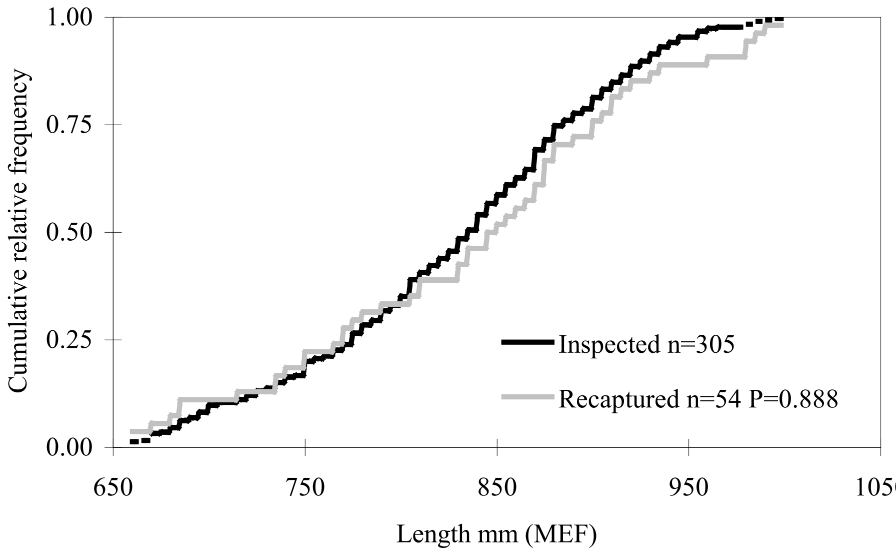

Figure 20.–Cumulative relative frequencies of large Chinook salmon (≥660 mm MEF) inspected on the spawning grounds in 2008 compared with those recaptured on the spawning grounds.

These results indicate that size-selective sampling did not occur during either event for large-sized fish (Case I, Appendix A1).

There was evidence of gender selectivity during event 2 sampling of large fish (χ^2 = 3.137, df = 1, P = 0.077 for M vs. C; χ^2 = 4.305, df = 1, P = 0.038 for M vs. R; and χ^2 = 1.309, df = 1, P = 0.253 for C vs. R; Case II, Appendix A1). This is an atypical result and reflects multiple event 2 sampling limitations caused by the extensive flooding that occurred from 5 to 19 August; the major population at Cripple Creek was basically unsampled, total sample size was much lower than in prior years, sampling was almost totally reliant on hook-and-line snag gear, few carcasses were available for sampling, and both sampling and sampling effectiveness were skewed towards the latter stages of the spawning event in most if not all tributaries.

The results of the chi-square test suggest that for large fish, the set gillnets were not gender selective. However, gender misidentification did occur during event 1; of 52 fish with spaghetti tags that were sampled during event 2, 2 females and 1 male were misidentified during event 1. These results suggest that a bias of from approximately 2 to 6% would occur if event 1 samples were used to estimate the gender composition of the inriver return.

The samples from neither event could therefore be used to produce an unbiased estimate of gender composition and we believe the best alternative was to estimate the sex composition of large fish based on event 1 samples. Although the result could have a gender bias of up to 6% attributed to misidentification, the event 1 samples uniformly spanned the vast majority of the migration and gender selectivity was not otherwise indicated. In contrast, during event 2, testing indicated gender selectivity of significant but unknown magnitude did occur and sampling did not uniformly span the entire spawning population in either temporal or spatial terms.

The probability of capturing a large fish during event 2 that was tagged during event 1 was not significantly different between sampling locations (χ^2 = 4.161, df = 5, P = 0.527; Table 2), satisfying the equal proportions test (Appendix A2). The mixing test was marginally significant (χ^2 = 16.9, df = 10, P = 0.08), while the complete mixing test was significant (χ^2 =8.7, df = 2, P = 0.012).

Results from the diagnostic tests above indicated that the pooled estimator (Eq 1) was appropriate for estimating abundance of large Chinook salmon. Estimated abundance of large fish is 3,104 (M_L = 557; C_L = 305; R_L = 54; SE = 357; 95% CI = 2,528 – 3,991) which lies within the BEG range (1,800–3,800; Table 3, Figure 13).

Length distributions of fish between 540 mm MEF, the size of the smallest recaptured fish, and 659 mm MEF that were marked and inspected were significantly different (P = 0.078; Figure 21; M vs. C in Appendix A1). No difference was detected in the length distributions of fish 540–659 mm MEF that were marked and recaptured (P = 0.389; Figure 22; M vs. R in Appendix A1) or inspected and recaptured (P = 0.972; Figure 23; C vs. R in Appendix A1). These results indicate that further evaluation was required (Appendix A1) to determine if size-selective sampling occurred. The statistics did not fit any of the A-D scenarios in Appendix A1. We had small sample sizes for all of marked (84), recaptured (5) fish and inspected (64) fish, making option D the only candidate. P values for the inspected vs. recaptured test and marked vs. recaptured test were large at 0.98 and 0.39, respectively, however. We chose *Case IV* to be conservative. *Case IV* recommends stratification of data for one or both sampling events, which given the sparse number of recaptured fish, was an unsuitable alternative. Abundance of fish <660 mm MEF was therefore estimated indirectly by expanding the estimate for large fish by the estimated size composition of the spawning escapement (Eq 3; McPherson et al. 1997). Testing of the spawning grounds samples collected in 1994 and 1997–2007 has consistently found no evidence of size selectivity (Pahlke et al. 1996; Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002, Weller and McPherson 2003a-b. 2004, 2006a-b). No sampled fish <660 mm MEF was determined to be female during this study, consequently gender selectivity was considered to be irrelevant in estimating the sex composition of fish <660 mm MEF. Estimated abundance of fish <660 mm MEF is 875 (SE = 146), based on 86 fish <660 mm MEF and 305 large samples collected on the spawning grounds. Statistical bias of the estimate is 2% and the bootstrap-derived 95% confidence interval for the estimated abundance is 632 to 1,228.

EXPANSION FACTOR

In 2008 the peak survey count of large Chinook salmon in the six index streams of the Unuk River was 242 fish (Table 3; Appendix A4; Pahlke 2010). Of the estimated 3,104 large Chinook salmon immigrating to the Unuk River in 2008, 7.8% were counted during peak survey counts. This percentage was the lowest on record (Table 3; Pahlke et al 1996), and was attributed to flooding during the peak of spawning that precluded our ability to survey Cripple Creek and resulted in poor and/or incomplete surveys in the remaining five index streams. The 2008 expansion factor is 12.8 (Table 3). As the 2008 survey data was incomplete, the long-term mean expansion factor was not revised from 2007.

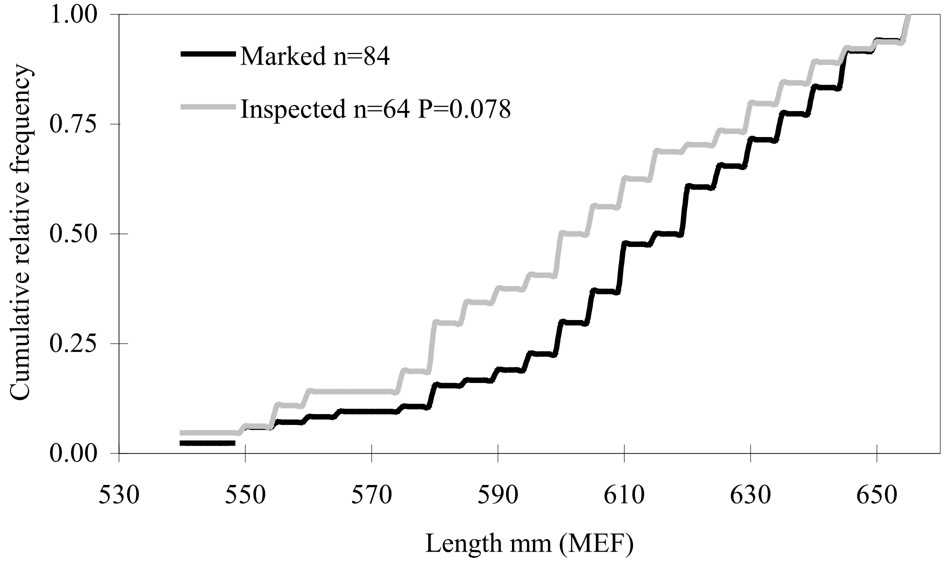

Figure 21.–Cumulative relative frequencies of Chinook salmon 540–659 mm MEF marked in the lower Unuk River in 2008 compared with those inspected on the spawning grounds.

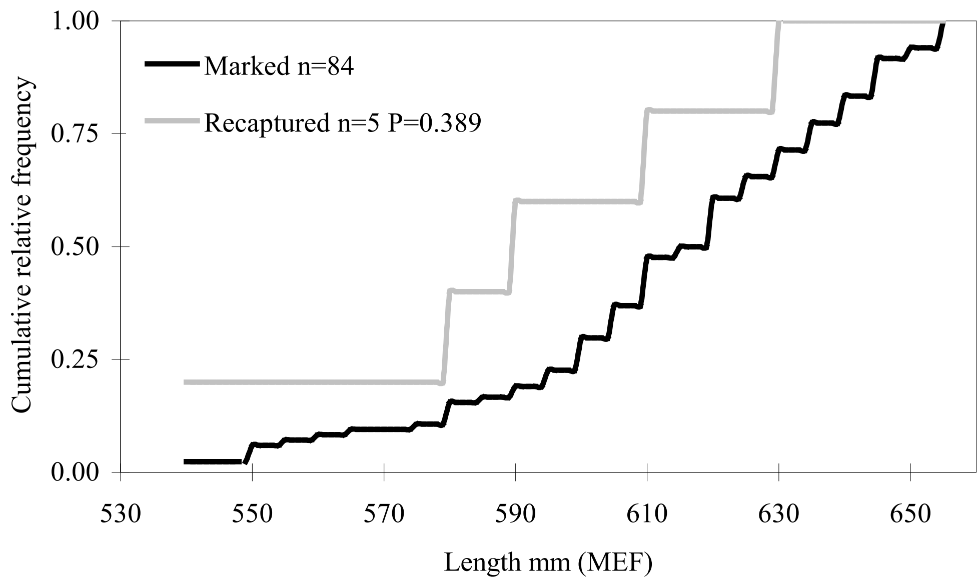

Figure 22.–Cumulative relative frequencies of Chinook salmon 540–659 mm MEF marked in the lower Unuk River in 2008 compared with those recaptured on the spawning grounds.

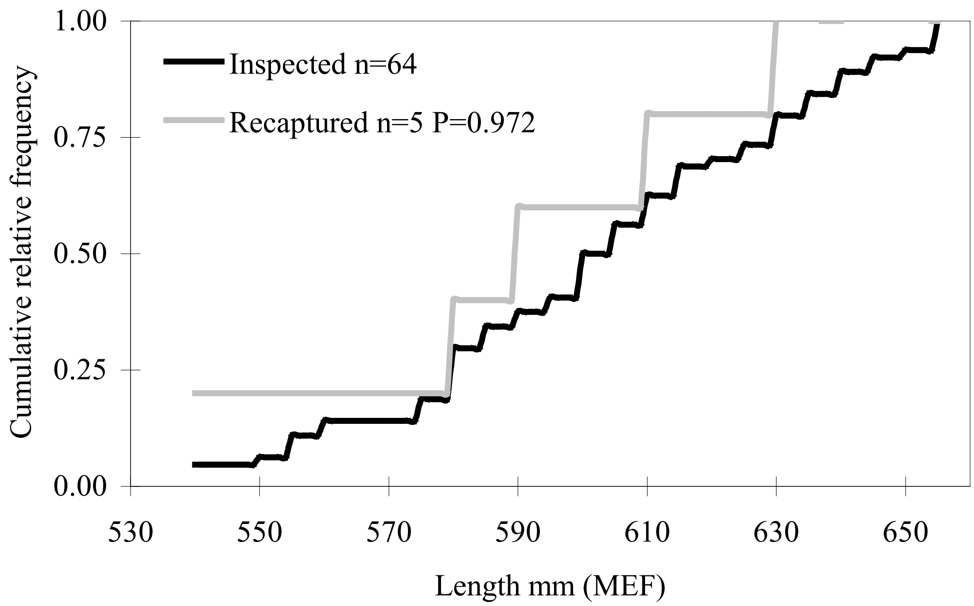

Figure 23.–Cumulative relative frequencies of Chinook salmon 540–659 mm MEF inspected on the spawning grounds in 2008 compared with those recaptured on the spawning grounds.

MIGRATORY TIMING

Migration past SN1 in 2008 was the second latest on record (19 July; 1997–2008; Table 4). The mean date of migration past SN1 was estimated to be 22 July for those Chinook salmon marked at the set gillnet site and subsequently recovered on the spawning grounds (Table 4). This compares to an average date of 11 July from 1997 through 2006.

For fish captured more than once at SN1, an average of 5.54 days elapsed between the time fish were tagged and released and they were subsequently recaptured at SN1 (sulking behavior; Appendix A7).

AGE AND SEX COMPOSITION

There was evidence of gender selectivity of large fish during event 2; therefore only event 1 samples were used to estimate the age and sex composition of large fish in the spawning population. Event 2 samples were used to estimate the age and sex composition of fish <660 mm MEF (see above). An estimated 41.0% (SE = 2.0%) of the spawning population of Chinook salmon was comprised of age-1.4 fish (Table 7). Age-1.3 and age-1.2 fish comprised 30.9% (SE = 1.8%) and 23.5% (SE = 2.0%) of the estimated spawning population, respectively.

There were an estimated 1,717 (SE = 209) spawning females, representing approximately 43% of the total spawning population in 2008 (Table 7). Estimated average lengths by age and sex were similar between events 1 and 2 in 2008 (Table 8).

Table 7.–Estimated age and sex composition of the escapement of small (<660 mm MEF; PANEL A), large (≥660 mm MEF; PANEL B), and combined small and large sized (PANEL C) Chinook salmon in the Unuk River in 2008, as determined from inriver set gillnet (large fish) and spawning grounds samples (small fish).

		Brood year and age class						
		2005	2004	2004	2003	2002	2001	
		1.1	1.2	0.3	1.3	1.4	1.5	Total
PANEL A: AGE COMPOSITION OF SMALL CHINOOK SALMON								
Males	Sample size	16	69		1			86
	p_{ijk} x100	18.6	80.2		1.2			100.0
	SE(p_{ijk}) x100	4.2	4.3		1.2			
	N_{ijk}	163	702		10			875
	SE(N_{ijk})	45	123		10			146
Sexes combined	Sample size	16	69		1			86
	p_{ij} x100	18.6	80.2		1.2			100.0
	SE(p_{ij}) x100	4.2	4.3		1.2			
	N_{ij}	163	702		10			875
	SE(N_{ij})	45	123		10			146
		1.1	1.2	0.3	1.3	1.4	1.5	Total
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON								
Males	Sample size		42	1	122	82	1	248
	p_{ijk} x100		7.6	0.2	22.0	14.8	0.2	44.7
	SE(p_{ijk}) x100		1.1	0.2	1.8	1.5	0.2	2.1
	N_{ijk}		235	6	682	459	6	1,387
	SE(N_{ijk})		44	6	95	70	6	172
Females	Sample size				96	210	1	307
	p_{ijk} x100				17.3	37.8	0.2	55.3
	SE(p_{ijk}) x100				1.6	2.1	0.2	2.1
	N_{ijk}				537	1,174	6	1,717
	SE(N_{ijk})				79	149	6	208
Sexes combined	Sample size		42	1	218	292	2	555
	p_{ij} x100		7.6	0.2	39.3	52.6	0.4	100.0
	SE(p_{ij}) x100		1.1	0.2	2.1	2.1	0.3	
	N_{ij}		235	6	1,219	1,633	11	3,104
	SE(N_{ij})		44	6	154	199	8	357
PANEL C: AGE COMPOSITION OF SMALL AND LARGE CHINOOK SALMON								
Males	Sample size	16	111	1	123	82	1	334
	p_{ik} x100	4.1	23.5	0.1	17.4	11.5	0.1	56.8
	SE(p_{ik}) x100	1.0	2.0	0.1	1.5	1.2	0.1	2.0
	N_{jk}	163	937	6	692	459	6	2,262
	SE(N_{jk})	46	149	6	97	71	6	290
Females	Sample size				96	210	1	307
	p_{ik} x100				13.5	29.5	0.1	43.2
	SE(p_{ik}) x100				1.3	1.8	0.1	2.0
	N_{jk}				537	1,174	6	1,717
	SE(N_{jk})				80	150	6	209
Sexes combined	Sample size	16	111	1	219	292	2	641
	p_j x100	4.1	23.5	0.1	30.9	41.0	0.3	100.0
	SE(p_j) x100	1.0	2.0	0.1	1.8	2.0	0.2	
	N_j	163	937	6	1,229	1,633	11	3,979
	SE(N_j)	46	149	6	155	198	8	470

Table 8.–Estimated average length (MEF in mm) by age class, sex, and sampling event of Chinook salmon sampled in the Unuk River in 2008.

		Brood year and age class						
		2005	2004	2004	2003	2002	2001	
		1.1	1.2	0.3	1.3	1.4	1.5	Total
PANEL A: EVENT 1, LOWER UNUK RIVER SET GILLNET								
Males	Sample size	8	131	1	126	83	1	350
	Avg. length	399	634	750	764	905	930	741
	SD	30	47		64	57		129
	SE	11	4		6	6		7
Females[a]	Sample size				97	214	2	315
	Avg. length				806	886	913	861
	SD				48	42	25	57
	SE				5	3	18	3
Sexes[a] combined	Sample size	8	131	1	223	297	3	665
	Avg. length	399	634	750	782	891	918	798
	SD	30	47		61	48	20	118
	SE	11	4		4	3	12	5
PANEL B: EVENT 2, SPAWNING GROUNDS								
Males	Sample size	16	98		72	54	1	241
	Avg. length	393	623		780	896	955	717
	SD	34	56		56	62		150
	SE	8	6		7	8		10
Females[b]	Sample size				49	99	1	150
	Avg. length				802	876	855	851
	SD				47	39		54
	SE				7	4		4
Sexes combined[b]	Sample size	16	98		121	153	2	391
	Avg. length	393	623		789	883	905	768
	SD	34	56		54	49	71	138
	SE	8	6		5	4	50	7

[a] Total includes two fish of undetermined age.

[a] Total includes one fish of undetermined age.

SMOLT ABUNDANCE AND OVERWINTER SURVIVAL

Details of daily catch, CPUE, and tagging of juvenile Chinook salmon from 1993–2004 are reported in Hendrich et al. (2008; Tables D1–D3). Details of daily catch, CPUE, and tagging of juvenile Chinook salmon from 2005 through spring 2009 are provided in Appendices B1–B3, and mean length and weight of juvenile Chinook salmon from 1978 through spring of 2009 are provided in Appendix B4.

Brood Year 1992

A total of 13,789 fingerlings and 2,642 smolt from 1992 brood were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). The proportion of adipose-finclipped brood year 1992 fingerlings that survived to smolt, overwinter survival or $\hat{S}$, was estimated to be 0.805 (SE = 0.400), resulting in an estimated total of 13,856 finclipped smolt emigrating from the Unuk River in 1994 (Table 9). The estimated abundance of brood year 1992 fingerlings and smolt was 507,650 (SE = 334,752) and 408,521 (SE = 176,932; cv_{smolt} = 44.3%), respectively (Table 10).

Brood Year 1993

A total of 20,526 fingerlings and 3,227 smolt from brood year 1993 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival of fingerlings was estimated to be 0.738 (SE = 0.169), resulting in an estimated total of 18,380 finclipped smolt emigrating from the Unuk River in 1995 (Table 9). The estimated abundance of brood year 1993 fingerlings and smolt was 255,674 (SE = 78,576) and 188,746 (SE = 38,709; cv_{smolt} = 20.5%), respectively (Table 10).

Brood Year1994

A total of 40,206 fingerlings and 7,456 smolt from brood year 1994 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival of fingerlings was estimated to be 0.343 (SE = 0.082), resulting in an estimated total of 21,263 finclipped smolt emigrating from the Unuk River in 1996 (Table 9). The estimated abundance of brood year 1994 fingerlings and smolt was 693,103 (SE = 208,312) and 238,023 (SE = 43,531; cv_{smolt} = 18.3%), respectively (Table 10).

Brood Year1995

A total of 39,177 fingerlings and 12,517 smolt from brood year 1995 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival of fingerlings was estimated to be 0.574 (SE = 0.083), resulting in an estimated total of 35,014 finclipped smolt emigrating from the Unuk River in 1997 (Table 9). The estimated abundance of brood year 1995 fingerlings and smolt was 547,876 (SE = 101,921) and 314,609 (SE = 35,875; cv_{smolt} = 11.4%), respectively (Table 10).

Brood Year 1996

A total of 61,905 fingerlings and 17,121 smolt from brood year 1996 were released with valid CWTs (Table 9; appendix B1; Hendrich et al. 2008). Overwinter survival of fingerlings was estimated to be 0.636 (SE = 0.093), resulting in an estimated total of 56,474 finclipped smolt emigrating from the Unuk River in 1998 (Table 9). The estimated abundance of brood year 1996 fingerlings and smolt was 765,584 (SE = 143,055) and 486,678 (SE = 56,694; cv_{smolt} = 11.6%), respectively (Table 10).

Brood Year 1997

A total of 33,888 fingerlings and 7,948 smolt from brood year 1997 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival of fingerlings was estimated to be 0.678 (SE = 0.185), resulting in an estimated total of 30,909 finclipped smolt emigrating from the Unuk River in 1999 (Table 9). The estimated abundance of brood year 1997 fingerlings and smolt was 462,826 (SE = 162,422) and 313,589 (SE = 69,072; cv_{smolt} = 22.0%), respectively (Table 10).

Brood Year 1998

A total of 16,661 fingerlings and 13,333 smolt from the brood year 1998 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival of fingerlings was estimated to be 0.736 (SE = 0.135), resulting in an estimated total of 25,591 finclipped smolt emigrating from the Unuk River in 2000 (Table 9). The estimated abundance of brood year 1998 fingerlings and smolt was 369,347 (SE = 78,984) and 271,735 (SE = 30,003; cv_{smolt} = 11.0%), respectively (Table 10).

Brood Year 1999

A total of 31,925 fingerlings and 16,561 smolt from brood year 1999 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival was estimated to be 0.483 (SE = 0.129), resulting in an estimated total of 31,980 finclipped smolt emigrating from the Unuk River in 2001 (Table 9). The estimated abundance of brood year 1999 fingerlings and smolt was 623,264 (SE = 196,006) and 301,019 (SE = 49,889; cv_{smolt} = 16.6%), respectively (Table 10).

Brood Year 2000

A total of 44,371 fingerlings and 11,971 smolt from brood year 2000 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival was estimated to be 0.531 (SE = 0.082), resulting in an estimated total of 35,545 finclipped smolt emigrating from the Unuk River in 2002 (Table 9). The estimated abundance of brood year 2000 fingerlings and smolt was 779,643 (SE = 152,740) and 414,007 (SE = 49,935; cv_{smolt} = 12.1%), respectively (Table 10).

Brood Year 2001

A total of 54,546 fingerlings and 11,837 smolt from brood year 2001 were released with valid CWTs (Table 9; Appendix B1; Hendrich et al. 2008). Overwinter survival was estimated to be 0.273 (SE = 0.058), resulting in an estimated total of 26,709 finclipped smolt emigrating from the Unuk River in 2003 (Table 9). The estimated abundance of brood year 2001 fingerlings and smolt was 954,079 (SE = 248,475) and 260,132 (SE = 38,476; cv_{smolt} = 14.8%), respectively (Table 10).

Brood Year 2002

A total of 44,498 fingerlings and 14,396 smolt from brood year 2002 were released with valid CWTs (Table 9; Appendix B1). Overwinter survival was estimated to be 0.599 (SE = 0.108), resulting in an estimated total of 41,044 finclipped smolt emigrating from the Unuk River in 2004 (Table 9). The estimated abundance of brood year 2002 fingerlings and smolt was 754,516 (SE = 169,230) and 451,847 (SE = 59,987; cv_{smolt} = 13.3%), respectively (Table 10). BY 2002 estimates are preliminary pending returns of age-1.5 fish in 2009.

Table 9.–Number of fall fingerlings M_f and spring smolt M_s released with adipose fin clips, the estimated number of those fish that were released with valid CWTs ($\hat{M}_{f,valid}$, $\hat{M}_{s,valid}$), the number of fish with valid coded wire tags that were subsequently recovered ($\hat{v}_{\bullet,f}$, $\hat{v}_{\bullet,s}$), the estimated proportion of coded wire tagged fingerlings that survived to the following spring $\hat{S}$, the estimated number of adipose-finclipped fingerlings that survived to smolt $\hat{M}_{f\to s}$, and the estimated total number of adipose-finclipped smolt $\hat{M}$, 1992–2005 brood years. Note that estimates for the 2002–2005 brood years are preliminary, pending complete brood year returns.

Brood year	Year tagged	Season fish were marked	M_f, M_s	$\hat{M}_{f,valid}$, $\hat{M}_{s,valid}$	$\hat{v}_{\bullet,f}$, $\hat{v}_{\bullet,s}$	Recovery years	Recovery ages	$\hat{S}$	$SE(\hat{S})$	$\hat{M}_{f\to s}$	$SE(\hat{M}_{f\to s})$	$\hat{M}$
1992	1993	Fall	13,935	13,789	21	1996–1999	1.2–1.5	0.805	0.400	11,214	5,518	
1992	1994	Spring	2,642	2,642	5	1996–1999	1.2–1.5					13,856
1993	1994	Fall	20,526	20,526	108	1996–2000	1.1–1.5	0.738	0.169	15,153	3,468	
1993	1995	Spring	3,227	3,227	23	1996–2000	1.1–1.5					18,380
1994	1995	Fall	40,206	40,206	50	1997–2001	1.1–1.5	0.343	0.082	13,807	3,293	
1994	1996	Spring	7,456	7,456	27	1997–2001	1.1–1.5					21,263
1995	1996	Fall	39,177	39,177	133	1998–2002	1.1–1.5	0.574	0.083	22,497	3,255	
1995	1997	Spring	12,517	12,517	74	1998–2002	1.1–1.5					35,014
1996	1997	Fall	61,905	61,905	154	1999–2003	1.1–1.5	0.636	0.093	39,353	5,749	
1996	1998	Spring	17,121	17,121	67	1999–2003	1.1–1.5					56,474
1997	1998	Fall	33,888	33,888	52	2000–2004	1.1–1.5	0.678	0.185	22,961	6,273	
1997	1999	Spring	7,948	7,948	18	2000–2004	1.1–1.5					30,909
1998	1999	Fall	16,661	16,661	57	2001–2005	1.1–1.5	0.736	0.135	12,258	2,245	
1998	2000	Spring	13,333	13,333	62	2001–2005	1.1–1.5					25,591
1999	2000	Fall	31,925	31,925	27	2002–2006	1.1–1.5	0.483	0.129	15,419	4,121	
1999	2001	Spring	16,561	16,561	29	2002–2006	1.1–1.5					31,980
2000	2001	Fall	44,394	44,371	124	2003–2007	1.1–1.5	0.531	0.082	23,574	3,637	
2000	2002	Spring	11,971	11,971	63	2003–2007	1.1–1.5					35,545
2001	2002	Fall	54,546	54,546	49	2004–2008	1.1–1.5	0.273	0.058	14,872	3,188	
2001	2003	Spring	11,837	11,837	39	2004–2008	1.1–1.5					26,709
2002	2003	Fall	44,498	44,498	87	2005–2008	1.1–1.4	0.599	0.108	26,648	4,817	
2002	2004	Spring	14,396	14,396	47	2005–2008	1.1–1.4					41,044
2003	2004	Fall	27,129	27,129	18	2006–2008	1.1–1.3	0.300	0.099	8,133	2,073	
2003	2005	Spring	8,618	8,585	19	2006–2008	1.1–1.3					16,751
2004	2005	Fall	24,271	24,271	9	2007–2008	1.1–1.2	0.670	0.316	16,269	7,668	
2004	2006	Spring	16,371	16,269	9	2007–2008	1.1–1.2					32,640
2005	2006	Fall	32,799	32,799	2	2007–2008	1.0–1.1					
2005	2007	Spring	4,731	4,721	0	2007–2008	1.0–1.1					

-continued-

Table 9.–Page 2 of 2.

Brood year	Year tagged	Season fish were marked	M_f , M_s	$\hat{M}_{f,valid}$, $\hat{M}_{s,valid}$	$\hat{v}_{\bullet,f}$, $\hat{v}_{\bullet,s}$	Recovery years	Recovery ages	$\hat{S}$	$SE(\hat{S})$	$\hat{M}_{f\to s}$	$SE(\hat{M}_{f\to s})$	$\hat{M}$
2006	2007	Fall	45,148	45,089	0							
2006	2008	Spring	10,519	10,489	0							
2007	2008	Fall	16,608	16,595	0							
2007	2009	Spring	5,581	5,573	0							

Table 10.–The estimated total number of smolt released with adipose fin clips $\hat{M}$, the number of returning adults that were examined in river for the presence of an adipose fin clip $n_\bullet$, the number of fish examined that possessed an adipose fin clip $a_\bullet$, the estimated abundance of smolt $\hat{N}_{smolt}$ and the associated standard error of the estimate $SE(\hat{N}_{smolt})$, and the estimated abundance of fingerlings $\hat{N}_{fingerling}$ and the associated error of the estimate $SE(\hat{N}_{fingerling})$, 1992–2005 brood years. Note that estimates for the 2002–2005 brood years are preliminary, pending complete brood year returns.

Brood year	Recovery ages	$\hat{M}$	Recovery years	$n_\bullet$	$a_\bullet$	$\hat{N}_{smolt}$	$SE(\hat{N}_{smolt})$	$\hat{N}_{fingerling}$	$SE(\hat{N}_{fingerling})$
1992	1.1–1.5	13,856	1995–1999	795	26	408,521	176,932	507,650	334,752
1993	1.1–1.5	18,380	1996–2000	1,375	133	188,746	38,709	255,674	78,576
1994	1.1–1.5	21,263	1997–2001	1,040	92	238,023	43,531	693,103	208,312
1995	1.1–1.5	35,014	1998–2002	1,805	200	314,609	35,875	547,876	101,921
1996	1.1–1.5	56,474	1998–2003	2,343	271	486,678	56,694	765,584	143,055
1997	0.1–1.5	30,909	2000–2004	1,186	116	313,589	69,072	462,826	162,422
1998	1.1–1.5	25,591	2001–2005	2,112	198	271,735	30,003	369,347	78,984
1999	1.1–1.5	31,980	2002–2006	752	79	301,019	49,889	623,264	196,006
2000	1.1–1.5	35,545	2003–2007	2,573	220	414,007	49,935	779,643	152,740
2001	1.1–1.5	26,709	2004–2008	1,119	114	260,132	38,476	954,079	248,475
2002	1.1–1.4	41,044	2005–2008	2,553	231	451,847	59,987	754,516	169,230
2003	1.1–1.3	16,751	2006–2008	571	54	174,221	35,371	581,134	224,517
2004	1.1–1.2	32,640	2007–2008	256	23	349,530	104,579	521,448	291,102
2005	0.1–1.1		2008	26	2				

Brood Year 2003

A total of 27,129 fingerlings and 8,585 smolt from brood year 2003 were released with valid CWTs (Table 9; Appendix B1). Overwinter survival was estimated to be 0.300 (SE = 0.099), resulting in an estimated total of 16,751 finclipped smolt emigrating from the Unuk River in 2005 (Table 9). The estimated abundance of brood year 2003 fingerlings and smolt was 581,134 (SE =224,517) and 174,221 (SE = 35,371), respectively (Table 10). Brood year 2003 estimates are preliminary pending returns of age-1.4 in 2009 and age-1.5 fish in 2010.

Brood Year 2004

A total of 24,271 fingerlings and 16,269 smolt from brood year 2004 were released with valid CWTs (Table 9; Appendix B1). Preliminary estimates of overwinter survival and juvenile abundance based on age-1.1 and -1.2 returns are presented in Tables 9 and 10.

Brood Year 2005

A total of 32,799 fingerlings and 4,721 smolt from brood year 2005 were released with valid CWTs (Table 9; Appendix B1).

Brood Year 2006

A total of 45,089 fingerlings and 10,489 smolt from brood year 2006 were released with valid CWTs (Table 9; Appendix B1).

Brood Year 2007

A total of 16,595 fingerlings and 5,573 smolt from brood year 2007 were released with valid CWTs (Table 9; Appendix B1).

HARVEST, INCIDENTAL FISHING MORTALITY, TOTAL FISHING MORTALITY, PRODUCTION, EXPLOITATION RATE, AND MARINE SURVIVAL RATE ESTIMATES

Incidental mortality, fishing mortality (harvest), spawning abundance of age-1.1 fish, total production, and exploitation rate estimates for the 1992–1998 broods include revisions of previously published results (Hendrich et al. 2008). Results for the 2002–2005 broods are incomplete, pending further cohort returns. Results in tables presented by age class and brood or return year are subject to rounding error.

Estimation of Fraction of Adults Bearing CWTs

The estimated fractions of Chinook salmon bearing a valid CWT ($\hat{\theta}$) from the 1992–2001 brood years (broods with completed returns) ranged from .0282 (SE = 0.0055) for brood year 1992 to 0.1075 (SE = 0.0065) for brood year 1996 (Table 11; Appendix B5; Hendrich et al. 2008). Preliminary estimates of $\hat{\theta}$ from the 2002–2005 broods, pending further returns, ranged from 0.0615 (SE = 0.0056) for the 2002 brood to 0.0832 (SE = 0.0116) for brood year 2003.

Two strays from Crystal Lake Hatchery were recovered in the Unuk River: one in 1998 (released at Neets Bay, District 101-95; brood year 1995; Figure 5), and one in 2006 (released at Anita Bay, District 107-35; brood year 2001; Figure 5). One brood year 1999 stray from Deer Mountain Hatchery (released at Ketchikan Creek; District 101-47) was recovered in the Unuk River in 2003 (Figure 5).

Fishing Mortality, Production, Exploitation, and Marine Survival

Brood Year 1992

An estimated 538 (SE = 237) fish were harvested from brood year 1992 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 86.3% of the harvest estimate. Use of AEQ factors (Table 13) results in an estimated harvest of 492 (SE = 224) AEQs (Table 14). An estimated 205 (SE = 144) fish were harvested by troll gear, approximately 38% of the total harvest (Table 15; hereafter, all estimates of harvest by gear or location are in nominal fish). Approximately 29% of the harvest was by recreational gear (155 fish; SE = 155). Drift gillnet (143 fish; SE = 101) and purse seine (35 fish; SE = 35) gear accounted for roughly 27% and 7% of the estimated total harvest, respectively (Table 15). Harvest only occurred in the Northwest (47%; 255 fish; SE = 184), Southeast (46%; 248 fish; SE = 146), and Northeast (7%; 35 fish; SE = 35) Quadrants of SEAK (Table 16). Age-1.3 and age-1.4 fish accounted for roughly 50% (267 fish; SE = 157) and 29% (155 fish; SE = 155) of the estimated harvest, respectively (Table 12).

An estimated 261 fish (SE = 260) from the 1992 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 181 (SE = 209) adult equivalents (Table 14).

Table 11.–The number of returning adults that were examined inriver for the presence of an adipose fin clip n_i, the number of fish examined that possessed an adipose fin clip a_i, the number of adipose-finclipped fish that were sacrificed for coded wire tag verification a_i', the number of sacrificed fish that possessed a valid Unuk River Chinook salmon coded wire tag t_i, the estimated fraction of adults that possessed a valid Unuk River Chinook salmon coded wire tag $\hat{\theta}$ and the associated standard error, and the estimated variance (var) and squared coefficient of variability (G) for $\widehat{\theta^{-1}}$, 1992–2005 brood years. Note that estimates for the 2002–2005 brood years are preliminary, pending complete brood year returns.

Brood year	n_i	a_i	a_i'	t_i	$\hat{\theta}$	$SE(\hat{\theta})$	$var(\widehat{\theta^{-1}})$	$G(\widehat{\theta^{-1}})$
1992	795	26	22	19	0.0282447	0.0055462	61.1658980	0.0487959
1993	1,375	133	103	94	0.0882754	0.0073500	0.9397383	0.0073230
1994	1,040	92	53	46	0.0767779	0.0080460	2.0152755	0.0118798
1995	1,805	200	99	94	0.1052072	0.0071420	0.4272615	0.0047292
1996	2,343	271	113	105	0.1074751	0.0065360	0.3269891	0.0037770
1997	1,186	116	37	29	0.0766601	0.0087904	2.4286386	0.0142726
1998	2,112	198	53	53	0.0937500	0.0063111	0.5258979	0.0046221
1999	752	79	22	19	0.0907278	0.0117072	2.3067048	0.0189877
2000	2,573	220	74	71	0.0820370	0.0053940	0.6638722	0.0044679
2001	1,119	114	36	33	0.0933870	0.0093547	1.2188911	0.0106301
2002	2,553	231	74	54	0.0660273	0.0056358	1.7379676	0.0075768
2003	571	54	25	22	0.0832224	0.0116422	3.2363218	0.0224147
2004	256	23	19	13	0.0614720	0.0128740	15.4162400	0.0582551
2005	26	2	2	2	0.0769231	0.0465864	60.4654451	0.3577837

Total fishing mortality for the 1992 brood was estimated to be 672 (SE = 307) AEQs (Table 17). Based on an estimated spawning abundance of 3,199 (SE = 397) fish (Jones III et al. 1998; Jones III and McPherson 1999, 2000; Hendrich et al. 2008; Table 12), production was estimated to be 3,871 AEQs (SE = 502), and the exploitation rate was therefore estimated to be 0.1737 (SE = 0.0679; Table 17). The marine survival rate was estimated to be 0.00948 (SE = 0.00441; Table 17).

Brood Year 1993

An estimated 1,288 (SE = 249) fish were harvested from brood year 1993 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 37.8% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,233 (SE = 242) AEQs (Table 14). An estimated 645 (SE = 158) fish were harvested by troll gear, approximately 50% of the total harvest (Table 15). Approximately 38% of the harvest was by recreational gear (486 fish; SE = 178). Drift gillnet (77 fish; SE = 46) and high seas trawl (43 fish; SE = 43) gear accounted for roughly 6% and 3% of the estimated total harvest, respectively (Table 15). Harvest primarily occurred in the Southeast (41%; 530 fish; SE = 167), Northwest (32%; 418 fish; SE = 137), and Northeast (15%; 197 fish; SE = 90) Quadrants of SEAK (Table 16). An estimated 3% of harvest (36 fish; SE = 36) occurred in Canadian waters and roughly 3% of harvest occurred in the Gulf of Alaska (trawl fisheries; 43 fish; SE = 43; Table 16). Age-1.4 and age-1.3 fish accounted for roughly 55% (707 fish; SE = 198) and 33% (420 fish; SE = 134) of the estimated harvest, respectively (Table 12).

An estimated 448 fish (SE = 225) from the 1993 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 312 (SE = 182) AEQs (Table 14).

Total fishing mortality for the 1993 brood was estimated to be 1,545 (SE = 303) AEQs (Table 17). Based on an estimated spawning abundance of 5,142 (SE = 375) fish (Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002; Hendrich et al. 2008; Table 12), production was estimated to be 6,687 AEQs (SE = 482), and the exploitation rate was therefore estimated to be 0.2310 (SE = 0.0371; Table 17). The marine survival rate was estimated to be 0.03543 (SE = 0.00774; Table 17).

Brood Year 1994

An estimated 1,082 (SE = 240) fish were harvested from brood year 1994 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 43.3% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,024 (SE = 229) AEQs (Table 14). An estimated 573 (SE = 203) fish were harvested by recreational gear, approximately 53% of the total harvest (Table 15). Approximately 44% of the harvest was by commercial troll gear (471 fish; SE = 125), and drift gillnet (38 fish; SE = 26) accounted for the remaining 4% of the estimated total harvest (Table 15). Harvest primarily occurred in the Southeast (50%; 546 fish; SE = 188), Northwest (40%; 444 fish; SE = 139), and Northeast (5%; 58 fish; SE = 41) Quadrants of SEAK (Table 14). Approximately 3% of the estimated harvest occurred in Cook Inlet (recreational fisheries; 34 fish; SE = 33; Table 16). Age-1.3 and age-1.4 fish accounted for roughly 53% (573 fish; SE = 186) and 33% (362 fish; SE = 132) of the estimated harvest, respectively (Table 12).

An estimated 373 fish (SE = 216) from the 1994 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQs (Table 13) results in an estimated incidental mortality of 254 (SE = 171) AEQs (Table 14).

Total fishing mortality for the 1994 brood was estimated to be 1,278 (SE = 285) AEQs (Table 17). Based on an estimated spawning abundance of 4,704 (SE = 394) fish (Jones III et al. 1998; Jones III and McPherson 1999, 2000, 2002; Weller and McPherson 2003a; Table 12), production was estimated to be 5,982 AEQs (SE = 486), and the exploitation rate was therefore estimated to be 0.2136 (SE = 0.0401; Table 17). The marine survival rate was estimated to be 0.02513 (SE = 0.00506; Table 17).

Brood Year 1995

An estimated 2,135 (SE = 271) fish were harvested from brood year 1995 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 25.0% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,980 (SE = 250) AEQs (Table 14). An estimated 1,212 (SE = 169) fish were harvested by troll gear, approximately 57% of the total harvest (Table 15). Approximately 23% of the harvest was by recreational gear (489 fish; SE = 174). Purse seine (101 fish; SE = 73), drift gillnet (99 fish; SE = 51), and trawl (94 fish; SE = 66) gear each accounted for roughly 5% of the estimated total harvest (Table 15). Harvest occurred primarily in the Southeast (41%; 884 fish; SE = 188) and Northwest (39%; 823 fish; SE = 154) Quadrants of SEAK (Table 16). An estimated 4% of harvest (83 fish; SE = 45) occurred in Canadian waters, 3% of harvest occurred in Cook Inlet (73 fish; SE = 41), and roughly 4% of harvest occurred in the Gulf of Alaska (trawl fisheries; 94 fish; SE = 66; Table 16). Age-1.3 and age-1.4 fish accounted for roughly 56% (1,204 fish; SE = 219) and 28% (608 fish; SE = 118) of the estimated harvest, respectively (Table 12).

An estimated 721 fish (SE = 241) from the 1995 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQs (Table 13) results in an estimated incidental mortality of 521 (SE = 193) adult equivalents (Table 14).

Total fishing mortality for the 1995 brood was estimated to be 2,501 (SE = 316) AEQs (Table 17). Based on an estimated spawning abundance of 9,553 (SE = 784) fish (Jones III and McPherson 1999, 2000, 2002; Weller and McPherson 2003a-b; Table 12), production was estimated to be 12,054 AEQs (SE = 845), and the exploitation rate was therefore estimated to be 0.2075 (SE = 0.0248; Table 17). The marine survival rate was estimated to be 0.03831 (SE = 0.00514; Table 17).

Brood Year 1996

An estimated 2,506 (SE = 330) fish were harvested from brood year 1996 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 25.4% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 2,327 (SE = 297) AEQs (Table 14). An estimated 1,118 (SE = 280) fish were harvested by recreational gear, approximately 45% of the total harvest (Table 15). An estimated 41% of the harvest was by commercial troll gear (1,034 fish; SE = 140). Approximately 5% of the estimated harvest was by drift gillnet gear (130 fish; SE = 56), while high seas trawl and private non-profit (PNP) hatchery fisheries each accounted for roughly 3% of total harvest (Table 15). Harvest occurred primarily in the Southeast (67%; 1,678 fish; SE = 288), Northwest (16%; 396 fish; SE = 99), and Southwest (8%: 203 fish; SE = 96) Quadrants of SEAK (Table 16). An estimated 5% of harvest (116 fish; SE = 62) occurred in Canadian waters, and roughly 3% of harvest occurred in the Gulf of Alaska (trawl fisheries; 75 fish; SE = 53; Table 16). Age-1.3, -1.4, and -1.2 fish accounted for roughly 42% (1,046 fish; SE = 181), 30% (755 fish; SE = 154), and 27% (686 fish; SE = 228) of the estimated harvest, respectively (Table 12).

Table 12.–Nominal estimates of landed catch, incidental mortality, spawning abundance, and total returns of Unuk River Chinook salmon, by age class, for brood years 1992–2005. Rounding error is present.

	Landed catch						Incidental mortality						Spawning abundance[a]						Total return					
	Age class						Age class						Age class						Age class					
Brood year	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total
1992	35	81	267	155		538	129	111	15	6		261		736	1,240	1,207	16	3,199	165	927	1,523	1,368	16	3,999
SE	35	80	157	155		237						260		349	128	140	12	397	35	358	203	209	12	531
1993		161	420	707		1,288	206	197	15	29		448		916	2,595	1,581	50	5,142	206	1,274	3,030	2,317	50	6,878
SE		67	134	198		249						225		151	267	215	21	375	0	165	299	292	21	503
1994		147	573	362		1,082	218	115	31	9		373	49	1,269	1,918	1,447	21	4,704	267	1,531	2,522	1,818	21	6,159
SE		73	186	132		240						216	18	235	255	185	15	394	18	246	316	228	15	509
1995	101	223	1,204	608		2,135	291	345	67	18		721	224	2,427	3,499	3,337	66	9,553	616	2,994	4,771	3,962	66	12,410
SE	73	81	219	118		271						241	62	540	394	404	28	784	96	546	451	421	28	864
1996	19	686	1,046	755		2,506	702	442	76	16		1,236	240	3,140	6,923	3,188	46	13,537	962	4,268	8,045	3,958	46	17,279
SE	13	228	181	154		330						366	78	947	789	392	17	1,296	79	974	810	421	17	1,386
1997		96	630	566	23	1,315	267	126	19	13		425	15	946	2,887	1,474	19	5,341	282	1,169	3,536	2,053	42	7,082
SE		50	164	187	23	254						221	15	127	358	139	10	405	15	137	394	233	25	527
1998	59	244	829	222	41	1,396	294	212	24	4		534	83	2,485	3,941	1,756	13	8,278	435	2,942	4,794	1,982	54	10,208
SE	58	86	191	67	41	231						221	31	697	317	160	9	783	66	702	370	174	42	846
1999		81	658	493	59	1,291	136	100	231	18		480		592	1,289	842		2,723	136	773	2,178	1,346	59	4,493
		53	414	142	59	445						418		69	122	97		170	0	87	432	172	59	634
2000	12	488	2,083	906		3,490	508	894	60	17		1,479	191	2,937	3,808	2,100	30	9,066	711	4,319	5,951	3,025	30	14,036
SE	12	205	309	188		417						423	37	335	321	215	13	513	39	393	447	285	13	785
2001	21	67	572	462		1,122	233	198	19	10		460	76	521	2,147	1,045	11	3,800	330	786	2,738	1,517	11	5,382
SE	5	34	140	141		201						200	24	106	215	105	8	263	24	111	256	176	8	387
2002	15	713	1,593	384		2,705	544	608	126	8		1,287	237	3,256	4,522	1,633		9,648	797	4,586	6,241	2,025		13,639
SE	15	182	260	110		336						365	67	436	360	198		603	69	472	444	227		781
2003	16	45	358			419	184	224	17			425	221	842	1,229			2,292	421	1,111	1,604			3,136
SE	15	26	105			110						192	47	95	155			188	49	99	187			290
2004		97				97	306	83				389	184	943				1,127	490	1,123				1,613
SE		51				51						248	34	149				153	34	157				296
2005						0	446					446	163					163	609					609
SE						0							46					46	46					46

[a] Estimates of spawning abundance (and associated standard errors) of fish from minor age classes are included in the spawning abundance estimates for fish from major age classes of the same total age and brood year e.g.an estimated spawning abundance of 10 age-2.3 fish from BY 2001 are included in the spawning abundance estimate of age-1.4 fish in BY 2001.

An estimated 1,236 fish (SE = 366) from the 1996 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 846 (SE = 275) AEQs (Table 14).

Total fishing mortality for the 1996 brood was estimated to be 3,173 (SE = 405) AEQs (Table 17). Based on an estimated spawning abundance of 13,537 (SE = 1,296) fish (Jones III and McPherson 2000, 2002; Weller and McPherson 2003a-b, 2004; Table 12), production was estimated to be 16,710 AEQs (SE = 1,358), and the exploitation rate was therefore estimated to be 0.1899 (SE = 0.0245; Table 17). The marine survival rate was estimated to be 0.03433 (SE = 0.00489; Table 17).

Brood Year 1997

An estimated 1,315 (SE = 254) fish were harvested from brood year 1997 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 37.9% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,267 (SE = 248) AEQs (Table 14). An estimated 810 (SE = 189) fish were harvested by troll gear, approximately 62% of the total harvest (Table 15). Approximately 33% of the harvest was by recreational gear (432 fish; SE = 154), and the remaining 5% of total harvest occurred in PNP fisheries (Table 15). Harvest occurred primarily in the Southeast (47%; 614 fish; SE = 162), Northwest (28%; 366 fish; SE = 129), and Northeast (7%; 94 fish; SE = 54) Quadrants of SEAK (Table 16). An estimated 13% of harvest (170 fish; SE = 126) occurred in Canadian waters, and roughly 4% of harvest occurred in Cook Inlet (50 fish; SE = 49; Table 16). Age-1.3 and age-1.4 fish accounted for roughly 48% (630 fish; SE = 164), and 43% (566 fish; SE = 187) of the estimated harvest, respectively (Table 12).

An estimated 425 fish (SE = 221) from the 1997 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQs (Table 13) results in an estimated incidental mortality of 279 (SE = 174) adult equivalents (Table 14).

Table 13.–Adult equivalent conversion factors for Unuk River Chinook salmon by age class and brood year (1992–2005).

	Age class				
Brood year	1.1	1.2	1.3	1.4	1.5
1992	0.5572	0.7960	0.9460	1.0000	1.0000
1993	0.5507	0.7867	0.9492	1.0000	1.0000
1994	0.5643	0.8033	0.9496	1.0000	1.0000
1995	0.5636	0.7986	0.9447	1.0000	1.0000
1996	0.5698	0.8088	0.9616	1.0000	1.0000
1997	0.5549	0.7919	0.9559	1.0000	1.0000
1998	0.5747	0.8195	0.9623	1.0000	1.0000
1999	0.5530	0.7883	0.9533	1.0000	1.0000
2000	0.5712	0.8109	0.9536	1.0000	1.0000
2001	0.5546	0.7862	0.9572	1.0000	1.0000
2002	0.5837	0.8274	0.9682	1.0000	
2003	0.5635	0.8016	0.9547		
2004	0.5635	0.8016			
2005	0.5635				

Note:Conversion factors provided by John Carlile of ADF&G.

Table 14.–Estimates of landed catch, incidental mortality, spawning abundance, total return, and exploitation rate of Unuk River Chinook salmon in adult equivalents (AEQs) for the 1992–2005 broods through return year 2008. Rounding error present.

	Landed catch						Incidental mortality						Spawning abundance						Total return					
	Age class						Age class						Age class						Age class					
Brood year	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total
1992	20	64	253	155		492	72	88	15	6		181		736	1,240	1,207	16	3,199	92	888	1,507	1,368	16	3,871
SE	19	64	148	155		224						209		349	128	140	12	397						502
1993		126	399	707		1,233	114	155	14	29		312		916	2,595	1,581	50	5,142	114	1,198	3,008	2,317	50	6,687
SE		53	128	198		242						182		151	267	215	21	375						482
1994		118	544	362		1,024	123	93	30	9		254	49	1,269	1,918	1,447	21	4,704	172	1,480	2,492	1,818	21	5,982
SE		58	177	132		229						171	18	235	255	185	15	394						486
1995	57	178	1,138	608		1,980	164	275	64	18		521	224	2,427	3,499	3,337	66	9,553	445	2,880	4,700	3,962	66	12,054
SE	41	65	207	118		250						193	62	540	394	404	28	784						845
1996	11	555	1,006	755		2,327	400	358	73	16		846	240	3,140	6,923	3,188	46	13,537	651	4,052	8,002	3,958	46	16,710
SE	7	185	174	154		297						275	78	947	789	392	17	1,296						1,358
1997		76	602	566	23	1,267	148	100	18	13		279	15	946	2,887	1,474	19	5,341	163	1,122	3,507	2,053	42	6,888
SE		40	156	187	23	248						174	15	127	358	139	10	405						506
1998	34	200	798	222	41	1,295	169	174	23	4		370	83	2,485	3,941	1,756	13	8,278	286	2,859	4,762	1,982	54	9,944
SE	34	71	184	67	41	215						174	31	697	317	160	9	783						830
1999		64	627	493	59	1,243	75	79	221	12		387		592	1,289	842		2,723	75	735	2,136	1,346	59	4,352
SE		42	395	142	59	426						361		69	122	97		170						584
2000	7	396	1,986	906		3,296	290	725	57	17		1,090	191	2,937	3,808	2,100	30	9,066	488	4,058	5,852	3,024	30	13,451
SE	7	166	296	188		388						341	37	335	321	215	13	513						728
2001	12	53	547	462		1,074	129	156	18	10		313	76	521	2,147	1,045	11	3,800	217	729	2,712	1,517	11	5,187
SE	3	27	134	141		196						160	24	106	215	105	8	263						365
2002	9	590	1,542	384		2,525	318	503	122	8		951	237	3,256	4,522	1,633		9,648	564	4,348	6,186	2,025		13,124
SE	9	150	252	110		313						297	67	436	360	198		603						741
2003	9	36	342			387	104	179	17			300	221	842	1,229			2,292	334	1,057	1,587			2,978
SE	9	21	100			103						151	47	95	155			188						262
2004		78				78	173	66				239	184	943				1,127	357	1,087				1,444
SE		41				41						160	34	149				153						225
2005							251					251	163					163	414					414
SE													46					46						46

Table 15.–Nominal harvest estimates of Unuk River Chinook salmon from the 1992–2005 broods, by gear type, through 2008. Rounding error is present.

		Gear type							
Brood year	Age classes	Troll	Recreational	Drift gillnet	Purse seine	PNP[a]	Trawl	Other[b]	Total
1992	1.1–1.5	205	155	143	35				538
SE		144	155	101	35				237
1993	1.1–1.5	645	486	77			43	36	1,288
SE		158	178	46			43	36	249
1994	1.1–1.5	471	573	38					1,082
SE		125	203	26					240
1995	1.1–1.5	1,212	489	99	101	51	94	89	2,135
SE		169	174	51	73	26	66	46	271
1996	1.1–1.5	1,034	1,118	130	19	64	75	65	2,506
SE		140	280	56	4	53	53	46	330
1997	1.1–1.5	810	432			73			1,315
SE		189	154			73			254
1998	1.1–1.5	844	487	46			19		1,396
SE		163	160	32			18		231
1999	1.1–1.5	405	364	505				16	1,291
SE		127	135	404				16	445
2000	1.1–1.5	1,929	933	603	12			12	3,490
SE		262	247	209	12			12	417
2001	1.1–1.5	659	287	66	89			21	1,122
SE		145	121	37	57			14	202
2002	1.1–1.4	1,776	315	470	153				2,705
SE		266	115	150	83				336
2003	1.1–1.3	342	36	12	28				419
SE		104	25	12	19				110
2004	1.1–1.2			43	16	38			97
SE				30	16	37			51
2005	1.1–1.1								0
SE									
Total		10,322	5,677	2,232	453	226	232	241	19,383
SE		599	602	502	132	101	96	78	1,008
Percent		53	29	12	2	1	1	1	100

[a] Private non-profit fisheries in this case have unknown gear type.

[b] Includes all Canadian mixed net and seine, test fishery, and set gillnet gear.

Table 16.–Nominal harvest estimates of Unuk River Chinook salmon from the 1992–2005 broods, by harvest location, through 2008. Rounding error is present.

		Harvest location								
Brood year	Age classes	Kodiak	Cook Inlet	Gulf of Alaska	NW Quadrant	NE Quadrant	SW Quadrant	SE Quadrant	British Columbia	Total
1992	1.1–1.5				255	35		248		538
SE					184	35		146		237
1993	1.1–1.5			43	418	197	64	530	36	1,288
SE				43	137	90	64	167	36	249
1994	1.1–1.5		34		444	58		546		1,082
SE			33		139	41		188		240
1995	1.1–1.5	16	73	94	823	148	15	884	83	2,135
SE		15	41	66	154	78	14	188	45	271
1996	1.1–1.5			75	396	38	203	1,678	116	2,506
SE				53	99	18	96	288	62	330
1997	1.1–1.5		50		366	94	20	614	170	1,315
SE			49		129	54	20	162	126	254
1998	1.1–1.5			19	353	95	20	909		1,396
SE				18	120	66	20	185		231
1999	1.1–1.5				293	82	58	778	80	1,291
SE					125	67	57	412	65	445
2000	1.1–1.5				1,052	393	151	1,874	20	3,490
SE					210	131	81	325	19	417
2001	1.1–1.5				375	26	27	678	17	1,122
SE					114	18	26	163	17	202
2002	1.1–1.4				815	180	356	1,222	131	2,705
SE					203	68	110	221	79	336
2003	1.1–1.3				97	73		248		419
SE					56	36		87		110
2004	1.1–1.2							97		97
SE								51		51
2005	1.1									0
SE										
Total		16	156	232	5,685	1,420	915	10,306	654	19,383
SE		15	72	96	503	230	193	790	185	1,008
Percent		0.1	0.8	1.2	29.3	7.3	4.7	53.2	3.4	100

Table 17.–Estimated spawning abundance $\hat{N}$, landed catch $\hat{R}$, incidental fishing mortality $I\hat{M}$, fishing mortality $F\hat{M}$ (rounding error present), total return or production $\hat{T}$, exploitation rate $\hat{U}$, and marine survival rate $\hat{Q}$ for the 1992–2005 broods, through 2008, using adult equivalents.

Brood year	$\hat{N}$	$\hat{R}$	$I\hat{M}$	$F\hat{M}$	$\hat{T}$	$\hat{U}$	$\hat{Q}$
1992	3,199	492	181	672	3,871	0.1737	0.00948
SE	397	224	209	307	502	0.0679	0.00441
1993	5,142	1,233	312	1,545	6,687	0.2310	0.03543
SE	375	242	182	303	482	0.0371	0.00774
1994	4,704	1,024	254	1,278	5,982	0.2136	0.02513
SE	394	229	171	285	486	0.0401	0.00506
1995	9,553	1,980	521	2,501	12,054	0.2075	0.03831
SE	784	250	193	316	845	0.0248	0.00514
1996	13,537	2,327	846	3,173	16,710	0.1899	0.03433
SE	1,296	297	275	405	1,358	0.0245	0.00489
1997	5,341	1,267	279	1,547	6,888	0.2246	0.02196
SE	405	248	174	303	506	0.0365	0.00513
1998	8,278	1,295	370	1,666	9,944	0.1675	0.03659
SE	783	215	174	276	830	0.0266	0.00508
1999	2,723	1,243	387	1,629	4,352	0.3744	0.01446
SE	170	426	361	558	584	0.0816	0.00310
2000	9,066	3,296	1,090	4,385	13,451	0.3260	0.03249
SE	513	388	341	517	728	0.0287	0.00431
2001	3,800	1,074	313	1,387	5,187	0.2674	0.01994
SE	263	196	160	253	365	0.0382	0.00328
2002[a]	9,648	2,525	951	3,476	13,124	0.2649	0.02905
SE	603	313	297	431	741	0.0271	0.00420
2003[a]	2,292	387	300	686	2,978	0.2304	0.01709
SE	188	103	151	183	262	0.0495	0.00382
2004[a]	1,127	78	239	317	1,444	0.2195	0.00413
SE	153	41	160	165	225	0.0921	0.00142
2005[a]	163		251	251	414		
SE	46				46		

[a]Brood year returns are incomplete pending the return of additional age class(es).

Total fishing mortality for the 1997 brood was estimated to be 1,547 (SE = 303) AEQs (Table 17). Based on an estimated spawning abundance of 5,341 (SE = 405) fish (Jones III and McPherson, 2002; Weller and McPherson 2003a-b, 2004 2006a; Table 12), production was estimated to be 6,888 AEQs (SE = 506), and the exploitation rate was therefore estimated to be 0.2246 (SE = 0.0365; Table 17). The marine survival rate was estimated to be 0.02196 (SE = 0.00513; Table 17).

Brood Year 1998

An estimated 1,396 (SE = 231) fish were harvested from brood year 1998 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 32.2% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,295 (SE = 215) adult equivalents (Table 14). An estimated 844 (SE = 163) fish were harvested by troll gear, approximately 60% of the total harvest (Table 15). Roughly 35% of the harvest was by recreational gear (487 fish; SE = 160; Table 15). Harvest occurred primarily in the Southeast (65%; 909 fish; SE = 185), Northwest (25%; 353 fish; SE = 120), and Northeast (7%; 95 fish; SE = 66) Quadrants of SEAK (Table 16). Roughly 1% of harvest occurred in the Gulf of Alaska (trawl fisheries; 19 fish; SE = 18; Table 16). Age-1.3, -1.2, and -1.4 fish accounted for roughly 59% (829 fish; SE = 191), 17% (244 fish; SE = 86), and 16% (222 fish; SE = 67) of the estimated harvest, respectively (Table 12).

An estimated 534 fish (SE = 221) from the 1998 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 370 (SE = 174) AEQs (Table 14).

Total fishing mortality for the 1998 brood was estimated to be 1,666 (SE = 276) AEQs (Table 17). Based on an estimated spawning abundance of 8,278 (SE = 783) fish (Weller and McPherson 2003a-, 2004 2006a-b; Table 12), production was estimated to be 9,944 AEQs (SE = 830), and the exploitation rate was therefore estimated to be 0.1675 (SE = 0.0266; Table 17). The marine survival rate was estimated to be 0.03659 (SE = 0.00508; Table 17).

Brood Year 1999

An estimated 1,291 (SE = 445) fish were harvested from brood year 1999 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 67.6% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,243 (SE = 426) AEQs (Table 14). An estimated 505 (SE = 404) fish were harvested by drift gillnet gear, approximately 39% of the total harvest (Table 15). Recreational (364 fish; SE = 135) and troll (405 fish; SE = 127) gear each accounted for approximately 28% and 31% of the total estimated harvest, respectively (Table 15). Harvest occurred primarily in the Southeast (60%; 778 fish; SE = 412) and Northwest (23%; 293 fish; SE = 125) Quadrants of SEAK (Table 16). Roughly 6% of harvest occurred in the waters of British Columbia (80 fish; SE = 65) and in the Northeast Quadrant (82 fish; SE = 67; Table 14). Age-1.3 and age-1.4 fish accounted for roughly 51% (658 fish; SE = 414) and 38% (493 fish; SE = 142) of the estimated harvest, respectively (Table 12).

An estimated 480 fish (SE = 418) from the 1999 brood died as a result of incidental fishing mortality (nominal fish; Tables 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 387 (SE = 361) AEQs (Table 14).

Total fishing mortality for the 1999 brood was estimated to be 1,629 (SE = 558) AEQs (Table 17). Based on an estimated spawning abundance of 2,723 (SE = 170) fish (Weller and McPherson 2003b, 2004, 2006a-b; Weller and Evans 2009; Table 12), production was estimated to be 4,352 AEQs (SE = 584), and the exploitation rate was therefore estimated to be 0.3744 (SE = 0.0816; Table 17). The marine survival rate was estimated to be 0.01446 (SE = 0.00310; Table 17).

Brood Year 2000

An estimated 3,490 (SE = 417) fish were harvested from brood year 2000 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 23.3% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 3,296 (SE = 388) AEQs (Table 14). An estimated 1,929 (SE = 262) fish were harvested by commercial troll gear, approximately 55% of the total harvest (Table 15). Recreational (933 fish; SE = 247) and drift gillnet (603 fish; SE = 209) gear accounted for approximately 27% and 17% of the total estimated harvest, respectively (Table 15). Harvest occurred primarily in the Southeast (54%;

1,874 fish; SE = 325), Northwest (30%; 1,052 fish; SE = 210), and Northeast (11%; 393 fish; SE = 131) Quadrants of SEAK (Table 16). Approximately 1% of harvest occurred in the waters of British Columbia (20 fish; SE = 19; Table 16). Age-1.3 and age-1.4 fish accounted for roughly 60% (2,083 fish; SE = 309) and 26% (906 fish; SE = 188) of the estimated harvest, respectively (Table 12).

An estimated 1,479 fish (SE = 423) from the 2000 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 1,090 (SE = 341) AEQs (Table 14).

Total fishing mortality for the 2000 brood was estimated to be 4,385 (SE = 517) AEQs (Table 17). Based on an estimated spawning abundance of 9,066 (SE = 513) fish (Weller and McPherson 2004, 2006a-b; Weller and Evans 2009; Table 12), production was estimated to be 13,451 AEQs (SE = 728), and the exploitation rate was therefore estimated to be 0.3260 (SE = 0.0287; Table 17). The marine survival rate was estimated to be 0.03249 (SE = 0.00431; Table 17).

Brood Year 2001

An estimated 1,122 (SE = 201) fish were harvested from brood year 2001 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 35.1% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 1,074 (SE = 196) AEQs (Table 14). An estimated 659 (SE = 145) fish were harvested by commercial troll gear, approximately 59% of the total harvest (Table 15). Recreational (287 fish; SE = 121), purse seine (89; SE = 57), and drift gillnet (66 fish; SE = 37) gear accounted for approximately 26%, 8%, and 6% of the total estimated harvest, respectively (Table 15). Harvest occurred primarily in the Southeast (60%; 678 fish; SE = 163) and Northwest (33%; 375 fish; SE = 114) Quadrants of SEAK (Table 16). An estimated 2% of harvest occurred in the waters of British Columbia (17 fish; SE = 17; Table 16). Age-1.3 and age-1.4 fish accounted for roughly 51% (572 fish; SE = 140) and 41% (462 fish; SE = 141) of the estimated harvest, respectively (Table 12).

An estimated 460 fish (SE = 200) from the 2001 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 313 (SE = 160) AEQs (Table 14).

Total fishing mortality for the 2001 brood was estimated to be 1,387 (SE = 253) AEQs (Table 17). Based on an estimated spawning abundance of 3,800 (SE = 263) fish (Weller and McPherson 2006a, 2006b; Weller and Evans 2009; Table and 12), production was estimated to be 5,187 AEQs (SE = 365), and the exploitation rate was therefore estimated to be 0.2674 (SE = 0.0382; Table 17). The marine survival rate was estimated to be0 .01994 (SE = 0.00328; Table 17).

Brood Year 2002

Brood year 2002 returns are incomplete pending the return of age-1.5 fish in 2009. However, through 2008 an estimated 2,705 (SE = 336) fish were harvested from brood year 2002 returns (Table 12; Appendix B6). The half-width of the calculated 95% confidence interval is 24.2% of the harvest estimate. Use of AEQ conversion factors (Table 13) results in an estimated harvest of 2,525 (SE = 313) AEQs (Table 14). An estimated 1,776 (SE = 266) fish were harvested by commercial troll gear, approximately 66% of the total harvest (Table 15). Drift gillnet (470 fish; SE = 150), recreational (315 fish; SE = 115), and purse seine (153; SE = 83) gear accounted for approximately 17%, 12%, and 6% of the total estimated harvest, respectively (Table 15). Harvest occurred primarily in the Southeast (45%; 1,222 fish; SE = 221), Northwest (30%; 815 fish; SE = 203), and Southwest (13%; 356 fish; SE = 110) Quadrants of SEAK (Table 16). Approximately 5% of harvest occurred in the waters of British Columbia (131 fish; SE = 79; Table 16). Through 2008, age-1.3, -1.2, and -1.4 fish accounted for roughly 59% (1,593 fish; SE = 260), 26% (713 fish; SE = 182), and 14% (384; SE = 110) of the estimated harvest, respectively (Table 12).

Through 2008, an estimated 1,287 fish (SE = 365) from the 2002 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 951 (SE = 297) AEQs (Table 14).

Through 2008, total fishing mortality for the 2002 brood was estimated to be 3,476 (SE = 431) AEQs (Table 17). Based on an estimated spawning abundance of 9,648 (SE = 603) fish (Weller and McPherson 2006b; Weller and Evans 2009; Table 12), production through 2008 was estimated to be 13,124 AEQs (SE = 741), and the exploitation rate was therefore estimated to be 0.2649 (SE = 0.0271; Table 17). The marine survival rate was estimated to be 0.02906 (SE = 0.00420; Table 17).

Brood Year 2003

Brood year 2003 returns are incomplete pending the return of age-1.4 fish in 2009 and age-1.5 fish in 2010. Through 2008, an estimated 419 (SE = 110) fish have been harvested from brood year 2003 returns (Table 12; Appendix B6). Use of AEQ conversion factors (Table 13) results in an estimated harvest of 387 (SE = 103) AEQs (Table 14). An estimated 342 (SE = 104) fish were harvested by commercial troll gear, approximately 82% of the total harvest (Table 15). Recreational (36 fish; SE = 25), purse seine (28 fish; SE = 19), and drift gillnet (12 fish; SE = 12) gear accounted for approximately 9%, 7%, and 3% of the total estimated harvest, respectively (Table 15). Harvest only occurred in the Southeast (248 fish; SE = 87), Northwest (97 fish; SE = 56), and Northeast (73 fish; SE = 36) Quadrants of SEAK (Table 16).

An estimated 425 fish (SE = 192) from the 2003 brood died as a result of incidental fishing mortality (nominal fish; Table 12). Use of AEQ factors (Table 13) results in an estimated incidental mortality of 300 (SE = 151) AEQs (Table 14).

Brood Year 2004

An estimated 97 (SE = 51) age-1.2 fish were harvested in 2008, no harvest of age-1.1 fish occurred in 2007 (Table 12; Appendix B6). Incidental mortality was estimated to be 389 fish (Table 12).

Brood Year 2005

No age-1.1 fish were harvested from the 2005 brood in 2008, however incidental mortality was estimate to be 446 fish (Table 12).

Estimates by return year

Total returns averaged 9,324 fish from 1998 to 2008, and ranged from an estimated 6,546 (SE = 1,777) fish in 1998 to 13,633 (SE = 925) fish in 2001 (Table 18). In AEQs, total production averaged 9,011 AEQs from 1998 to 2008, and ranged from 6,301 AEQs (SE = 442) in 1998 to 13,394 AEQs (SE = 922) in 2001 (Table 19). During this period, harvest and incidental mortality averaged 1,614 and 521 AEQs, respectively, for an average annual fishing mortality of 2,135 AEQs and an average exploitation rate of 22.9%.

Table 18.–Nominal estimates of landed catch, incidental mortality, spawning abundance, and total returns of Unuk River Chinook salmon, by age class and return year, 1995–2008. Rounding error is present.

	Landed catch						Incidental mortality						Spawning abundance						Total return					
	Age class						Age class						Age class						Age class					
Return	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total
1995	35					35	129					129						0	165					165
SE	35					35												0	35					35
1996		81				81	206	111				317		736				736	206	927				1,134
SE		80				80								349				349		358				358
1997		161	267			428	218	197	15			430	49	916	1,240			2,205	267	1,274	1,523			3,063
SE		67	157			171							18	151	128			199	18	165	203			262
1998	101	147	420	155		823	291	115	15	6		428	224	1,269	2,595	1,207		5,295	616	1,531	3,030	1,368		6,546
SE	73	73	134	707		727							62	235	267	1,581		1,622	96	246	299	1,732		1,777
1999	19	223	573	707		1,522	702	345	31	29		1,107	240	2,427	1,918	1,581	16	6,182	962	2,994	2,522	2,317	16	8,811
SE	13	81	186	198		284							78	540	255	215	12	640	79	546	316	292	12	700
2000		686	1,204	362		2,252	267	442	67	9		786	15	3,140	3,499	1,447	50	8,151	282	4,268	4,771	1,818	50	11,189
SE		228	219	132		343							15	947	394	185	21	1,043	15	974	451	228	21	1,098
2001	59	96	1,046	608		1,809	294	126	76	18		514	83	946	6,923	3,337	21	11,310	435	1,169	8,045	3,962	21	13,633
SE	58	50	181	118		229							31	127	789	404	15	896	66	137	810	421	15	925
2002		244	630	755		1,629	136	212	19	16		383		2,485	2,887	3,188	66	8,626	136	2,942	3,536	3,958	66	10,638
SE		86	164	154		240								697	358	392	28	877		702	394	421	28	909
2003	12	81	829	566		1,488	508	100	24	13		645	191	592	3,941	1,474	46	6,244	711	773	4,794	2,053	46	8,377
SE	12	53	191	187		273							37	69	317	139	17	355	39	87	370	233	17	448
2004	21	488	658	222	23	1,413	233	894	231	4		1,362	76	2,937	1,289	1,756	19	6,077	330	4,319	2,178	1,982	42	8,852
SE	4	205	414	67	23	467							24	335	122	160	10	392	24	393	432	174	25	610
2005	15	67	2,083	493	41	2,699	544	198	60	128		814	237	521	3,808	842	13	5,421	797	786	5,951	1,346	54	8,934
SE	15	34	311	142	41	346							67	106	321	97	9	358	69	111	447	172	42	498
2006	16	713	572	906	59	2,266	184	608	19	17		828	221	3,256	2,147	2,100		7,724	421	4,576	2,738	3,024	59	10,818
SE	15	182	140	188	59	303							47	436	215	215		534	49	472	256	285	59	613
2007[a]		45	1,593	462		2,099	306	224	126	10		667	184	842	4,522	1,045	30	6,623	490	1,111	6,241	1,517	30	9,384
SE		26	260	141		297							34	95	360	105	13	389	34	99	444	176	13	489
2008		97	358	384		839	446	83	17	8		554	163	943	1,229	1,633	11	3,979	609	1,123	1,604	2,025	11	5,372
SE		51	105	110		161							46	149	155	198	8	296	46	157	187	227	8	337

[a]Estimated spawning abundance in 2007 does not include an estimated 5 age-1.0 fish; rounding error also present.

Table 19.–Estimates of landed catch, incidental mortality, spawning abundance, and total returns of Unuk River Chinook salmon in adult equivalents (AEQs), by age class and return year, 1995–2008. Rounding error is present.

	Landed catch						Incidental mortality						Spawning abundance						Total return					
	Age class						Age class						Age class						Age class					
Return	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total	1.1	1.2	1.3	1.4	1.5	Total
1995	20					20	72					72							92					92
SE	19					19													19					19
1996		64				64	114	88				202		736				736	114	888				1,002
SE		64				64								349				349	0	355				355
1997		126	253			379	123	155	15			293	49	916	1,240			2,205	172	1,198	1,507			2,877
SE		53	148			158							18	151	128			199	18	160	196			254
1998	57	118	399	155		729	164	93	14	6		277	224	1,269	2,595	1,207		5,295	445	1,480	3,008	1,368		6,301
SE	41	58	128	155		213							62	235	267	140		387	74	242	296	209		442
1999	11	178	544	707		1,440	400	275	30	29		734	240	2,427	1,918	1,581	16	6,182	651	2,880	2,492	2,317	16	8,356
SE	7	65	177	198		274							78	540	255	215	12	640	78	544	310	292	12	696
2000		555	1,138	362		2,054	148	358	64	9		578	15	3,140	3,499	1,447	50	8,151	163	4,052	4,700	1,818	50	10,784
SE		185	207	132		307							15	947	394	185	21	1,043	15	965	445	228	21	1,087
2001	34	76	1,006	608		1,724	169	100	73	18		360	83	946	6,923	3,337	21	11,310	286	1,122	8,002	3,962	21	13,394
SE	34	40	174	118		217							31	127	789	404	15	896	46	133	808	421	15	922
2002		200	602	755		1,557	75	174	18	16		283		2,485	2,887	3,188	66	8,626	75	2,859	3,507	3,958	66	10,466
SE		71	157	154		230								697	358	392	28	877	0	701	391	421	28	906
2003	7	64	798	566		1,434	290	79	23	13		405	191	592	3,941	1,474	46	6,244	488	735	4,762	2,053	46	8,084
SE	7	42	184	187		266							37	69	317	139	17	355	38	81	367	233	17	444
2004	12	396	627	222	23	1,280	129	725	221	4		1,079	76	2,937	1,289	1,756	19	6,077	217	4,058	2,136	1,982	42	8,436
SE	3	166	395	67	23	434							24	335	122	160	10	392	24	374	413	174	25	585
2005	9	53	1,986	493	41	2,582	318	156	57	12		543	237	521	3,808	842	13	5,421	564	729	5,852	1,346	54	8,545
SE	9	27	296	142	41	332							67	106	321	97	9	358	68	109	437	172	42	489
2006	9	590	547	908	59	2,112	104	503	18	17		642	221	3,256	2,147	2,100		7,724	334	4,348	2,712	3,024	59	10,477
SE	9	150	134	188	59	282							47	436	215	215		534	48	461	253	285	59	603
2007[a]		35	1,542	462		2,040	173	179	122	10		485	184	842	4,522	1,045	30	6,623	357	1,057	6,186	1,517	30	9,148
SE		21	252	141		289							34	95	360	105	13	389	34	97	439	176	13	484
2008		78	342	384		804	251	66	17	8		342	163	943	1,229	1,633	11	3,979	414	1,087	1,687	2,025	11	5,125
SE		41	101	110		155							46	149	155	198	8	296	46	155	185	227	8	334

[a]Estimated spawning abundance in 2007 does not include an estimated 5 age-1.0 fish; rounding error also present.

DISCUSSION

Estimates of fishing mortality for age-1.1 Chinook salmon should be considered minimum estimates. Most age-1.1 fish are harvested by purse seine gear, as these fish are generally too small to be entangled by drift gillnet gear, and except in relatively rare situations, length restrictions forbid the retention of Chinook salmon of this size in recreational and commercial troll fisheries. However, the number of jacks (<28 in TL or approximately 710 mm TL) documented as landed catch are known to be under reported. ADF&G management regulations for SEAK traditional purse seine fisheries allow retention, but not sale, of Chinook salmon between 21 and 28 in TL (approximately 530–710 mm TL). These fish are consequently rarely reported and almost never sampled for CWTs. ADF&G management regulations permit the retention and sale of purse seine-caught Chinook salmon <21 in TL. Most individual purse seiners sell their catch to tenders, larger vessels that purchase fish from multiple purse seiners, and subsequently transport the fish to processing plants. In most such instances, pink salmon are kept in separate holds from “money” fish (the more valuable Chinook, sockeye, coho, and chum salmon), or separate vessels purchase pink salmon and “money” fish. For a number of reasons, Chinook salmon <21 in TL are bought by tenders as pink salmon: they are similar in size and appearance to pink salmon, inexperienced purse seine crews often do not distinguish between pink salmon and small Chinook salmon, and the value of these fish is comparable. Dockside samplers rarely sample pink salmon deliveries for jack Chinook salmon CWTs because of cost inefficiencies or fish having been bought from multiple districts and their consequent undesirability for CWT harvest expansion purposes, so many if not most Chinook salmon <21 in TL delivered by tenders go unreported and unsampled. Most CWT samples from jack Chinook salmon occur in the increasingly uncommon event that individual purse seiners deliver their catch directly to a processor, and a CWT sampler is present to look for tagged Chinook and coho salmon. Although sampling of jacks likely represents a relatively small fraction of the catch under these circumstances, the number of jacks sampled is still generally larger than reported catch, and can be 3 times the reported catch from some districts of SEAK (Table 20).

Voluntary recoveries of Unuk River Chinook salmon possessing CWTs occurred in 4 recreational fisheries from 1995 to 2008; the NBC recreational fishery (5 recoveries), the Ketchikan recreational fishery (6 recoveries), the Cook Inlet (Homer) recreational fishery (1 recovery), and in the District 101 recreational fishery as part of a special ADF&G genetic sampling program of sublegal Chinook salmon (3 recoveries; Appendix B7). Hendrich et al. (2008) used an awareness factor, based on extrapolations of data from previous years by the CTC of the PSC, to expand the NBC and Ketchikan recreational fishery recoveries:

$$\hat{r}_{uj} = 4m_{uj}\hat{\theta}_j^{-1}; \quad \mathrm{var}(\hat{r}_{uj}) = (\hat{r}_{uj})^2 \tag{38}$$

where 4 equals the awareness approximation, m_{uj} equals the number of voluntary CWT recoveries with relevant tag codes from brood year j in fishery stratum u, and $\hat{\theta}_j$ equals the estimated fraction of juveniles tagged from brood year j. We feel however that the awareness factor is not a defensible scientific method, is in essence little better than a guess, and have therefore not used it to estimate harvest from voluntary recoveries. The presence of the voluntary recoveries in the Canadian recreational fisheries of NBC, where all recoveries are strictly voluntary, indicates that Canadian harvest of Chinook salmon originating from the Unuk River is underestimated to some unknown degree in 1999, 2000, 2002, and 2005 (Appendix B7). In 5 of the 6 cases when voluntary recoveries occurred in the Ketchikan recreational fishery, recoveries occurred during the period that ADF&G was conducting creel sampling of harvest for CWTs. Expansion of those 5 recoveries would result in overestimation of harvest therefore, and inclusion in the harvest estimation process is contraindicated.

Table 20.–Number of Chinook salmon <21 in TL (approximately 530 m m TL) reported in the ADF&G Division of Commercial Fisheries Mark Tag and Age Laboratory's database as landed catch (harvest), and sampled for coded wire tags, from traditional purse seine fisheries in Southeast Alaska Districts 101–106 (PANEL A) and Districts 107–114 (PANEL B), 1998–2008.

PANEL A : DISTRICTS 101–106

	District 101		District 102		District 103		District 104		District 105		District 106	
Year	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled
1998	45	183		9	1		35	62	5		8	7
1999	279	275	8	67	2		9	22	3		10	6
2000	144	311	35	203	5	47	29	247	11	6	3	9
2001	55	336	39	138	15	22	714	43	19	8	68	65
2002	39	22	51	16	10	3	28	3				
2003	134	45	78	111	10	4	101	39	11	2	390	771
2004	25	272	13	145	2	3	24	73	4		10	7
2005	39	205	35	88	34		50	21	3		145	136
2006	16	36	31	50	4		42	29			8	7
2007	4	205	83	197	29	26	189	242	6		125	219
2008	33	227	59	292	17	4	5	20			18	42
Total	813	2,117	432	1,316	129	109	1,226	801	62	16	785	12,698
Percent sampled		260		305		84		65		26		162

PANEL B :DISTRICTS 107–114

	District 107		District 109		District 110		District 112		District 113		District 114	
Year	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled	Harvest	Sampled
1998	37	18	422	218	459	283	28	70	4	3		
1999	341	192	221	171	263	240	114	322	87	35	23	18
2000	57	57	90	124	72	115	31	169	16	5	3	9
2001	300	137	60	134	61	68	56	220	21	48		92
2002	85	5	177	257	168	230	54	204	59	39	5	46
2003	84	28	109	58	144	158	30	58	2	2	10	4
2004	13	15	41	37	250	218	178	48	15	5	14	14
2005	72	36	15	11	61	69	185	31	22	10	2	3
2006	40	13	148	37	104	142	89	105	28	6	1	10
2007	114	107	14	17	27	16	350	78	71	10	12	6
2008	34	30			12	11	5	2	16	8		
Total	1,177	638	1,297	1,064	1,621	1,550	1,120	1,307	341	171	70	202
Percent sampled		54		82		96		117		50		289

CONCLUSIONS AND RECOMMENDATIONS

Annex IV Chapter 3 of the 2008 PST provides for harvest opportunities on abundant stocks, and mandates harvest regimes be established based on annual estimates of stock abundance and maximum sustained yield (MSY). The escapement range that provides MSY for the Unuk stock has recently been estimated by Hendrich et al. (2008) as 1,800–3,800 large spawning fish, and the revision has been approved by ADF&G and the PSC. Based on point estimates of spawning abundance from 1997–2006, as determined by annual mark-recapture experiments, the upper range of MSY was exceeded by a minimum of 17,000 fish during this period. No directed fishery on the Unuk River stock has existed since the 1950s because of stock concerns. As one prerequisite to the development of increased harvest opportunities on returns surplus to escapement, a reliable forecast model for the Unuk stock needs to be developed, as noted in Chapter 3, Paragraph 13 of the PST. The forecast model would be based on cohort analysis and be dependent on high quality harvest and escapement estimation. Consequently we recommend continued collection of high quality harvest and escapement information on this stock, refinement of the current rudimentary forecast model, and development by relevant management entities of possible strategies to harvest returns surplus to escapement.

The current algorithm used by the CTC of the PSC, in some instances, groups dissimilar fisheries when estimating incidental fishing mortality. This practice can lead to significant error in the estimation of incidental fishing mortality for certain relevant fisheries, such as the SEAK gillnet fishery, as previously noted. Although this practice was necessary when the algorithm was first developed as a result of computer memory limitations at that time, we recommend that the CTC incidental fishing mortality algorithm be updated to preclude grouping of dissimilar fisheries. The Chinook salmon recreational fishery in NBC is a mixed stock interception fishery. Reliable harvest and harvest contribution estimates from this fishery are therefore of interest to numerous entities in both the United States and Canada. We recommend the initiation of a defensible scientific sampling program for this fishery.

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APPENDIX A

Appendix A1.–Detection of size- and/or sex-selective sampling during a two-sample mark-recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Students *t*-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:		
Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:		
Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:		
Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \tag{1}$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \left(\sum_{i=1}^{j} \hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}[\hat{N}_i] \right). \tag{2}$$

where: j = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size k among fish in stratum i;

$\hat{N}_i$ = the estimated abundance in stratum i; and,

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix A2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

Tests of consistency for Petersen estimator

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Mixing Test[a]

Area/time	Time/area where recaptured				Not recaptured
where marked	1	2	…	t	(n_1-m_2)
1					
2					
…					
s					

II.-Equal Proportions Test (SPAS terminology)[b]

	Area/time where examined			
	1	2	…	*t*
Marked (m_2)				
Unmarked (n_2-m_2)				

III.-Complete Mixing Test (SPAS terminology) [c]

	Area/time where marked			
	1	2	…	s
Recaptured (m_2)				
Not recaptured (n_1-m_2)				

[a] This tests the hypothesis that movement probabilities (θ) from time or area i (i = 1, 2, s) to section j (j = 1, 2, t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i\theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i. Note that failure to reject H_0 means the Pooled Petersen estimator can be considered consistent only if the degree of closure among tagging strata is constant ($\Sigma_j\theta_{ij} = \lambda$,) (Schwarz and Taylor 1998). One way this may be achieved is to sample all or the large majority of spawning areas.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j\theta_{ij}p_j$ = d, where p_j is the probability of capturing a fish in section j during the second event, and d is a constant.

The expansion factor provides a means of predicting escapement in years where only an index count of the escapement is available, i.e. no weir counts or mark-recapture experiments were conducted. The expansion factor is the average over several years of the ratio of the escapement estimate (or weir count) to the index count.

Systems where escapement is known

On systems where escapement can be completely enumerated with weirs or other complete counting methods, the expansion factor is an estimate of the expected value of the "population" of annual expansion factors (π 's) for that system:

$$\bar{\pi} = \frac{\sum_{y=1}^{k} \pi_y}{k} \tag{1}$$

where $\pi_y = N_y / C_y$ is the observed expansion factor in year y, N_y is the known escapement in year y, C_y is the index count in year y, and k is the number of years for which these data are available to calculate an annual expansion factor.

The estimated variance for expansion of index counts needs to reflect two sources of uncertainty for any predicted value of π, (π_p). First is an estimate of the process error ($var(\pi)$-the variation across years in the π's, reflecting, for example, weather or observer-induced effects on how many fish are counted in a survey for a given escapement)), and second is the sampling variance of $\bar{\pi}$ ($var(\bar{\pi})$), which will decline as we collect more data pairs.

The variance for prediction will be estimated (Neter and Wasserman 1990):

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\bar{\pi}) \tag{2}$$

where

$$v\hat{a}r(\pi) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k-1} \tag{3}$$

and

$$v\hat{a}r(\bar{\pi}) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k(k-1)} \tag{4}$$

such that

$$v\hat{a}r(\pi_p) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k-1} + \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k(k-1)} \tag{5}$$

Systems where escapement is estimated

On systems where escapement is estimated, the expansion factor is an estimate of the expected value of the "population" of annual expansion factors (π 's) for that system:

$$\bar{\pi} = \frac{\sum_{y=1}^{k} \hat{\pi}_y}{k} \tag{6}$$

where $\hat{\pi}_y = \hat{N}_y / C_y$ is the estimate of the expansion factor in year *y*, $\hat{N}_y$ is the estimated escapement in year *y*, and other terms are as described above.

The variance for prediction will again be estimated:

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\bar{\pi}) \tag{7}$$

The estimate of *var*(π) should again reflect only process error. Variation in $\hat{\pi}$ across years, however, represents process error **plus** measurement error within years (e.g. the mark-recapture induced error in escapement estimation) and is described by the relationship (Mood et al. 1974):

$$V(\hat{\pi}) = V[E(\hat{\pi})] + E[V(\hat{\pi})] \tag{8}$$

This relationship can be rearranged to isolate process error, that is:

$$V[E(\hat{\pi})] = V[\hat{\pi}] - E[V(\hat{\pi})] \tag{9}$$

An estimate of *var*(π) representing only process error therefore is:

$$v\hat{a}r(\pi) = v\hat{a}r(\hat{\pi}) - \frac{\sum_{y=1}^{k} v\hat{a}r(\hat{\pi}_y)}{k} \tag{10}$$

where $v\hat{a}r(\hat{\pi}_y) = v\hat{a}r(\hat{N}_y) / C_y^2$ and $v\hat{a}r(\hat{N}_y)$ is obtained during the experiment when N_y is estimated.

We can calculate:

$$v\hat{a}r(\hat{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \bar{\pi})^2}{k-1} \tag{11}$$

and we can estimate $var(\bar{\pi})$ similarly to as we did above:

$$v\hat{a}r(\bar{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \bar{\pi})^2}{k(k-1)} \tag{12}$$

where both process and measurement errors need to be included.

For large *k* ($k > 30$), equations (11) and (12) provide reasonable parameter estimates, however for small *k* the estimates are imprecise and may result in negative estimates of variance when the results are applied as in equation (7).

Because *k* is typically < 10, we will estimate $var(\hat{\pi})$ and $var(\bar{\pi})$ using parametric bootstrap techniques (Efron and Tibshirani 1993). The sampling distributions for each of the $\hat{\pi}_y$ are modeled using Normal distributions with means $\hat{\pi}_y$ and variances $v\hat{a}r(\hat{\pi}_y)$. At each bootstrap iteration, a bootstrap value $\hat{\pi}_{y(b)}$ is drawn from each of these Normal distributions and the bootstrap value $\hat{\pi}_{(b)}$ is randomly chosen from the k values of $\hat{\pi}_{y(b)}$. Then, a bootstrap sample of size k is drawn from the k values of $\hat{\pi}_{y(b)}$ by sampling with replacement, and the mean of this bootstrap is the bootstrap value $\bar{\pi}_{(b)}$. This procedure is repeated B = 1,000,000 times. We can then estimate $var(\hat{\pi})$ using:

$$v\hat{a}r_B(\hat{\pi}) = \frac{\sum_{b=1}^{B}(\hat{\pi}_{(b)} - \overline{\hat{\pi}_{(b)}})^2}{B-1} \tag{13}$$

where

$$\overline{\hat{\pi}_{(b)}} = \frac{\sum_{b=1}^{B}\hat{\pi}_{(b)}}{B} \tag{14}$$

and we can calculate $var_B(\bar{\pi})$ using equations (13) and (14) with appropriate substitutions. The variance for prediction is then estimated:

$$v\hat{a}r(\pi_p) = v\hat{a}r_B(\hat{\pi}) - \frac{\sum_{y=1}^{k}\mathrm{v\hat{a}r}(\hat{\pi}_y)}{k} + v\hat{a}r_B(\bar{\pi}) \tag{15}$$

As the true sampling distributions for the $\hat{\pi}_y$ are typically skewed right, using a Normal distribution to approximate these distributions in the bootstrap process will result in estimates of $var(\hat{\pi})$ and $var(\bar{\pi})$ that are biased slightly high, but simulation studies using values similar to those realized for this application indicated that the bias in equation (15) is < 1%.

Predicting Escapement

In years when an index count (C_p) is available but escapement (N_p) is not known, it can be predicted:

$$\hat{N}_p = \bar{\pi}\, C_p \tag{16}$$

and

$$v\hat{a}r(\hat{N}_p) = C_p^2 v\hat{a}r(\pi_p) \tag{17}$$

Appendix A4.–Peak survey counts, and abundance estimates with associated estimates of standard error, of the spawning population of large (≥660 mm MEF) Chinook salmon in the Unuk River using the 1997–2004a, b mean expansion factor (EF), the 1997–2007 mean EF, and the results from mark-recapture studies, 1977–2008. The 1997–2004 mean EF is 4.83 (SE = 0.59) and the 1997–2007 mean EF is 5.52 and the SE (prediction) for 1997–2007 is 1.32. Preferred abundance estimates are in bold font.

Year	Peak count from surveys	Abundance estimated using the 1997–2004 mean EF		Abundance estimated using the 1997–2007 mean EF		Abundance estimated using mark-recapture experiments		Preferred abundance estimates	
		$\hat{N}$	$SE(\hat{N})$	$\hat{N}$	$SE(\hat{N})$	$\hat{N}$	$SE(\hat{N})$	$\hat{N}$	$SE(\hat{N})$
1977	974	**4,704**	**575**	5,376	1,286			4,704	575
1978	1,106	**5,342**	**653**	6,105	1,460			5,342	653
1979	576	**2,782**	**340**	3,180	760			2,782	340
1980	1,016	**4,907**	**599**	5,608	1,341			4,907	599
1981	731	**3,531**	**431**	4,035	965			3,531	431
1982	1,351	**6,525**	**797**	7,458	1,783			6,525	797
1983	1,125	**5,434**	**664**	6,210	1,485			5,434	664
1984	1,837	**8,873**	**1,084**	10,140	2,425			8,873	1,084
1985	1,184	**5,719**	**699**	6,536	1,563			5,719	699
1986	2,126	**10,269**	**1,254**	11,736	2,806			10,269	1,254
1987	1,973	**9,530**	**1,164**	10,891	2,604			9,530	1,164
1988	1,746	**8,433**	**1,030**	9,638	2,305			8,433	1,030
1989	1,149	**5,550**	**678**	6,342	1,517			5,550	678
1990	591	**2,855**	**349**	3,262	780			2,855	349
1991	655	**3,164**	**386**	3,616	865			3,164	386
1992	874	**4,221**	**516**	4,824	1,154			4,221	516
1993	1,068	**5,158**	**630**	5,895	1,410			5,158	630
1994	711	**3,434**	**419**	3,925	939	4,623	1,266	3,434	419
1995	772	**3,729**	**455**	4,261	1,019			3,729	455
1996	1,167	**5,637**	**689**	6,442	1,540			5,637	689
1997	636	3,072	375	3,511	840	**2,970**	**277**	2,970	277
1998	840	4,057	496	4,637	1,109	**4,132**	**413**	4,132	413
1999	680	3,284	401	3,754	898	**3,914**	**490**	3,914	490
2000	1,341	6,477	791	7,402	1,770	**5,872**	**644**	5,872	644
2001	2,019	9,752	1,191	11,145	2,665	**10,541**	**1,181**	10,541	1,181
2002	897	4,333	529	4,951	1,184	**6,988**	**805**	6,988	805
2003	1,121	5,527	661	6,188	1,480	**5,546**	**433**	5,546	433
2004	1,008	4,869	595	5,564	1,331	**3,963**	**325**	3,963	325
2005	929	4,487	548	5,128	1,226	**4,742**	**396**	4,742	396
2006	940	4,540	555	5,189	1,241	**5,645**	**476**	5,645	476
2007	709	3,424	418	3,914	936	**5,668**	**446**	5,668	446
2008	242	1,169	143	1,336	319	**3,104**	**390**	3,104	390

[a] Excludes 2002 due to relatively poor survey counts in that year (Weller and McPherson 2006a).

[b] This EF is currently the ADF&G and PSC approved predictive EF.

Appendix A5.–Elapsed time between release and recapture (sulking period) of Chinook salmon in the lower Unuk River in 2007.

			Sulking period		
Spaghetti tag no.	Release date/time	Recapture date/time	Days	Hours	Minutes
2013	06/26/07 10:30	06/29/07 14:32	3	4	2
2033	07/03/07 17:26	07/09/07 07:01	5	13	35
2080	07/18/07 14:30	07/20/07 13:50	1	23	20
2091	07/18/07 15:30	07/21/07 17:15	3	1	45
2094	07/18/07 16:07	07/21/07 13:18	2	21	11
2095	07/18/07 16:20	07/23/07 13:46	4	21	26
2109	07/19/07 05:40	07/22/07 08:42	3	3	2
2116	07/19/07 06:30	07/23/07 16:19	4	9	49
2118	07/19/07 06:33	07/23/07 08:21	4	1	48
2122	07/19/07 06:47	07/22/07 12:32	3	5	45
2122	07/22/07 12:32	08/01/07 14:10	10	1	38
2128	07/19/07 07:20	07/21/07 17:56	2	10	36
2130	07/19/07 08:20	07/24/07 08:45	5	0	25
2132	07/19/07 08:26	07/26/07 17:01	7	8	35
2136	07/19/07 10:00	07/22/07 06:50	2	20	50
2137	07/19/07 10:20	07/21/07 06:10	1	19	50
2138	07/19/07 10:50	07/20/07 14:40	1	3	50
2142	07/19/07 12:10	07/19/07 17:56		5	46
2156	07/19/07 15:52	07/22/07 09:12	2	17	20
2165	07/19/07 18:27	07/23/07 16:45	3	22	18
2178	07/20/07 09:11	07/23/07 08:22	2	23	11
2178	07/23/07 08:22	07/26/07 16:04	3	7	42
2181	07/20/07 10:00	07/20/07 10:40			40
2196	07/20/07 12:49	07/22/07 07:24	1	18	35
2201	07/20/07 13:04	07/21/07 17:05	1	4	1
2211	07/20/07 14:41	07/22/07 18:45	2	4	4
2218	07/20/07 15:40	07/30/07 16:32	10	0	52
2218	07/30/07 16:32	08/01/07 13:42	1	21	10
2244	07/21/07 08:40	08/01/07 10:11	11	1	31
2251	07/21/07 10:38	07/24/07 15:16	3	4	38
2257	07/21/07 12:00	07/22/07 10:51		22	51
2264	07/21/07 12:34	07/21/07 15:23		2	49
2270	07/21/07 13:36	07/22/07 16:37	1	3	1
2271	07/21/07 13:38	07/21/07 18:12		4	34
2275	07/21/07 14:00	08/01/07 12:35	10	22	35
2276	07/21/07 14:04	07/28/07 11:09	6	21	5
2280	07/21/07 14:42	07/22/07 18:45	1	4	3

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Spaghetti tag no.	Release date/time	Recapture date/time	Sulking period Days	Hours	Minutes
2282	07/21/07 15:08	07/21/07 15:15			7
2282	07/21/07 15:15	07/21/07 15:35			20
2282	07/21/07 15:35	07/29/07 06:41	7	15	6
2283	07/21/07 15:10	07/26/07 14:21	4	23	11
2284	07/21/07 15:17	07/22/07 08:40		17	23
2289	07/21/07 15:50	07/22/07 11:04		19	14
2292	07/21/07 16:03	07/30/07 15:41	8	23	38
2332	07/22/07 13:23	07/25/07 18:12	3	4	49
2353	07/22/07 17:17	07/30/07 09:31	7	16	14
2363	07/22/07 18:34	07/26/07 08:45	3	14	11
2365	07/23/07 06:02	07/25/07 15:03	2	9	1
2378	07/23/07 09:04	07/30/07 16:16	7	7	12
2394	07/23/07 14:30	07/30/07 16:17	7	1	47
2406	07/23/07 16:06	07/27/07 11:48	3	19	42
2413	07/23/07 16:34	07/25/07 17:52	2	1	18
2420	07/24/07 06:48	08/01/07 12:58	8	6	10
2425	07/24/07 09:34	07/26/07 14:42	2	5	8
2431	07/24/07 10:48	07/26/07 07:19	1	20	31
2436	07/24/07 13:32	07/26/07 17:02	2	3	30
2442	07/24/07 16:04	07/24/07 16:21			17
2445	07/24/07 16:12	07/28/07 14:26	3	22	14
2449	07/24/07 16:53	07/30/07 16:31	5	23	38
2450	07/24/07 17:28	07/31/07 16:28	6	23	0
2450	07/31/07 16:28	08/02/07 11:08	1	18	40
2455	07/25/07 06:40	07/25/07 10:24		3	44
2467	07/25/07 13:04	07/31/07 16:52	6	3	48
2476	07/25/07 14:44	07/31/07 13:00	5	22	16
2477	07/25/07 15:12	07/30/07 17:33	5	2	21
2484	07/25/07 16:32	07/28/07 12:07	2	19	35
2487	07/25/07 16:47	07/31/07 12:10	5	19	23
2495	07/26/07 06:31	08/01/07 13:00	6	6	29
2506	07/26/07 11:15	08/01/07 15:27	6	4	12
2514	07/26/07 13:48	07/31/07 14:24	5	0	36
2550	07/28/07 11:10	07/29/07 06:54		19	44
2620	08/02/07 11:00	08/02/07 14:55		3	55

Average = 3 days, 18 hours, and 16 minutes; maximum = 11 days, 1 hours, and 31 minutes; minimum = 7 minutes.

Appendix A6.–Estimated annual escapement of Chinook salmon in the Unuk River by age class and gender, 1997–2008.

		Age class													
Year		1.0	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	1.5	2.4	Total
	Male			46		881			724	5	323		14		1,992
1997	%			1.3		24.0			19.7	0.1	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			1,250	5	1,425		60		3,671
	%			1.3		24.1			34.0	0.1	38.8		1.6		100.0
	Male			232		1,299			1,392	6	325		6		3,259
1998	%			4.4		24.4			26.1	0.1	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			2,564	6	1,195		35		5,330
	%			4.4		24.4			48.1	0.1	22.4		0.7		100.0
	Male			211		2,189			1,134		492		9		4,036
1999	%			3.4		35.4			18.3		8.0		0.1		65.3
estimated	Female					26			914		1,196		9		2,145
escapement	%					0.4			14.8		19.3		0.1		34.7
	Total			211		2,216			2,049		1,688		18		6,181
	%			3.4		35.8			33.1		27.3		0.3		100.0
	Male			9		2,444			2,312		517		19		5,302
2000	%			0.1		30.0			28.4		6.3		0.2		65.1
estimated	Female					47			1,636		1,128		38		2,848
escapement	%					0.6			20.1		13.8		0.5		34.9
	Total			9		2,491			3,948		1,645		56		8,150
	%			0.1		30.6			48.4		20.2		0.7		100.0
	Male			83		936			3,680		894		21		5,613
2001	%			0.7		8.3			32.5		7.9		0.2		49.6
estimated	Female					10			3,243		2,443				5,697
escapement	%					0.1			28.7		21.6				50.4
	Total			83		946			6,923		3,337		21		11,310
	%			0.7		8.4			61.2		29.5		0.2		100.0
	Male					2,437			1,675		1,146		22		5,280
2002	%					28.3			19.4		13.3		0.3		61.2
estimated	Female					48			1,212		2,042		33	11	3,346
escapement	%					0.6			14.1		23.7		0.4	0.1	38.8
	Total					2,485			2,887		3,188		55	11	8,626
	%					28.8			33.5		37.0		0.6	0.1	100.0
	Male			192		580		6	2,135		447		11		3,371
2003	%			3.1		9.3		0.1	34.2		7.2		0.2		54.0
estimated	Female					11			1,795	6	1,027		34		2,874
escapement	%					0.2			28.7	0.1	16.4		0.5		46.0
	Total			192		592		6	3,930	6	1,474		46		6,244
	%			3.1		9.5		0.1	62.9	0.1	23.6		0.7		100.0

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Year		Age class													Total
		1.0	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	1.5	2.4	
	Male			75		2,909			912		523				4,419
2004	%			1.2		47.9			15.0		8.6				72.7
estimated	Female					27			377		1,234		19		1,658
escapement	%					0.4			6.2		20.3		0.3		27.3
	Total			75		2,936			1,289		1,756		19		6,077
	%			1.2		48.3			21.2		28.9		0.3		100.0
	Male			368		507			2,454	5	247		6		3,587
2005	%			6.6		9.1			44.3	0.1	4.5		0.1		64.7
estimated	Female					6			1,348		589	6	6		1,956
escapement	%					0.1			24.3		10.6	0.1	0.1		35.3
	Total			368		513			3,802	5	836	6	12		5,543
	%			6.6		9.3			68.6	0.1	15.1	0.1	0.2		100.0
	Male			221		3,197			1,209		631				5,258
2006	%			2.9		41.4			15.7		8.2				68.1
estimated	Female					58			938		1,469				2,465
escapement	%					0.8			12.1		19.0				31.9
	Total			221		3,255			2,147		2,100				7,723
	%			2.9		42.1			27.8		27.2				100.0
	Male	5	5	179		837	5		2,619		325	5			3,980
2007	%	0.1	0.1	2.7		12.6	0.1		39.5		4.9	0.1			60.0
estimated	Female								1,903		710	5	30		2,649
escapement	%								28.7		10.7	0.1	0.5		40.0
	Total	5	5	179		837	5		4,522		1,035	10	30		6,629
	%	0.1	0.1	2.7		12.6	0.1		68.2		15.6	0.2	0.5		100.0
	Male			163	6	937			692		459		6		2,262
2008	%			4.1	0.1	23.5			17.4		11.5		0.1		56.8
estimated	Female								537		1,174		6		1,717
escapement	%								13.5		29.5		0.1		43.2
	Total			163	6	937			1,229		1,633		11		3,979
	%			4.1	0.1	23.5			30.9		41.0		0.3		100.0
	Male			144		1,738		1	1,763	2	555		11		4,212
1997–2006	%			2.1		25.2		<0.1	25.6	<0.1	8.1%		0.%		61.2
mean	Female					24			1,316	1	1,310	1	21	1	2,674
annual	%					0.3			19.1	<0.1	19.0	<0.1	0.3	<0.1	38.8
estimated	Total			144		1,762		1	3,079	2	1,864	1	32	1	6,886
escapement	%			2.1		25.6		<0.1	44.7	<0.1	27.1	<0.1	0.5	<0.1	100.0
	Male	<1	<1	147	<1	1,656	<1	1	1,841	1	534	<1	10		4,191
1997–2007	%	<0.1	<0.1	2.1	<0.1	24.1	<0.1	<0.1	26.8	<0.1	7.8	<0.1	0.1		61.1
mean	Female					22			1,369	1	1,255	1	22	1	2,672
annual	%					0.3			20.0	<0.1	18.3	<0.1	0.3	<0.1	38.9
estimated	Total	<1	<1	147	<1	1,678	<1	1	3,210	2	1,789	1	32	1	6,862
escapement	%	<0.1	<0.1	2.1	<0.1	24.4	<0.1	<0.1	46.8	<0.1	26.1	<0.1	0.5	<0.1	100.0

Appendix A7.–Elapsed time between release and recapture (sulking period) of Chinook salmon in the lower Unuk River in 2008.

			Sulking period		
Spaghetti tag no.	Release date/time	Recapture date/time	Days	Hours	Minutes
9009	06/20/08 06:06	06/20/08 06:40			34
9038	07/02/08 16:48	07/12/08 13:24	9	20	36
9116	07/13/08 17:52	07/16/08 13:28	2	19	36
9134	07/15/08 10:21	07/26/08 16:02	11	5	41
9140	07/15/08 13:30	07/19/08 06:14	3	16	44
9165	07/16/08 15:48	07/25/08 12:51	8	21	3
9165	07/25/08 12:51	07/25/08 13:12			21
9173	07/17/08 13:00	07/17/08 14:09		1	9
9176	07/17/08 13:21	07/31/08 05:55	13	16	34
9194	07/17/08 16:01	07/17/08 16:23			22
9203	07/18/08 05:52	07/18/08 17:35		11	43
9207	07/18/08 06:18	08/04/08 12:54	17	6	36
9240	07/18/08 14:37	07/25/08 07:46	6	17	9
9262	07/18/08 17:40	07/27/08 12:41	8	19	1
9308	07/22/08 06:15	07/30/08 10:30	8	4	15
9319	07/22/08 13:55	07/31/08 11:53	8	22	58
9334	07/23/08 06:48	08/04/08 05:59	11	23	11
9337	07/23/08 07:08	07'24'08 14:20	1	7	12
9355	07/23/08 10:41	08/02/08 13:03	10	2	22
9360	07/23/08 12:31	08/01/08 08:30	8	19	59
9366	07/23/08 14:20	07/30/08 12:41	6	22	21
9366	07/30/08 12:41	08/30/08 13:04			23
9372	07/23/08 15:54	07/26/08 17:23	3	1	29
9377	07/23/08 17:02	07/28/08 15:46	4	22	44
9400	07/24/08 12:40	08/03/08 14:01	10	1	21
9421	07/24/08 15:00	07/27/08 14:13	2	23	13
9434	07/25/08 06:30	08/04/08 12:41	10	6	11
9444	07/25/08 08:25	07/28/08 17:28	3	9	3
9447	07/25/08 09:30	07/25/08 11:41		2	11
9447	07/25/08 11:41	07/31/08 13:33	6	1	52
9461	07/25/08 13:13	07/31/08 17:14	6	4	1
9463	07/25/08 13:41	07/26/08 12:45		23	4
9464	07/25/08 13:43	08/04/08 17:41	10	3	58
9483	07/26/08 05:48	07/29/08 15:01	3	9	13
9484	07/26/08 06:09	08/03/08 07:15	8	1	6
9490	07/26/08 10:50	08/04/08 13:41	9	2	51
9509	07/26/08 16:03	07/30/08 17:23	4	1	20
9511	07/26/08 16:27	08/03/08 07:16	6	14	49
9524	07/27/08 14:41	07/27/08 14:51			10
9527	07/28/08 11:41	08/03/08 11:00	5	23	19
9528	07/28/08 12:14	08/03/08 12:22	6	0	8
9553	07/29/08 14:11	08/01/08 10:00	2	19	49
9569	07/30/08 15:02	07/30/08 16:49		1	47
9573	07/31/08 07:15	07/31/08 08:30		1	15

Average = 5 days, 13 hours, and 9 minutes; maximum = 17 days, 6 hours, and 36 minutes; minimum = 10 minutes.

APPENDIX B

Appendix B1.–Numbers of Unuk River Chinook salmon fall fingerlings and spring smolt captured and released after excision of the adipose fin (adipose fin clips) and the number of adipose-clipped fish implanted with coded wire tags and estimated to have retained their tags for 24 hours (valid coded wire tags), 1993- spring 2009.

Brood year	Year tagged	Fall/ spring	Tag code	Dates tagged	Number released with adipose clipsa	Estimated number released with valid CWTs
1992	1993	Fall	04-38-03	10/13-10/22/93	10,304	10,263
1992	1993	Fall	04-38-04	10/25/1993	439	433
1992	1993	Fall	04-38-05	10/16-10/21/93	3,192	3,093
1992	1994	Spring	04-42-06	5/05-5/23/94	2,642	2,642
1992 Brood year total					16,577	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	3,227	3,227
1993 Brood year total					23,773	23,753
1994	1995	Fall	04-35-56	10/07-10/10/95	11,537	11,476
1994	1995	Fall	04-35-58	10/11-10/16/65	11,645	11,645
1994	1995	Fall	04-35-59	10/17-10/24/95	11,100	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	6,099	6,099
1994	1996	Spring	04-42-08	4/23-4/27/96	1,357	1,357
1994 Brood year total					48,062	47,662
1995	1996	Fall	04-47-12	9/30-9/15/96	24,224	24,224
1995	1996	Fall	04-42-36	10/16-10/19/96	11,200	11,200
1995	1996	Fall	04-42-18	10/20-10/21/96	3,753	3,753
1995	1997	Spring	04-38-29	3/31-4/18/97	12,517	12,517
1995 Brood year total					51,694	51,694
1996	1997	Fall	04-47-13	10/04-10/11/97	24,303	24,176
1996	1997	Fall	04-47-14	10/06-10/11/97	22,975	22,583
1996	1997	Fall	04-47-15	10/11-10/20/97	15,396	15,146
1996	1998	Spring	04-46-46	3/29-4/05/98	11,188	11,134
1996	1998	Spring	04-43-39	4/08-4/13/98	5,987	5,987
1996 Brood year total					79,849	79,026
1997	1998	Fall	04-01-39	10/04-10/13/98	22,374	22,366
1997	1998	Fall	04-01-40	10/13-10/23/98	11,640	11,522
1997	1999	Spring	04-01-44	4/08-5/01/99	7,948	7,948
1997 Brood year total					41,962	41,836
1998	1999	Fall	04-01-42	10/04-10/17/99	16,661	16,661
1998	2000	Spring	04-02-56	4/01-4/27/00	11,124	11,124
1998	2000	Spring	04-02-57	4/29-5/4/00	2,209	2,209
1998 Brood year					29,994	29,994
1999	2000	Fall	04-03-74	10/06-10/20/00	21,853	21,853
1999	2000	Fall	04-02-88	10/20-10/29/00	10,072	10,072
1999	2001	Spring	04-01-45	4/2-4/23/01	16,561	16,561
1999 Brood year total					48,486	48,486

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Brood year	Year tagged	Fall/ spring	Tag code	Dates tagged	Number released with adipose clips[a]	Estimated number released with valid CWTs
2000	2001	Fall	04-02-92	9/29-10/05/01	10,950	10,950
2000	2001	Fall	04-04-57	10/05-10/09/01	11,231	11,231
2000	2001	Fall	04-04-58	10/09-10/14/01	11,223	11,200
2000	2001	Fall	04-04-60	10/14-10/23/01	10,990	10,990
2000	2002	Spring	04-05-38	4/4-4/24/02	10,904	10,904
2000	2002	Spring	04-05-39	4/25-4/26/02	1,067	1,067
2000 Brood year total					56,365	56,342
2001	2002	Fall	04-05-23	9/28-10/05/02	11,402	11,402
2001	2002	Fall	04-05-24	10/05-10/13/02	11,538	11,538
2001	2002	Fall	04-05-25	10/13-10/17/02	11,778	11,778
2001	2002	Fall	04-05-26	10/17-10/20/02	11,425	11,425
2001	2002	Fall	04-46-52	10/20-10/25/02	8,403	8,403
2001	2003	Spring	04-08-07	4/8-5/10/03	11,354	11,354
2001	2003	Spring	04-08-03	5/10/2003	483	483
2001 Brood year total					66,383	66,383
2002	2003	Fall	04-08-42	9/29-10/10/03	23,255	23,255
2002	2003	Fall	04-08-10	10/10-10/14/03	11,464	11,464
2002	2003	Fall	04-04-61	10/14-10/18/03	9,779	9,779
2002	2004	Spring	04-09-75	03/29-04/10/04	11,666	11,666
2002	2004	Spring	04-09-76	04/10-04/17/04	2,730	2,730
2002 Brood year total					58,894	58,894
2003	2004	Fall	04-09-77	9/19-10/03/04	11,789	11,789
2003	2004	Fall	04-09-78	10/03-10/19/04	11,417	11,417
2003	2004	Fall	04-09-81	10/19-10/21/04	3,923	3,923
2003	2005	Spring	04-09-80	4/10-4/28/05	8,618	8,585
2003 Brood year total					35,747	35,714
2004	2005	Fall	04-11-55	9/24-10/18/05	23,330	23,330
2004	2005	Fall	04-11-56	10/18/05	941	941
2004	2006	Spring	04-11-52	4/2-4/23/06	16,371	16,269
2004 Brood year total					40,642	40,540
2005	2006	Fall	04-13-05	10/3-10/12/06	23,406	23,406
2005	2006	Fall	04-11-51	10/12-10/19/06	9,393	9,393
2005	2007	Spring	04-12-81	4/9-4/27/07	4,731	4,721
2005 Brood year total					37,530	37,520
2006	2007	Fall	04-12-82	9/30-10/03/07	11,777	11,777
2006	2007	Fall	04-12-83	10/03-10/07/07	11,716	11,716
2006	2007	Fall	04-12-84	10/07-10/13/07	11,756	11,756
2006	2007	Fall	04-12-85	10/13-10/21/07	9,840	9,840
2006	2008	Spring	04-14-62	4/19-4/27/08	10,489	10,489
2006 Brood year total					55,578	55,578
2007	2008	Fall	04-14-65	10/03-10/21/08	16,595	16,595
2007	2009	Spring	04-14-63	4/17-5/02/09	5,578	5,573
2007 Brood year total					22,173	22,168

[a]Refer to Table 9 for estimates of the number of adipose-finclipped fish, by brood year, that survived to smolt.

Appendix B2.–Number of Unuk River Chinook salmon smolt caught in the spring and subsequently released with valid coded wire tags, mean smolt length and weight, and water temperature and depth, 2005–2009.

Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL A: 2005													
9-Apr	73	511	7										1.3
10-Apr	153	1,052	7	116	5	1,563	7	100.0	1,556	68.5	2.5	3.0	5.1
11-Apr	178	1,033	6	65	4	1,033	1	100.0	1,032	68.8	2.5	4.0	5.1
12-Apr	181	855	5	50	2	855	1	100.0	854	71.2	2.9	5.0	3.8
13-Apr	170	582	3									3.0	5.1
14-Apr	155	431	3	65	3	1,013		98.2	995	64.8	3.3	4.0	1.3
15-Apr	158	618	4	55	1	618	2	100.0	616	68.0	2.6	3.0	1.3
16-Apr	163	709	4									3.5	0.0
17-Apr	144	511	4	111	3	1,220	6	100.0	1,214	69.2	2.5		
18-Apr	141	544	4									5.0	2.5
19-Apr	113	395	3	84	2	939	1	100.0	938	70.0	2.7	5.0	8.9
20-Apr	135	365	3									4.0	26.7
21-Apr	118	476	4	75	1	841	2	100.0	839	67.5	2.4	4.0	31.8
22-Apr	91	248	3									3.0	49.5
23-Apr	121	179	1	32		427	9	96.4	403	65.6	2.1	4.0	54.6
24-Apr	130	98	<1									4.0	77.5
25-Apr	122	29	<1	6	1	127		100.0	127	66.1	2.3	3.5	96.5
26-Apr	92	10	<1									4.0	102.9
27-Apr	34	1	<1									4.0	110.5
28-Apr						11		100.0	11	68.0	2.5	4.0	113.0
Total	2,472	8,647		659	22	8,647	29		8,585				
Max.	181	1,052	7	116	5	1,563	7	100.0	1,556	71.2	3.3	5.0	113.0
Min.	34	1	<1	0	0	11	0	96.4	11	64.8	2.1	3.0	0.0
Mean	130	455	3	60	2	786	3	99.5	780	68.1[f]	2.7[f]	3.9	36.6

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Appendix B2.–Page 2 of 5.

Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL B: 2006													
2-Apr	119	939	8	118		939	1	100.0	938	71.0	3.4	2.5	0.0
3-Apr	141	977	7	83	2	977	27	100.0	950	68.5	3.1	3.0	3.8
4-Apr	147	830	6	68	1	830	1	100.0	829	69.3	3.4	2.5	7.6
5-Apr	149	648	4									3.0	10.2
6-Apr	147	507	3	92	3	1,155		99.0	1,144	65.2	2.9	3.0	12.7
7-Apr	149	611	4	54	1	611		100.0	611	71.8	3.7	3.5	14.0
8-Apr	117	626	5	36		626		99.1	621	68.5	3.3	3.0	27.9
9-Apr	141	525	4	29	1	525		100.0	525	68.6	3.2	3.0	31.8
10-Apr	142	724	5	12		724	2	99.2	716	70.2	3.4	3.0	27.9
11-Apr	156	916	6	24	1	916		100.0	916	67.6	3.0	3.5	24.1
12-Apr	154	1,104	7									3.0	24.1
13-Apr	141	971	7	49	2	2,075		100.0	2,075	67.5	3.2	2.0	22.9
14-Apr	134	409	3									2.0	24.1
15-Apr	136	701	5	58		1,110		100.0	1,110	71.3	3.7	3.0	19.1
16-Apr	153	953	6	102	4	953	4	98.4	933	66.8	3.1	3.0	15.2
17-Apr	154	931	6	53	3	931		100.0	931	71.2	3.8	3.5	14.0
18-Apr												3.5	14.0
19-Apr	149	763	5									3.0	16.5
20-Apr	152	525	3	65	2	1,288		100.0	1,288	70.9	3.6	3.0	19.1
21-Apr	147	664	5	31		664		99.0	658	70.1	3.7	3.5	16.5
22-Apr	166	1,120	7	109	3	1,120		100.0	1,120	68.8	3.4	4.0	15.2
23-Apr	173	962	6	89		962		94.0	904	69.1	3.4	4.0	14.0
Total	3,067	16,406		1,072	23	16,406	35		16,269				
Max.	173	1,120	8	118	3	2,075	27	100.0	2,075	71.8	3.8	4.0	31.8
Min.	117	409	3	12	0	525	0	94.0	525	65.2	2.9	2.0	0.0
Mean	146	781	5	63	1	965	2	99.3	957	69.2[f]	3.4[f]	3.1	17.0

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Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL C: 2007													
7-Apr	38	213	6										0.0
8-Apr	73	124	2									1.5	12.7
9-Apr	30	31	1	30		269		100.0	269	69.0	3.9	1.5	26.7
10-Apr												2.0	30.5
11-Apr	98	200	2									2.0	24.1
12-Apr	132	466	4	51	2	444			444	65.3	3.0	2.0	17.8
13-Apr	145	459	3									2.5	16.5
14-Apr	154	376	2	69	1	642		100.0	642	65.9	3.1	2.5	17.8
15-Apr	106	394	4									2.0	15.2
16-Apr	141	379	3	66	2	570		100.0	570	65.8	2.9	1.5	19.1
17-Apr	160	509	3									2.5	19.1
18-Apr	152	592	4	88	3	846		100.0	846	64.3	2.8	2.5	17.8
19-Apr	147	614	4									2.0	15.2
20-Apr	170	627	4	92	4	1,022		99.0	1,012	64.4	2.9	2.0	20.2
21-Apr	172	447	3									3.0	22.9
22-Apr	141	275	2	53		519		100.0	519	65.4	2.9	2.5	30.5
23-Apr	122	244	2									2.5	33.0
24-Apr	85	118	1									2.0	45.7
25-Apr	67	69	1	31	2	287		100.0	287	69.0	3.5	2.0	47.0
26-Apr	86	115	1									2.5	41.9
27-Apr	55	77	1	11		132		100.0	132	67.8	3.4	2.0	38.1
28-Apr												2.0	35.6
29-Apr													33.0
Total	2,274	6,329	53	491	14	4,731	0		4,721				
Max.	172	627	6	92	4	1,022		100.0	1,012	69.0	3.9	3.0	47.0
Min.	30	31	1	0	0	132		99.0	132	64.3	2.8	1.5	0.0
Mean	114	316	3	55	2	526		99.9	525	66.4[f]	3.1[f]	2.1	25.1

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Appendix B2.–Page 4 of 5.

Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL D: 2008													
16-Apr	39	621	16										16.5
17-Apr	22	224	10									2.0	24.1
18-Apr	43	324	8									1.5	14.0
19-Apr	69	658	10	230	3	1,551	9	100.0	1,542	64.0	2.7	1.0	8.9
20-Apr	76	714	9									1.0	6.4
21-Apr	84	1,054	13	213		1,622	6	100.0	1,616	65.2	3.0	1.5	2.5
22-Apr	103	1,603	16									2.0	0.0
23-Apr	111	1,534	14	225	1	2,821	3	100.0	2,818	68.9	3.4	2.0	2.5
24-Apr	115	1,357	12									2.0	6.4
25-Apr	109	1,345	12	153	1	2,400	10	100.0	2,390	68.2	3.1	2.0	6.4
26-Apr	132	1,519	12	121	1	1,386	2	100.0	1,384	68.2	3.3	2.0	5.1
27-Apr	87	775	9	30		739		100.0	739	69.6	3.5	2.5	8.9
Total	990	11,728	139	972	6	10,519	30		10,489				
Max.	132	1,603	16	230	3	2,821	10	100.0	2,818	69.6	3.5	2.5	24.1
Min.	22	224	8	30	0	739	0	100.0	739	64.0	2.7	1.0	0.0
Mean	83	977	12	162	1	1,753	5	100.0	1,748	67.6[f]	3.2[f]	1.8	8.4

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Appendix B2.–Page 5 of 5.

Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL E: 2009													
15-Apr	10	26	3										0.3
16-Apr	37	184	5									3.0	0.0
17-Apr	81	255	3	28	1	465		100.0	465	64.3	2.7	3.5	4.1
18-Apr	88	211	2									3.5	13.2
19-Apr	91	227	2	30		438		100.0	438	65.5	3.0	3.5	12.4
20-Apr	44	165	4									3.5	13.2
21-Apr	98	352	4									3.5	28.2
22-Apr	96	293	3									3.0	21.8
23-Apr	84	426	5	60		1,236		100.0	1,236	61.9	2.4	3.0	18.0
24-Apr	103	530	5									3.5	15.7
25-Apr	131	597	5	74	2	1,127	2	100.0	1,125	66.7	3.1	3.5	14.2
26-Apr	116	508	4									4.0	15.5
27-Apr	107	435	4	54	2	943	1	100.0	942	62.3	2.6	3.5	20.6
28-Apr	106	372	4									3.5	33.3
29-Apr	102	271	3									3.5	39.6
30-Apr	90	246	3	23		890		100.0	890	65.6	3.0	4.0	45.5
1-May	59	152	3									4.0	52.3
2-May	95	330	3	20		482		99.0	477	65.6	2.9	3.5	70.1
3-May												2.5	98.8
4-May												3.0	79.8
Total	1,538	5,581		289	5	5,581	3		5,573				
Max.	131	597	5	74	2	1,236	2	100.0	1,236	66.7	3.1	4.0	98.8
Min.	10	26	2	20	0	438	1	99.0	438	61.9	2.4	2.5	0.0
Mean	85	310	4	41	1	797	2	99.9	796	64.8[f]	2.8[f]	3.4	29.7

[a] Equals the total number of trap checks that day, i.e. individual traps checked twice daily would count as two traps checked.
[b] Equals the number of previously untagged Chinook salmon smolt captured.
[c] Equals the average number of previously untagged Chinook salmon smolt captured per trap check.
[d] Total valid tagged equals total tagged minus overnight mortalities times percent tag retention.
[e] Depth standardized such that 0 in represents minimal depth recorded each season.
[f] Of all lengths or weights collected.

Appendix B3.–Number of Unuk River Chinook salmon fingerlings caught in the fall and subsequently released with valid coded wire tags, mean smolt length and weight, and water temperature and depth, 2005–2008.

Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL A: 2005													
24-Sep	101	2,060	20			2,060	3	100.0	2,057	75.5	5.1	9.0	20.3
25-Sep	123	1,860	15			1,860	6	100.0	1,854	70.7	4.0	8.0	22.9
26-Sep	83	574	7			574		100.0	574	71.8	3.8	8.0	30.5
27-Sep	147	1,716	12	33		1,716	3	100.0	1,713	68.8	3.5	6.0	15.2
28-Sep	69	180	3									7.0	50.8
29-Sep												6.0	94.0
30-Sep												7.0	61.0
1-Oct	76	177	2									7.0	40.6
2-Oct	156	1,540	10	58	2	1,897	12	100.0	1,885	69.4	4.1	5.0	20.3
3-Oct	171	2,074	12	45	1	2,074		100.0	2,074	69.1	3.7	5.0	11.4
4-Oct	160	1,967	12	29		1,967		100.0	1,967	66.5	3.7	6.0	3.8
5-Oct	169	2,725	16	30	1	2,725	4	100.0	2,721	66.9	3.4	6.0	0.0
6-Oct	153	1,365	9	31	1	1,365	5	100.0	1,360	66.3	3.5	6.0	43.2
7-Oct	119	612	5									7.0	35.6
8-Oct	101	672	7	61	1	1,284	3	100.0	1,281	68.9	3.9	6.0	31.8
9-Oct	149	1,244	8	76		1,244	3	100.0	1,241	68.2	3.7	6.0	20.3
10-Oct												6.0	71.1
11-Oct	148	690	5									5.0	47.0
12-Oct	138	835	6	66		1,525	5	100.0	1,520			5.0	54.6
13-Oct	141	870	6	41		870		100.0	870	66.4	3.7	5.0	47.0
14-Oct	84	333	4									5.0	20.3
15-Oct	113	658	6									5.0	7.6
16-Oct	26	132	5	90		1,123	2	100.0	1,121	70.3	4.4	5.0	2.5
17-Oct	128	996	8									4.0	22.9
18-Oct	163	1,037	6	163		2,033		100.0	2,033	66.0	3.7	5.0	12.7
Total	2,718	24,317		723	6	24,317	46		24,271				
Max.	171	2,725	20	163	2	2,725	12	100.0	2,721	75.5	5.1	9.0	94.0
Min.	26	132	2	0	0	574	0	100.0	574	66.0	3.4	4.0	0.0
Mean	124	1,105	9	48	0	1,621	3	100.0	1,618	68.2[f]	3.8[f]	6.0	32.0

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Appendix 3.–Page 2 of 4.

Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL B: 2006													
3-Oct	155	1,415	9			1,415	1	100.0	1,414	65.6	3.3	4.0	29.2
4-Oct	164	2,108	13			2,108		100.0	2,108	59.8	2.4	5.0	21.6
5-Oct	172	2,207	13	14		2,207	4	100.0	2,203	63.5	2.9	6.0	40.6
6-Oct	169	1,447	9	20		1,447		100.0	1,447	62.0	2.6	6.0	22.9
7-Oct	164	2,556	16									6.5	12.7
8-Oct	156	2,890	19	186	2	5,446	3	100.0	5,443	61.7	2.7	5.0	5.1
9-Oct	164	2,881	18	106	2	2,881	2	100.0	2,879	62.1	2.7	5.5	0.0
10-Oct	184	3,358	18	271	2	3,358	2	100.0	3,356	62.6	2.8	6.0	2.5
11-Oct	183	3,003	16	291	3	3,003	3	100.0	3,000	62.5	2.8	6.5	6.4
12-Oct	176	1,767	10	179	1	1,767		100.0	1,767	64.9	3.2	7.0	20.3
13-Oct	167	871	5									7.0	19.1
14-Oct	193	920	5	231		1,791	2	100.0	1,789	63.6	2.9	7.0	34.3
15-Oct	78	217	3									6.0	34.3
16-Oct	194	1,241	6	188	3	1,458	3	100.0	1,455	62.1	2.8	5.0	15.2
17-Oct	213	1,411	7	226	3	1,411	31	100.0	1,380	62.0	2.8	5.0	2.5
18-Oct	192	2,612	14	402	4	2,612	2	100.0	2,610	63.7	3.0	5.0	1.35
19-Oct	205	1,282	6									6.0	34.3
20-Oct	56	306	5									6.0	36.8
21-Oct	56	360	6	367	2	1,948		100.0	1,948	64.7	3.1	6.0	14.0
Total	3,041	32,852		2,481	22	32,852	53		32,799				
Max.	213	3,358	19	402	4	5,446	31	100.0	5,443	64.9	3.1	7.0	40.6
Min.	78	217	3	0	0	1,411	0	100.0	1,380	59.8	2.4	4.0	0.0
Mean	160	1,729	10	177	2	2,347	4	100.0	2,343	62.8[f]	2.8[f]	5.8	18.5

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Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL C: 2007													
29-Sep												6.0	22.9
30-Sep	89	2,999	34			3,097	2	100.0	3,095	62.6	3.3	6.0	20.3
1-Oct	143	4,769	33	4		4,850	35	100.0	4,815	58.6	2.3	6.0	17.8
2-Oct	155	3,889	25									6.0	50.8
3-Oct	12	487	41	47		4,378	4	100.0	4,374	61.9	2.7	6.0	31.8
4-Oct	141	4,794	34	84		3,633	2	100.0	3,631	59.3	2.4	6.0	17.8
5-Oct	139	3,796	27	93		4,074	2	100.0	4,072	59.3	2.5	5.0	8.9
6-Oct	129	3,222	25	116		3,106		100.0	3,106	57.4	2.3	5.0	21.1
7-Oct	141	3,154	22	175		2,942	10	100.0	2,932	61.2	2.9	5.0	17.3
8-Oct	151	3,694	24	258		3,386		100.0	3,386	62.0	2.9	5.0	15.2
9-Oct	150	2,982	20	180		2,751	2	100.0	2,749	61.4	2.8	5.0	8.9
10-Oct	160	3,077	19									6.0	12.7
11-Oct	156	2,064	13									5.0	45.7
12-Oct												5.0	22.9
13-Oct				336		4,476	2	100.0	4,474	61.6	2.8	5.0	33.0
14-Oct												5.0	111.8
15-Oct												5.0	83.8
16-Oct	18	0	0									5.0	48.3
17-Oct	104	1,927	19									5.0	33.0
18-Oct	115	2,402	21	390		3,854		100.0	3,854	62.7	2.8	4.0	22.9
19-Oct	113	2,143	19									4.0	12.7
20-Oct	98	1,389	14	326		3,244		100.0	3,244	60.0	2.6	3.0	5.1
21-Oct	80	1,368	17	105		1,357		100.0	1,357	60.7	2.7	3.0	0.0
22-Oct												4.0	10.2
Total	2,094	48,156		2,114	0	45,148	59		45,089				
Max.	160	4,794	41	390		4,850	35	100.0	4,815	62.7	3.3	6.0	111.8
Min.	12	0	0	0		1,357	0	100.0	1,357	57.4	2.3	3.0	0.0
Mean	116	2,675	23	163		3,473	5	100.0	3,468	60.7[f]	2.7[f]	5.0	28.2

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Date	Traps checked [a]	Catch [b]	CPUE [c]	Recaptures with tags	Recaptures without tags	Total tagged	Overnight mortalities	Tag retention (%)	Total valid tagged [d]	Mean length (mm)	Mean weight (g)	Water temperature (°C)	Water depth [e] (cm)
PANEL D: 2008													
28-Sep													0.0
29-Sep													129.5
30-Sep	38	0	0										94.0
1-Oct	29	51	2										69.9
2-Oct	49	106	2										61.0
3-Oct	55	107	2			223	1	100.0	222	62.4	2.8		80.0
4-Oct													
5-Oct													40.6
6-Oct	61	355	6										26.7
7-Oct	78	1,123	14			1,333		100.0	1,333	62.1	2.7		17.8
8-Oct	92	1,674	18	1		1,678	1	100.0	1,677	59.4	2.4		12.7
9-Oct	97	2,431	25	72		2,320		100.0	2,320	58.9	2.3		7.6
10-Oct	100	2,467	25										0.0
11-Oct	58	1,021	18	95		2,128	4	100.0	2,124	57.1	2.0	5.0	7.6
12-Oct	45	894	20	67		1,817	3	100.0	1,814	57.4	2.1	4.5	25.4
13-Oct	45	504	11									4.5	38.1
14-Oct	67	387	6	110		739	3	100.0	736	60.1	2.5	4.0	17.8
15-Oct	83	1,176	14									4.5	15.2
16-Oct	94	1,573	17	349		2,354		100.0	2,354	56.7	2.0	4.5	7.6
17-Oct	96	1,388	14									4.5	12.7
18-Oct	95	973	10	319	1	2,045	1	100.0	2,044	57.9	2.1	4.0	7.6
19-Oct	95	892	9									4.5	3.8
20-Oct	82	769	9	344	1	1,426		100.0	1,426	59.5	2.4	4.5	22.9
21-Oct	80	702	9	190		545		100.0	545	55.8	1.9	4.5	10.2
22-Oct												4.5	66.0
Total	1,439	18,593		1,547	2	16,608	13		16,595				
Max.	100	2,467	25	349	1	2,354	4	100.0	2,354	62.4	2.8	5.0	129.5
Min.	29	0	0	1	1	223	1	100.0	222	55.8	1.9	4.0	0.0
Mean	72	930	12	141	0	1,510	1	100.0	1,509	58.6[f]	2.3[f]	4.5	32.5

[a] Equals the total number of trap checks that day, i.e. individual traps checked twice daily would count as two traps checked.
[b] Equals the number of previously untagged juvenile Chinook salmon captured, either as smolt or as fingerlings.
[c] Equals the average number of previously untagged Chinook salmon fingerlings captured per trap check.
[d] Total valid tagged equals total tagged minus overnight mortalities times percent tag retention.
[e] Depth standardized such that 0 in represents minimal depth recorded each season.

Appendix B4.–Mean length, weight, and associated statistics of Unuk River Chinook salmon spring smolt and fall fingerlings, 1978 through spring of 2009.

			Length						Weight					
Sample year	Brood year	Spring/ fall	Mean sample date	Sample size	Mean length	Variance	SD	SE	Mean sample date	Sample size	Mean weight	Variance	SD	SE
1978	1977	Fall	1-Dec	50	64.7									
1982	1980	Spring	15-Apr	650	67.4									
1982	1981	Fall	13-Dec	246	68.2									
1983	1981	Spring	10-Apr	703	69.0									
1983	1982	Fall	30-Oct	500	63.8									
1984	1982	Spring	7-Apr	650	67.4									
1985	1983	Spring	11-Apr	703	69.0	44.0	6.6	0.25						
1986	1984	Spring	2-Apr	400	66.0	49.4	7.0	0.35						
1988	1986	Spring	13-Apr	423	69.6	41.4	6.4	0.31						
1994	1992	Spring	14-May	327	75.3	52.3	7.2	0.40	14-	327	4.6	1.9	1.4	0.08
1994	1993	Fall	16-Oct	393	69.2	40.3	6.4	0.32	16-Oct	393	3.6	1.5	1.2	0.06
1995	1993	Spring	24-Apr	260	73.2	60.6	7.8	0.48						
1995	1994	Fall	20-Oct	823	65.3	38.9	6.2	0.22						
1996	1994	Spring	19-Apr	291	70.2	41.2	6.4	0.38	19-Apr	291	3.5	1.2	1.1	0.06
1996	1995	Fall	11-Oct	804	67.3	33.9	5.8	0.21	11-Oct	804	3.4	0.8	0.9	0.03
1997	1995	Spring	7-Apr	327	71.2	36.2	6.0	0.33	7-Apr	327	3.6	0.9	1.0	0.05
1997	1996	Fall	10-Oct	624	61.6	44.8	6.7	0.27	11-Oct	133	2.7	1.0	1.0	0.09
1998	1996	Spring	2-Apr	421	65.8	61.8	7.9	0.38	2-Apr	421	2.8	1.3	1.1	0.06
1998	1997	Fall	14-Oct	398	67.4	46.3	6.8	0.34	17-Oct	243	3.3	1.2	1.1	0.07
1999	1997	Spring	18-Apr	266	70.6	67.4	8.2	0.50	18-Apr	266	3.7	1.7	1.3	0.08
1999	1998	Fall	13-Oct	93	63.4	52.5	7.2	0.75	15-Oct	93	2.9	1.2	1.1	0.12
2000	1998	Spring	17-Apr	271	71.5	56.9	7.5	0.46	17-Apr	270	3.8	1.7	1.3	0.08
2000	1999	Fall	17-Oct	257	65.9	43.5	6.6	0.41	17-Oct	257	3.5	1.2	1.1	0.07
2001	1999	Spring	12-Apr	173	67.4	30.3	5.5	0.42	12-Apr	173	3.3	0.7	0.8	0.06
2001	2000	Fall	13-Oct	485	62.7	45.8	6.8	0.31	13-Oct	485	2.9	0.9	0.9	0.04
2002	2000	Spring	20-Apr	367	68.6	43.4	6.6	0.34	20-Apr	367	3.5	1.2	1.1	0.06
2002	2001	Fall	14-Oct	540	60.8	37.5	6.1	0.26	14-Oct	540	2.6	0.7	0.8	0.03
2003	2001	Spring	23-Apr	333	66.1	57.7	7.6	0.42	23-Apr	333	3.2	1.2	1.1	0.06
2003	2002	Fall	9-Oct	443	64.0	54.3	7.4	0.35	9-Oct	443	3.0	1.5	1.2	0.06
2004	2002	Spring	7-Apr	383	66.6	44.2	6.7	0.35	7-Apr	383	3.1	1.0	1.0	0.05
2004	2003	Fall	7-Oct	597	60.9	50.7	7.1	0.29	7-Oct	597	2.9	0.8	0.9	0.04
2005	2003	Spring	15-Apr	284	68.1	40.6	6.4	0.38	15-Apr	383	2.7	0.6	0.7	0.04
2005	2004	Fall	6-Oct	448	68.2	50.2	7.1	0.33	6-Oct	448	3.8	1.6	1.3	0.06
2006	2004	Spring	13-Apr	343	69.2	34.8	5.9	0.32	13-Apr	343	3.4	0.8	0.9	0.05
2006	2005	Fall	10-Oct	596	62.8	40.2	6.3	0.26	10-Oct	596	2.8	0.8	0.9	0.04
2007	2005	Spring	18-Apr	299	66.4	34.3	5.9	0.32	18-Apr	299	3.1	0.7	0.9	0.05
2007	2006	Fall	7-Oct	522	60.7	40.5	6.4	0.28	7-Oct	522	2.7	0.8	0.9	0.04
2008	2006	Spring	24-Apr	392	67.6	38.1	6.2	0.31	24-Apr	392	3.2	0.9	1.0	0.05
2008	2007	Fall	12-Oct	390	58.6	39.1	6.3	0.32	12-Oct	390	2.3	0.6	0.8	0.04
2009	2007	Spring	25-Apr	336	64.8	55.1	7.4	0.40	25-Apr	336	2.8	1.2	1.1	0.06

Appendix B5.–Numbers of Unuk River Chinook salmon examined for adipose fin clips, sacrificed for coded wire tag sampling purposes, valid coded wire tags decoded, percentage of sacrificed fish with valid coded wire tags, percentage of fish examined with adipose fin clips, the estimated fraction of examined fish with valid tags (marked fraction or □) by age class and mark-recapture sampling event, 1998 brood through 2008 returns.

Brood year	Age class	Year examined	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent valid tags	Percent adipose fin clips	Marked fraction (θ)	Event[a]
1998	1.1	2001	9	1	1		1	1	100.0	11.1	.111	1
1998	R.R→1.1	2001	3									1
1998	1.1	2001	17	2	2		2	2	100.0	11.8	.118	2
1998	R.1→1.1	2001	1									2
1998	R.R→1.1	2001	1									2
1998	1.2	2002	218	15	14	8	6	14	100.0	6.9	.069	1
1998	R.2→1.2	2002	32	3	2	2		2	100.0	9.4	.094	1
1998	R.R→1.2	2002	5									1
1998	1.2	2002	146	7	4	2	2	4	100.0	4.8	.048	2
1998	R.2→1.2	2002	17	1	1		1	1	100.0	5.9	.059	2
1998	R.R→1.2	2002	1									2
1998	0.4	2003	1									1
1998	2.2	2003	1	1	1	1		1	100.0	100.0	1.000	1
1998	1.3	2003	411	47	2		2	2	100.0	11.4	.114	1
1998	R.3→1.3	2003	80	7	2	1	1	2	100.0	8.8	.088	1
1998	R.R→1.3	2003	8	1						12.5		1
1998	1.3	2003	511	49	19	8	11	19	100.0	9.6	.096	2
1998	R.3→1.3	2003	93	11	5	2	3	5	100.0	11.8	.118	2
1998	R.R→1.3	2003	9	2						22.2		2
1998	1.4	2004	170	13						7.6		1
1998	R.4→1.4	2004	39	6						15.4		1
1998	R.R→1.4	2004	11	1						9.1		1
1998	1.4	2004	263	28	1	1		1	100.0	10.6	.106	2
1998	R.4→1.4	2004	55	3						5.5		2
1998	R.R→1.4	2004	4									2
1998	1.5	2005	4	1						25.0		1
1998	1.5	2005	2									2
1998 brood year total			2,112	199	54	25	29	54	100.0	9.4	.094	1&2
1999	1.1	2002	2									2
1999	R.R→1.1	2002	1									2
1999	0.2	2002	1									1
1999	1.2	2003	39	7	5	2	3	5	100.0	17.9	.179	1
1999	R.2→1.2	2003	12	2	2		1	1	50.0	16.7	.083	1
1999	R.R→1.2	2003	1									1
1999	1.2	2003	83	5	5	4	1	5	100.0	6.0	.060	2
1999	R.2→1.2	2003	11	1	1	1		1	100.0	9.1	.091	2
1999	R.R→1.2	2003	1									2
1999	1.3	2004	110	8	1	1		1	100.0	7.3	.073	1
1999	R.3→1.3	2004	29	7	1		1	1	100.0	24.1	.241	1

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Brood year	Age class	Year examined	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent valid tags	Percent adipose fin clips	Marked fraction (θ)	Event[a]
1999	R.R → 1.3	2004	4									1
1999	1.3	2004	193	29	1	1		1	100.0	15.0	.150	2
1999	R.3 → 1.3	2004	49	3						6.1		2
1999	R.R → 1.3	2004	11	2						18.2		2
1999	2.3	2005	3									1
1999	2.3	2005	1									2
1999	1.4	2005	52	4	2		1	1	50.0	7.7	.038	1
1999	R.4 → 1.4	2005	14	1	1					7.1		1
1999	R.R → 1.4	2005	2									1
1999	1.4	2005	104	9	2	1	1	2	100.0	8.7	.087	2
1999	R.4 → 1.4	2005	26	1	1		1	1	100.0	3.8	.038	2
1999	R.R → 1.4	2005	2									2
1999	R.5 → 1.5	2006	1									1
1999 brood year total			752	79	22	10	9	19	86.4	10.5	.091	1&2
2000	1.1	2003	7	1	1		1	1	100.0	14.3	.143	1
2000	R.1 → 1.1	2003	2									1
2000	R.R → 1.1	2003	5									1
2000	1.1	2003	39	2	2	1	1	2	100.0	5.1	.051	2
2000	R.1 → 1.1	2003	4									2
2000	R.R → 1.1	2003	15	1	1	1		1	100.0	6.7	.067	2
2000	1.2	2004	255	17	13	8	4	12	92.3	6.7	.062	1
2000	R.2 → 1.2	2004	83	4	3	2	1	3	100.0	4.8	.048	1
2000	R.R → 1.2	2004	10	1	1		1	1	100.0	10.0	.100	1
2000	1.2	2004	373	28	26	14	12	26	100.0	7.5	.075	2
2000	R.2 → 1.2	2004	76	12	9	5	4	9	100.0	15.8	.158	2
2000	R.R → 1.2	2004	7									2
2000	2.2	2005	1	1	1	1		1	100.0	100.0	1.000	2
2000	1.3	2005	412	46	3	2	1	3	100.0	11.2	.112	1
2000	R.3 → 1.3	2005	137	8								1
2000	R.R → 1.3	2005	6	2								1
2000	1.3	2005	468	40	11	7	2	9	81.8	8.5	.070	2
2000	R.3 → 1.3	2005	125	9								2
2000	R.R → 1.3	2005	10	2	1	1		1	100.0	20.0	.200	2
2000	1.4	2006	184	19						10.3		1
2000	R.4 → 1.4	2006	87	7	1	1		1	100.0	8.0	.080	1
2000	R.R → 1.4	2006	4									1
2000	1.4	2006	174	13	1	1		1	100.0	7.5	.075	2
2000	R.4 → 1.4	2006	77	7						9.1		2
2000	R.R → 1.4	2006	3									2
2000	2.3	2006	1									1
2000	R.5 → 1.5	2007	2									1
2000	1.5	2007	4									2
2000	R.5 → 1.5	2007	2									2

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Brood year	Age class	Year examined	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent valid tags	Percent adipose fin clips	Marked fraction (θ)	Event[a]
2000 brood year total			2,573	220	74	44	27	71	95.9	8.6	.082	1&2
2001	1.1	2004	1									1
2001	R.1 → 1.1	2004	1									1
2001	1.1	2004	31	7	7	5	2	7	100.0	22.6	.226	2
2001	R.1 → 1.1	2004	1									2
2001	R.R → 1.1	2004	2									2
2001	1.2	2005	73	5	3	3		3	100.0	6.8	.068	1
2001	R.2 → 1.2	2005	15									1
2001	R.R → 1.2	2005	3	1	1		1	1	100.0	33.3	.333	1
2001	1.2	2005	80	12	11	6	4	10	90.9	15.0	.136	2
2001	R.2 → 1.2	2005	13	1	1	1		1	100.0	7.7	.077	2
2001	R.R → 1.2	2005	2	1	1	1		1	100.0	50.0	.500	2
2001	1.3	2006	279	27	1	1		1	100.0	9.7	.097	1
2001	R.3 → 1.3	2006	75	6	1	1		1	100.0	8.0	.080	1
2001	R.R → 1.3	2006	5	1						20.0		1
2001	1.3	2006	208	16	4	2	1	3	75.0	7.7	.058	2
2001	R.3 → 1.3	2006	49	7	1	1		1	100.0	14.3	.143	2
2001	R.R → 1.3	2006	2									2
2001	2.2	2006	1									1
2001	1.4	2007	68	7						10.3		1
2001	R.4 → 1.4	2007	15	1						6.7		1
2001	2.3	2007	2									2
2001	1.4	2007	148	18	4	2	2	4	100.0	12.2	.122	2
2001	R.4 → 1.4	2007	41	3						7.3		2
2001	1.5	2008	2	1	1					50.0		1
2001	R.5 → 1.5	2008	1									1
2001	R.5 → 1.5	2008	1									2
2001 brood year total			1,119	114	36	23	10	33	91.7	10.2	.093	1&2
2002	1.1	2005	1									1
2002	R.1 → 1.1	2005	1									1
2002	1.1	2005	62	4	4		1	1	25.0	6.5	.016	2
2002	R.1 → 1.1	2005	1	1	1	1		1	100.0	100.0	1.000	2
2002	R.R → 1.1	2005	5									2
2002	1.2	2006	311	14	11	6	2	8	72.7	4.5	.033	1
2002	R.2 → 1..2	2006	75	3	3	2	1	3	100.0	4.0	.040	1
2002	R.R → 1.2	2006	4	1	1		1	1	100.0	25.0	.250	1
2002	1.2	2006	333	37	28	11	10	21	75.0	11.1	.083	2
2002	R.2 → 1 .2	2006	55	2	2	2		2	100.0	3.6	.036	2
2002	R.R → 1.2	2006	16	1	1					6.3		2
2002	1.3	2007	383	32	3	2	1	3	100.0	8.4	.084	1
2002	R.3 → 1.3	2007	89	7	1					7.9		1
2002	1.3	2007	663	65	14	8	3	11	78.6	9.8	.077	2
2002	R.3 → 1.3	2007	131	16	1					12.2		2
2002	1.4	2008	244	24	1					9.8		1
2002	R.4 → 1.4	2008	53	4						7.5		1

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Brood year	Age class	Year examined	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent valid tags	Percent adipose fin clips	Marked fraction (θ)	Event[a]
2002	1.4	2008	99	17	3	3		3	100.0	17.2	.172	2
2002	R.4 → 1.4	2008	26	3						11.5		2
2002	R.R → 1.4	2008	1									2
2002 brood year total			2,553	231	74	35	19	54	73.0	9.0	.066	1&2
2003	R.R → 1.1	2006	1									1
2003	1.1	2006	22	1	1	1		1	100.0	4.5	.045	2
2003	R.1 → 1.1	2006	2	1	1		1	1	100.0	50.0	.500	2
2003	R.R → 1.1	2006	3									2
2003	2.1	2007	1									2
2003	1.2	2007	54	4	4	2	2	4	100.0	7.4	.074	1
2003	R.2 → 1.2	2007	10	1	1		1	1	100.0	10.0	.100	1
2003	1.2	2007	135	16	15	6	7	13	86.7	11.9	.103	2
2003	R.2 → 1.2	2007	19	1	1					5.3		2
2003	1.3	2008	176	15						8.5		1
2003	R.3 → 1.3	2008	46	3						6.5		1
2003	R.R → 1.3	2008	1									1
2003	1.3	2008	81	9	1	1		1	100.0	11.1	11.1	2
2003	R.3 → 1.3	2008	20	3	1		1	1	100.0	15.0	.015	2
2003 brood year total			571	54	25	10	12	22	88.0	9.5	.083	1&2
2004	1.1	2007	2									1
2004	R.1 → 1.1	2007	1									1
2004	1.1	2007	29	5	5	2	3	5	100.0	17.2	.172	2
2004	R.1 → 1.1	2007	6									2
2004	0.2	2007	1									2
2004	1.2	2008	110	6	4	2	1	3	75.0	5.5	.041	1
2004	R.2 → 1 .2	2008	19	1						5.3		1
2004	R.R → 1.2	2008	2									1
2004	1.2	2008	72	10	9	2	3	5	55.6	13.9	.077	2
2004	R.2 → 1 .2	2008	12	1	1					8.3		2
2004	R.R → 1.2	2008	1									2
2004	0.3	2008	1									1
2004 brood year total			256	23	19	6	7	13	68.4	9.0	.061	1&2
2005	0.1	2007	1									2
2005	1.1	2008	8	1	1	1		1	100.0	12.5	.125	1
2005	1.1	2008	16	1	1	1		1	100.0	6.3	.063	2
2005	R.R → 1.1	2008	1									2
2005 brood year total			26	2	2	2		2	100.0	7.7	.077	1&2

[a] Fish captured in both events are only listed in event 1 to avoid double counting.

Appendix B6.–Estimated marine harvest ($\hat{r}_{uj}$) of Chinook salmon from the 1992–2004 broods (Panels A-G), bound for the Unuk River, and associated statistics, by harvest strata, from 1995–2008.

Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
PANEL A: 1992 BROOD YEAR																
Terminal purse seine	District 112-22	1995	1	7	26	4	208	0	208	14	14	14	14	1	35	35
Drift gillnet	District 106	1996	1	7	27	4	91	0	40	5	5	5	5	1	81	80
Traditional troll	NW Quadrant	1997	1	7	3	3	99,338	0	36,047	1,247	1,222	1,130	1,130	1	100	99
Experimental troll	District 101-45	1997	1	7	26	5	241	0	81	5	5	5	5	1	105	105
Drift gillnet	District 106	1997	1	7	27	4	258	0	157	15	14	13	13	1	62	62
Recreational DE	Sitka	1998	1	8		4	14,355	0	3,337	119	118	111	110	1	155	155
1992 brood year total							114,491	0	39,870	1,405	1,378	1,278	1,277	6	538	237
PANEL B: 1993 BROOD YEAR																
Traditional troll	NW Quadrant	1997	1	7	3	3	99,338	0	36,047	1,247	1,222	1,130	1,130	1	32	31
Traditional troll	NE Quadrant	1997	1	7	4	3	1,106	0	711	73	73	68	68	1	18	17
Traditional troll	NW Quadrant	1997	1	7	5	3	21,448	0	7,245	348	343	311	311	1	34	34
Traditional troll	NW Quadrant	1997	1	7	6	3	7,949	0	1,245	95	95	90	90	1	72	72
Drift gillnet	District 106	1997	1	7	25	4	277	0	198	12	11	10	10	1	17	17
Drift gillnet	District 106	1997	1	7	26	4	326	0	97	9	9	9	9	1	38	38
Drift gillnet	District 101 MIC	1997	1	7	27	4	77	0	40	8	8	8	8	1	22	21
NMFS trawl survey	Gulf of Alaska	1998	1	1	1	2	16,941	0	4,432	100	100	100	100	1	43	43
Traditional troll	NW Quadrant	1998	1	7	1	3	20,709	0	7,067	331	330	307	307	1	33	33
Traditional troll	NE Quadrant	1998	1	7	3	3	19,323	0	10,238	377	375	347	347	2	43	30
Traditional troll	NW Quadrant	1998	1	7	3	3	60,545	0	22,610	837	814	754	754	1	31	31
Traditional troll	NE Quadrant	1998	1	7	4	3	619	0	112	9	9	9	9	1	63	62
Traditional troll	NW Quadrant	1998	1	7	4	3	34,340	0	11,946	652	637	584	583	1	33	33
Traditional troll	NE Quadrant	1998	1	7	5	3	930	0	516	68	65	62	62	1	21	21
Traditional troll	NW Quadrant	1998	1	7	5	3	12,915	0	3,125	216	216	207	206	1	47	47
Terminal troll	SE Quadrant	1998	1	7	24	4	54	0	46	5	5	5	5	1	13	13
Experimental troll	District 101-45	1998	1	7	25	5	209	0	197	32	32	32	32	2	24	16
Experimental troll	District 101-45	1998	1	7	26	5	105	0	105	16	16	16	16	1	11	11
Recreational MB	Juneau	1998	1	8		4	1,297	0	310	54	49	46	46	1	52	52
Traditional troll	NW Quadrant	1999	1	7	1	3	12,321	0	3,096	188	187	174	174	1	45	45
Traditional troll	NW Quadrant	1999	1	7	3	3	67,195	0	22,737	999	992	906	904	1	34	33
Experimental troll	District 101-29	1999	1	7	23	5	131	0	131	16	16	13	13	3	34	19
Experimental troll	District 113-95	1999	1	7	25	5	142	0	29	4	4	4	4	1	55	55

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\text{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Mixed net and seine	Area 000 CDFO	1999	1	7	27	3	2,426	0	755	12	12	10	10	1	36	36
Recreational MB	Craig	1999	1	8		4	2,863	0	524	27	26	22	22	1	64	64
Recreational MB/DE	Ketchikan	1999	1	8		4	3,051	0	642	65	63	56	56	4	222	111
Recreational DE	Petersburg	1999	1	8		4	2,209	0	579	29	29	25	24	1	45	45
Recreational MB	Ketchikan	1999	1	8		4	5,696	0	639	63	62	52	52	1	103	102
1993 brood year total							394,542	0	135,419	5,892	5,800	5,357	5,352	35	1,288	249
PANEL C: 1994 BROOD YEAR																
Traditional troll	NW Quadrant	1998	1	7	3	3	60,545	0	22,610	837	814	754	754	1	36	35
Traditional troll	NW Quadrant	1998	1	7	4	3	34,340	0	11,946	652	637	584	583	2	77	54
Recreational DE	Juneau	1998	1	8		4	1,485	0	583	89	86	79	79	1	34	34
Recreational MB	Cook Inlet	1999	4	2	11	4	4,907	384	2,019	67	64	61	60	1	34	33
Traditional troll	NW Quadrant	1999	1	7	3	3	67,195	0	22,737	999	992	906	904	3	117	67
Experimental troll	District 101-29	1999	1	7	24	5	218	0	188	17	16	15	15	1	16	16
Experimental troll	District 101-45	1999	1	7	25	5	152	0	104	14	14	14	14	1	19	19
Drift gillnet	District 101	1999	1	7	26	4	510	0	315	5	5	5	5	1	21	21
Experimental troll	District 107-20	1999	1	7	26	5	90	0	33	2	2	2	2	1	36	35
Drift gillnet	District 101	1999	1	7	27	4	417	0	343	26	25	21	21	1	16	16
Recreational DE/MB	Ketchikan	1999	1	8		4	3,051	0	642	65	63	56	56	2	128	90
Recreational MB	Ketchikan	1999	1	8		4	5,696	0	639	63	62	52	52	1	118	117
Recreational MB	Sitka	1999	1	8		4	1,754	0	354	16	15	15	15	1	69	68
Traditional troll	NE Quadrant	2000	1	7	1	3	1,671	0	905	53	53	47	47	1	24	24
Traditional troll	NW Quadrant	2000	1	7	1	3	14,898	0	4,534	331	331	313	313	2	86	60
Experimental troll	District 113-95	2000	1	7	23	5	67	0	67	5	5	4	4	1	13	13
Experimental troll	District 101-45	2000	1	7	26	5	458	0	273	32	31	27	27	1	23	22
Experimental troll	District 101-45	2000	1	7	27	5	641	0	641	66	66	59	59	2	26	18
Recreational DE	Ketchikan	2000	1	8		4	2,740	0	497	33	33	28	28	2	144	101
Recreational MB	Sitka	2000	1	8		4	8,063	0	2,236	112	112	107	107	1	47	46
1994 brood year total							208,898	384	71,666	3,484	3,426	3,149	3,145	27	1,082	240
PANEL D: 1995 BROOD YEAR																
Terminal purse seine	District 112-22	1998	1	7	27	4	1,833	0	812	76	76	74	74	1	21	21
Traditional purse seine	District 110	1998	1	7	27	4	184	0	25	7	7	7	7	1	70	69
Traditional purse seine	District 110	1998	1	7	28	4	63	0	63	8	8	8	8	1	10	9

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
NMFS trawl survey	Gulf of Alaska	1999	1	1	1	3	30,600	0	6,175	145	145	145	145	2	94	66
Traditional troll	SE Quadrant	1999	1	7	3	3	2,015	0	1,410	80	80	77	77	1	14	13
Traditional troll	SW Quadrant	1999	1	7	3	3	7,861	0	5,043	159	158	143	143	1	15	14
Traditional troll	SE Quadrant	1999	1	7	4	3	340	0	295	33	33	30	30	3	33	18
Traditional troll	NW Quadrant	1999	1	7	5	3	16,299	0	7,072	616	612	575	574	4	88	43
Traditional set gillnet	Kodiak	1999	1	7	24	4	48	0	29	3	3	3	3	1	16	15
Mixed net and seine	Area 000 CDFO	1999	1	7	27	3	2,426	0	755	12	12	10	10	1	31	30
Private non-profit	District 101-95	1999	1	7	27	3	187	0	86	5	5	5	5	1	21	20
Traditional troll	NE Quadrant	2000	1	7	1	3	1,671	0	905	53	53	47	47	1	18	17
Traditional troll	NW Quadrant	2000	1	7	1	3	14,898	0	4,534	331	331	313	313	2	62	44
Traditional troll	NW Quadrant	2000	1	7	3	3	45,953	0	18,283	966	955	856	853	3	73	41
Traditional troll	NW Quadrant	2000	1	7	4	3	11,618	0	5,023	323	320	297	296	2	45	31
Traditional troll	SE Quadrant	2000	1	7	4	3	344	0	244	19	19	19	19	1	13	13
Traditional troll	NW Quadrant	2000	1	7	5	3	23,605	0	8,848	751	732	679	678	5	130	58
Traditional troll	NW Quadrant	2000	1	7	6	3	5,497	0	2,858	239	236	228	228	2	37	26
Traditional troll	NW Quadrant	2000	1	7	7	3	10,157	0	3,354	286	286	263	263	5	144	64
Experimental troll	District 101-45	2000	1	7	23	5	81	0	81	10	10	10	10	1	10	9
Experimental troll	District 101-45	2000	1	7	24	5	136	0	136	11	11	10	10	1	10	9
Experimental troll	District 110-31	2000	1	7	24	5	199	0	170	17	17	16	16	1	11	11
Experimental troll	District 101-29	2000	1	7	25	5	148	0	148	10	10	10	10	1	10	9
Experimental troll	District 101-45	2000	1	7	25	5	472	0	300	24	24	22	22	1	15	14
Experimental troll	District 105-41	2000	1	7	25	5	89	0	89	14	14	13	13	1	10	9
Experimental troll	District 106-30	2000	1	7	25	5	29	0	26	2	2	2	2	1	11	10
Mixed net and seine	Area 003 CDFO	2000	1	7	26	3	3,994	0	1,429	9	8	8	8	1	30	29
Drift gillnet	District 106	2000	1	7	26	4	215	0	71	9	9	5	5	3	86	49
Experimental troll	District 101-29	2000	1	7	26	5	627	0	613	44	44	42	42	1	10	9
Experimental troll	District 101-45	2000	1	7	26	5	458	0	273	32	31	27	27	2	33	23
Experimental troll	District 105-41	2000	1	7	26	5	63	0	63	4	4	4	4	1	10	9

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Experimental troll	District 113-35	2000	1	7	26	5	2,186	0	672	48	48	45	45	1	31	30
Experimental troll	District 113-37	2000	1	7	26	5	141	0	18	4	4	4	4	1	74	74
Experimental troll	District 101-45	2000	1	7	27	5	641	0	641	66	66	59	59	1	10	9
Drift gillnet	District 106	2000	1	7	28	4	237	0	184	14	14	13	13	1	12	12
Mixed net and seine	Area 003 CDFO	2000	1	7	29	3	3,689	0	2,712	30	30	28	28	1	13	12
Experimental troll	District 101-45	2000	1	7	29	5	83	0	67	11	10	8	8	1	13	12
Recreational DE	Ketchikan	2000	1	8	1	4	2,740	0	497	33	33	28	28	3	157	90
Recreational MB	Sitka	2000	1	8	2	4	8,063	0	2,236	112	112	107	107	1	34	34
Recreational MB	Ketchikan	2000	1	8	1	4	8,032	0	624	55	54	47	47	1	125	124
Recreational MB	Cook Inlet	2000	4	8	1	4	4,773	362	1,839	79	78	68	66	1	26	25
Recreational MB	Cook Inlet	2001	4	2	10	4	3,671	314	1,552	93	89	78	78	2	47	45
Recreational DE	Ketchikan	2001	1	2	11	4	439	0	390	32	31	30	30	3	33	18
Recreational DE	Sitka	2001	1	2	11	4	591	0	591	31	31	31	31	1	10	9
Recreational MB	Ketchikan	2001	1	2	12	4	829	95,632	143	22	21	18	18	1	58	57
Traditional troll	NW Quadrant	2001	1	7	1	3	9,337	0	3,522	328	327	309	309	2	51	35
Traditional troll	SE Quadrant	2001	1	7	3	3	1,693	0	902	66	58	53	53	1	20	20
Traditional troll	Area 000 CDFO	2001	1	7	17	3	202	0	202	16	16	16	16	1	10	9
Experimental troll	District 113-95	2001	1	7	20	5	86	0	86	8	8	6	6	1	10	9
Experimental troll	District 113-62	2001	1	7	21	5	79	0	75	7	7	7	7	1	10	10
Experimental troll	District 101-29	2001	1	7	22	5	84	0	69	3	3	3	3	1	12	11
Experimental troll	District 109-51	2001	1	7	22	5	284	0	149	19	19	18	18	1	18	18
Experimental troll	District 113-95	2001	1	7	22	5	384	0	320	23	23	17	17	1	11	11
Experimental troll	District 101-29	2001	1	7	23	5	568	0	369	23	23	21	21	2	29	20
Experimental troll	District 108-30	2001	1	7	23	5	170	0	84	3	3	2	2	1	19	19
Experimental troll	District 108-30	2001	1	7	24	5	124	0	119	9	9	9	9	1	10	9
Experimental troll	District 101-29	2001	1	7	25	5	636	0	476	18	18	15	15	1	13	12
Experimental troll	District 101-45	2001	1	7	25	5	783	0	399	26	26	22	22	2	37	26
Experimental troll	District 113-62	2001	1	7	25	5	113	0	82	7	7	6	6	1	13	13
Experimental troll	District 101-29	2001	1	7	26	5	545	0	222	16	16	13	13	1	23	23
Private non-profit	District 101-95	2001	1	7	26	5	150	0	140	14	14	12	12	3	31	17
1995 brood year total							233,463	96,308	88,595	5,514	5,453	5,041	5,033	93	2,135	271

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\text{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
PANEL E: 1996 BROOD YEAR																
Terminal purse seine	District 112-22	1999	1	7	28	4	911	0	906	78	76	69	69	2	19	13
NMFS trawl survey	Gulf of Alaska	2000	1	1	1	2	26,676	0	6,589	84	84	84	84	2	75	53
Traditional troll	SE Quadrant	2000	1	7	3	3	1,233	0	884	46	45	43	43	1	13	13
Traditional troll	SW Quadrant	2000	1	7	3	3	2,411	0	1,625	41	38	35	35	1	15	14
Traditional troll	NW Quadrant	2000	1	7	7	3	10,157	0	3,354	286	286	263	263	1	28	28
Experimental troll	District 101-45	2000	1	7	23	5	81	0	81	10	10	10	10	1	9	9
Experimental troll	District 101-29	2000	1	7	24	5	95	0	94	8	8	8	8	1	9	9
Experimental troll	District 101-29	2000	1	7	26	5	627	0	613	44	44	42	42	2	19	13
Experimental troll	District 101-45	2000	1	7	26	5	458	0	273	32	31	27	27	1	16	16
Experimental troll	District 114-27	2000	1	7	26	5	88	0	73	6	6	6	6	1	11	11
Mixed net and seine	Area 004 CDFO	2000	1	7	27	3	5,700	0	1,469	15	15	13	13	1	36	36
Drift gillnet	District 101	2000	1	7	27	4	265	0	99	8	8	5	5	1	25	24
Drift gillnet	District 106	2000	1	7	27	4	298	0	224	23	23	20	20	1	12	12
Drift gillnet	District 106	2000	1	7	28	4	237	0	184	14	14	13	13	1	12	11
Private non-profit	District 101-95	2000	1	7	28	5	267	0	214	24	24	22	22	1	12	11
Drift gillnet	District 106	2000	1	7	29	4	277	0	123	14	14	13	13	1	21	20
Recreational DE	Sitka	2000	1	8	2	4	8,063	0	2,236	112	112	107	107	1	34	33
Recreational MB	Ketchikan	2000	1	8	1	4	8,032	0	624	55	54	47	47	3	366	211
Recreational DE	Ketchikan	2001	1	2	11	4	439	0	390	32	31	30	30	3	32	18
Recreational DE	Sitka	2001	1	2	11	4	591	0	591	31	31	31	31	1	9	9
Recreational DT	Ketchikan	2001	1	2	12	4	56	786	14	1	1	1	1	1	37	37
Recreational MB	Ketchikan	2001	1	2	12	4	829	95,632	143	22	21	18	18	3	170	110
Recreational MB	Ketchikan	2001	1	2	13	4	1,567	56,236	413	48	46	42	42	3	111	65
Recreational MB	Craig	2001	1	2	14	4	1,117	0	268	7	7	7	7	1	39	38
Recreational MB	Ketchikan	2001	1	2	14	4	1,438	226,515	305	33	33	29	29	1	44	43
Recreational DE	Juneau	2001	1	2	17	4	200	0	200	13	13	12	12	1	9	9
Traditional troll	NW Quadrant	2001	1	7	3	3	54,077	0	24,142	1,387	1,378	1,252	1,247	3	63	36
Traditional troll	SE Quadrant	2001	1	7	3	3	1,693	0	902	66	58	53	53	1	20	19
Traditional troll	SW Quadrant	2001	1	7	3	3	8,269	0	5,980	231	212	191	191	2	28	19
Traditional troll	SE Quadrant	2001	1	7	4	3	1,001	0	792	84	83	72	72	1	12	11
Traditional troll	Area 000 CDFO	2001	1	7	19	3	226	0	226	13	13	13	12	1	10	10

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\text{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Experimental troll	District 105-41	2001	1	7	20	5	78	0	57	2	2	1	1	1	13	12
Experimental troll	District 113-41	2001	1	7	20	5	319	0	177	11	11	10	10	1	17	16
Experimental troll	District 101-45	2001	1	7	22	5	85	0	54	7	7	7	7	1	15	14
Experimental troll	District 101-29	2001	1	7	23	5	568	0	369	23	23	21	21	7	100	37
Experimental troll	District 101-45	2001	1	7	23	5	52	0	36	3	3	3	3	1	13	13
Experimental troll	District 101-45	2001	1	7	24	5	811	0	286	28	28	28	27	2	55	38
Experimental troll	District 114-21	2001	1	7	24	5	200	0	110	6	6	5	5	1	17	16
Drift gillnet	District 106	2001	1	7	25	4	336	0	147	10	10	7	7	1	21	21
Experimental troll	District 101-29	2001	1	7	25	5	636	0	476	18	18	15	15	2	25	17
Experimental troll	District 101-45	2001	1	7	25	5	783	0	399	26	26	22	22	2	37	25
Experimental troll	District 113-95	2001	1	7	25	5	551	0	402	30	30	28	28	1	13	12
Mixed net and seine	Area 003 CDFO	2001	1	7	26	3	4,485	0	1,486	27	26	24	24	1	29	29
Drift gillnet	District 101 MIC	2001	1	7	26	4	1,037	0	249	14	14	13	13	1	39	38
Experimental troll	District 101-21	2001	1	7	26	5	27	0	27	3	3	3	3	1	9	9
Experimental troll	District 101-29	2001	1	7	26	5	545	0	222	16	16	13	13	1	23	22
Experimental troll	District 101-45	2001	1	7	28	5	254	0	257	21	21	19	19	1	9	9
Recreational DE	Ketchikan	2002	1	2	10	4	261	0	231	19	19	15	15	1	11	10
Recreational MB	Craig	2002	1	2	11	4	789	0	121	8	8	7	7	2	121	85
Recreational DE	Ketchikan	2002	1	2	11	4	793	0	723	72	71	64	63	7	74	27
Recreational DE	Sitka	2002	1	2	11	4	467	0	467	36	36	34	33	1	10	9
Recreational MB	Ketchikan	2002	1	2	12	4	1,846	155,036	325	33	33	27	27	1	53	52
Traditional troll	NW Quadrant	2002	1	7	1	3	8,378	0	1,886	310	310	256	256	2	83	58
Traditional troll	NW Quadrant	2002	1	7	3	3	129,680	0	43,374	2,801	2,771	2,052	2,049	2	56	39
Experimental troll	District 114-27	2002	1	7	17	5	25	0	25	1	1	1	1	1	9	9
Experimental troll	District 101-29	2002	1	7	21	5	299	0	206	14	14	11	11	1	14	13
Experimental troll	District 106-30	2002	1	7	21	5	8	0	8	1	1	1	1	1	9	9
Experimental troll	District 113-95	2002	1	7	21	5	671	0	549	21	21	18	18	1	11	11
Traditional troll	Area 005 CDFO	2002	1	7	21	3	15,656	0	3,609	403	403	392	390	1	41	40
Experimental troll	District 101-29	2002	1	7	22	5	471	0	404	28	28	27	27	1	11	10
Experimental troll	District 109-62	2002	1	7	22	5	20	0	19	2	2	2	2	1	10	9
Experimental troll	District 101-29	2002	1	7	23	5	1,307	0	857	63	62	61	61	5	72	31
Experimental troll	District 101-90	2002	1	7	23	5	72	0	72	8	8	8	8	2	19	12

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Experimental troll	District 101-21	2002	1	7	24	5	214	0	96	9	9	7	7	1	21	20
Experimental troll	District 113-41	2002	1	7	24	5	707	0	297	17	17	13	13	1	22	22
Experimental troll	District 114-50	2002	1	7	24	5	476	0	376	25	24	19	19	1	12	12
Terminal troll	SE Quadrant	2002	1	7	24	4	27	0	27	2	2	2	2	1	9	9
Experimental troll	District 101-21	2002	1	7	25	5	680	0	432	45	45	33	33	1	15	14
Experimental troll	District 101-29	2002	1	7	25	5	351	0	155	9	9	8	8	1	21	21
Private non-profit	District 101-95	2002	1	7	26	5	3,032	0	540	60	60	52	52	1	52	52
1996 brood year total							314,376	534,205	113,584	7,100	7,017	5,907	5,893	107	2,506	330
PANEL F: 1997 BROOD YEAR																
Recreational DE	Ketchikan	2001	1	2	12	4	311	0	269	34	34	31	31	1	15	15
Traditional troll	NW Quadrant	2001	1	7	3	3	54,077	0	24,142	1,387	1,378	1,252	1,247	1	30	29
Traditional troll	NW Quadrant	2001	1	7	4	3	28,528	0	10,776	986	975	880	876	1	35	35
Traditional troll	SE Quadrant	2001	1	7	4	3	1,001	0	792	84	83	72	72	1	17	16
Recreational DE	Ketchikan	2002	1	2	10	4	261	0	231	19	19	15	15	2	29	20
Recreational DE	Ketchikan	2002	1	2	11	4	793	0	723	72	71	64	63	3	44	25
Recreational MB	Ketchikan	2002	1	2	13	4	1,744	89,176	454	28	28	28	28	1	50	50
Recreational MB	Ketchikan	2002	1	2	14	4	1,080	35,457	192	15	15	13	13	1	73	73
Traditional troll	NE Quadrant	2002	1	7	1	3	1,985	0	761	57	57	50	50	2	68	48
Traditional troll	NW Quadrant	2002	1	7	3	3	129,680	0	43,374	2,801	2,771	2,052	2,049	1	39	39
Traditional troll	SW Quadrant	2002	1	7	3	3	51,881	0	33,852	1,412	1,392	1,099	1,093	1	20	20
Traditional troll	NW Quadrant	2002	1	7	5	3	16,581	0	4,504	929	928	630	628	1	48	48
Experimental troll	District 113-95	2002	1	7	20	5	534	0	494	23	23	19	19	1	14	14
Experimental troll	District 113-01	2002	1	7	21	5	78	0	78	3	3	3	3	1	13	13
Experimental troll	District 101-90	2002	1	7	23	5	72	0	72	8	8	8	8	1	13	13
Traditional troll	Area 001 CDFO	2002	1	7	23	3	15,546	0	3,593	148	148	132	131	1	57	56
Experimental troll	District 101-29	2002	1	7	24	5	1,088	0	546	35	33	29	29	2	55	39
Experimental troll	District 101-29	2002	1	7	25	5	351	0	155	9	9	8	8	1	30	29
Private non-profit	District 101-95	2002	1	7	26	5	3,032	0	540	60	60	52	52	1	73	73
Recreational MB	Cook Inlet	2002	4	8		4	6,850	533	1,871	96	92	50	50	1	50	49
Recreational MB	Wrangell	2003	1	2	10	4	545	0	86	4	4	3	3	1	83	82
Recreational DE	Sitka	2003	1	2	11	4	419	0	419	19	19	17	17	1	13	13
Recreational MB	Sitka	2003	1	2	11	4	2,782	237,329	487	24	24	24	24	1	75	74

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Traditional troll	NW Quadrant	2003	1	7	1	3	26,879	0	5,317	1,179	1,156	633	633	1	67	67
Experimental troll	District 109-51	2003	1	7	19	5	212	0	105	11	11	11	11	1	26	26
Traditional troll	Area 001 CDFO	2003	1	7	20	3	10,368	0	1,194	51	51	50	50	1	113	113
Experimental troll	District 102-50	2003	1	7	23	5	182	0	186	12	12	10	10	1	13	12
Experimental troll	District 114-50	2003	1	7	23	5	150	0	122	10	10	10	10	2	32	22
Experimental troll	District 101-45	2003	1	7	24	5	179	0	113	10	10	10	10	1	21	20
Experimental troll	District 101-29	2003	1	7	25	5	1,002	0	639	52	48	45	45	2	44	31
Experimental troll	District 101-29	2003	1	7	26	5	1,044	0	922	72	70	55	55	2	30	21
Experimental troll	District 101-29	2004	1	7	25	5	1,244	0	714	44	43	36	36	1	23	23
1997 brood year total							360,478	362,495	137,723	9,694	9,585	7,391	7,369	40	1,315	254
PANEL G: 1998 BROOD YEAR																
Recreational MB	Ketchikan	2001	1	2	14	4	44	348	8	2	2	1	1	1	59	58
Recreational DE	Sitka	2002	1	2	11	4	467	0	467	36	36	34	33	1	11	10
Recreational MB	Ketchikan	2002	1	2	12	4	1,846	155,036	325	33	33	27	27	1	61	60
Traditional troll	SE Quadrant	2002	1	7	3	3	3,870	0	1,676	146	146	118	117	1	25	24
Traditional troll	NW Quadrant	2002	1	7	4	3	61,395	0	21,787	2,083	2,057	1,444	1,438	1	31	30
Traditional troll	SE Quadrant	2002	1	7	4	3	2,073	0	1,236	115	114	92	92	3	54	31
Experimental troll	District 101-29	2002	1	7	23	5	1,307	0	857	63	62	62	61	1	17	16
Drift gillnet	District 101 MIC	2002	1	7	25	4	397	0	183	12	12	12	12	2	46	32
Recreational DE	Ketchikan	2003	1	2	11	4	562	0	508	44	42	39	39	1	12	12
Recreational MB	Ketchikan	2003	1	2	11	4	235	5,486	41	2	2	2	2	1	61	61
Recreational MB	Ketchikan	2003	1	2	12	4	1,722	202,928	394	35	35	30	30	2	93	68
Recreational MB	Ketchikan	2003	1	2	13	4	2,503	571,144	453	33	31	30	30	2	125	92
Recreational MB	Sitka	2003	1	2	17	4	2,316	249,524	651	50	50	35	35	1	38	37
Traditional troll	NW Quadrant	2003	1	7	3	3	187,173	0	52,928	3,003	2,947	2,199	2,167	1	39	39
Traditional troll	SW Quadrant	2003	1	7	3	3	37,330	0	20,596	982	961	708	695	1	20	20
Traditional troll	NW Quadrant	2003	1	7	5	3	8,935	0	2,875	410	408	222	219	1	34	33
Experimental troll	District 108-30	2003	1	7	19	5	10	0	2	1	1	1	1	1	53	53
Experimental troll	District 113-31	2003	1	7	21	5	300	0	140	10	10	8	8	1	23	22
Experimental troll	District 108-30	2003	1	7	22	5	179	0	104	6	6	6	6	1	18	18
Experimental troll	District 109-62	2003	1	7	22	5	268	0	46	5	5	5	5	1	62	62
Experimental troll	District 113-95	2003	1	7	22	5	454	0	392	15	15	11	11	1	12	12

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Experimental troll	District 102-50	2003	1	7	23	5	182	0	186	12	12	10	10	1	10	10
Experimental troll	District 101-29	2003	1	7	25	5	1,002	0	639	52	48	45	45	4	72	35
Experimental troll	District 101-45	2003	1	7	25	5	274	0	172	11	11	11	11	1	17	16
Experimental troll	District 113-35	2003	1	7	25	5	1,465	0	201	12	12	9	9	1	78	77
Experimental troll	District 101-29	2003	1	7	26	5	1,044	0	922	72	70	55	55	5	62	27
Experimental troll	District 102-50	2003	1	7	26	5	168	0	171	11	11	7	7	1	10	10
Experimental troll	District 101-45	2003	1	7	27	5	327	0	169	20	20	20	20	1	21	20
NMFS trawl survey	Bering Sea	2004	1	1	1	2	51,134	0	28,783	9	9	9	9	1	19	18
Recreational DE	Ketchikan	2004	1	2	11	4	880	0	744	63	61	58	58	1	13	13
Recreational DE	Ketchikan	2004	1	2	12	4	368	0	325	27	24	22	22	1	14	13
Traditional troll	NW Quadrant	2004	1	7	5	3	9,672	0	2,510	354	354	210	209	1	41	41
Experimental troll	District 109-51	2004	1	7	18	5	151	0	89	11	11	10	10	1	18	18
Experimental troll	District 113-95	2004	1	7	19	5	313	0	245	7	7	6	6	1	14	13
Experimental troll	District 109-51	2004	1	7	22	5	125	0	88	5	5	4	4	1	15	15
Experimental troll	District 101-29	2004	1	7	23	5	932	0	513	41	38	34	34	1	21	20
Experimental troll	District 107-10	2004	1	7	24	5	40	0	40	4	4	4	4	1	11	10
Experimental troll	District 101-29	2004	1	7	25	5	1,244	0	714	44	43	36	36	1	19	19
Experimental troll	District 101-29	2004	1	7	26	5	1,079	0	883	53	53	46	46	1	13	13
Experimental troll	District 113-35	2004	1	7	26	5	2,132	0	714	48	47	39	39	1	33	32
1998 brood year total							385,918	1,184,466	143,777	7,942	7,815	5,721	5,663	52	1,396	231
PANEL H: 1999 BROOD YEAR																
Recreational MB	Ketchikan	2003	1	2	12	4	1,722	202,928	394	35	35	30	30	1	48	48
Experimental troll	District 114-50	2003	1	7	25	5	322	0	214	11	11	9	9	1	17	16
Mixed net and seine	Area 003 CDFO	2003	1	7	28	3	703	0	471	17	17	17	17	1	16	16
Recreational DE	Ketchikan	2004	1	2	11	4	880	202,928	744	63	61	58	58	1	13	13
Recreational MB	Sitka	2004	1	2	12	4	6,826	651,330	1,089	45	42	39	39	1	74	74
Traditional troll	NW Quadrant	2004	1	7	3	3	138,726	0	33,927	2,002	1,965	1,502	1,487	1	46	46
Traditional troll	NW Quadrant	2004	1	7	5	3	9,672	0	2,510	354	354	210	209	1	43	42
Experimental troll	District 101-29	2004	1	7	23	5	932	0	513	41	38	34	34	1	22	21
Drift gillnet	District 101 MIC	2004	1	7	25	4	112	0	42	2	2	2	2	1	29	29
Drift gillnet	District 106	2004	1	7	26	4	465	0	133	7	7	7	7	1	39	38
Drift gillnet	District 106	2004	1	7	27	4	801	0	22	4	4	4	4	1	401	401

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Experimental troll	District 101-29	2004	1	7	27	5	715	0	373	31	31	31	31	1	21	21
Experimental troll	District 102-50	2004	1	7	27	5	79	0	74	4	4	3	3	1	12	11
Recreational DE	Ketchikan	2005	1	2	11	4	1,134	0	898	52	51	49	48	3	43	25
Recreational MB	Sitka	2005	1	2	11	4	2,150	194,636	439	21	21	19	19	1	54	54
Recreational DE	Ketchikan	2005	1	2	12	4	693	0	619	50	44	43	43	1	14	14
Recreational MB	Craig	2005	1	2	13	4	2,343	0	447	22	22	20	20	1	58	57
Traditional troll	SE Quadrant	2005	1	7	1	3	3,933	0	1,167	62	60	43	42	1	39	39
Experimental troll	District 109-62	2005	1	7	19	5	811	0	548	30	30	27	27	1	16	16
Experimental troll	District 101-29	2005	1	7	23	5	750	0	535	29	27	25	25	2	33	23
Experimental troll	District 102-50	2005	1	7	24	5	323	0	244	17	17	16	16	1	15	14
Experimental troll	District 109-51	2005	1	7	24	5	607	0	102	9	9	8	8	1	66	65
Traditional troll	Area 005 CDFO	2005	1	7	24	3	24,262	0	4,472	249	233	217	217	1	64	63
Drift gillnet	District 108	2005	1	7	25	4	1,367	0	794	14	14	12	11	1	21	20
Drift gillnet	District 101	2005	1	7	26	4	624	0	495	18	17	14	14	1	15	14
Experimental troll	District 108-30	2005	1	7	27	5	38	0	34	3	3	3	3	1	12	12
Recreational MB	Ketchikan	2006	1	2	12	4	1,072	151,387	211	18	17	17	17	1	59	59
1999 brood year total							202,062	1,403,209	51,511	3,210	3,136	2,459	2,440	30	1,291	445
PANEL I: 2000 BROOD																
Traditional purse seine	District 106	2003	1	7	32	4	136	0	136	18	18	13	13	1	12	12
Drift gillnet	District 101	2004	1	7	26	4	560	0	586	26	26	20	20	1	12	11
Drift gillnet	District 101	2004	1	7	28	4	316	0	323	9	9	9	9	1	12	11
Drift gillnet	District 106	2004	1	7	25	4	195	0	73	4	4	4	4	1	33	32
Drift gillnet	District 106	2004	1	7	28	4	287	0	20	2	2	2	2	1	175	174
Drift gillnet	District 108	2004	1	7	25	4	1,897	0	371	6	6	6	6	1	62	62
Experimental troll	District 101-29	2004	1	7	27	5	715	0	373	31	31	31	31	1	23	23
Experimental troll	District 106-30	2004	1	7	25	5	95	0	80	8	8	8	8	1	14	14
Experimental troll	District 107-10	2004	1	7	24	5	40	0	40	4	4	4	4	1	12	12
Experimental troll	District 107-10	2004	1	7	26	5	20	0	20	1	1	1	1	1	12	12
Experimental troll	District 109-51	2004	1	7	19	5	178	0	37	4	4	4	4	1	59	58
Recreational MB	Ketchikan	2004	1	2	15	4	215	6,556	94	10	10	7	7	1	28	27
Test fishery	District 113	2004	1	7	33	4	26	0	26	4	4	4	4	1	12	12
Traditional troll	NE Quadrant	2004	1	7	3	3	4,423	0	1,619	106	105	87	87	1	34	33

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Traditional troll	NW Quadrant	2004	1	7	5	3	9,672	0	2,510	354	354	210	209	1	47	47
Traditional troll	SE Quadrant	2004	1	7	5	3	1,413	0	594	38	38	35	35	1	29	28
Drift gillnet	District 101	2005	1	7	28	4	148	0	96	6	6	6	6	1	19	18
Drift gillnet	District 108	2005	1	7	21	4	2,982	0	2,492	24	24	22	22	1	15	14
Drift gillnet	District 108	2005	1	7	25	4	1,367	0	794	14	14	12	11	2	46	32
Drift gillnet	District 108	2005	1	7	26	4	913	0	325	15	15	15	15	1	34	34
Experimental troll	District 101-29	2005	1	7	23	5	750	0	535	29	27	25	25	1	18	18
Experimental troll	District 101-29	2005	1	7	25	5	1,411	0	1,003	74	74	66	66	5	86	38
Experimental troll	District 101-29	2005	1	7	26	5	1,395	0	680	56	55	48	48	4	102	50
Experimental troll	District 101-45	2005	1	7	25	5	544	0	338	22	22	21	21	1	20	19
Experimental troll	District 101-45	2005	1	7	26	5	691	0	474	41	41	38	38	1	18	17
Experimental troll	District 102-50	2005	1	7	24	5	323	0	244	17	17	16	16	1	16	16
Experimental troll	District 102-50	2005	1	7	25	5	388	0	388	32	32	25	25	2	24	17
Experimental troll	District 102-50	2005	1	7	26	5	894	0	717	58	58	50	50	3	46	26
Experimental troll	District 106-30	2005	1	7	27	5	110	0	48	3	3	3	3	1	28	27
Experimental troll	District 108-40	2005	1	7	25	5	381	0	191	4	4	4	4	1	24	24
Experimental troll	District 109-62	2005	1	7	21	5	1,075	0	507	40	40	37	37	2	52	36
Experimental troll	District 113-31	2005	1	7	22	5	1,069	0	606	28	28	22	22	1	22	21
Experimental troll	District 113-31	2005	1	7	23	5	476	0	274	25	25	21	21	1	21	21
Experimental troll	District 113-31	2005	1	7	24	5	3,715	0	1,478	82	82	76	76	2	61	43
Experimental troll	District 113-35	2005	1	7	26	5	882	0	355	13	13	13	13	1	30	30
Experimental troll	District 113-41	2005	1	7	22	5	504	0	193	11	11	9	9	1	32	31
Experimental troll	District 113-62	2005	1	7	24	5	3,068	0	1,523	86	86	76	76	1	25	24
Troll	District 101 MIC	2005	1	7	2	3	196	0	178	11	10	9	9	1	15	14
Recreational MB	Craig	2005	1	2	11	4	303	0	177	7	7	7	7	1	21	20
Recreational MB	Craig	2005	1	2	13	4	2,343	0	447	22	22	20	20	1	64	63
Recreational MB	Elfin Cove	2005	1	2	13	4	540	0	108	12	12	11	11	1	61	60
Recreational DE	Ketchikan	2005	1	2	11	4	1,134	1,738	898	52	51	49	48	1	16	16
Recreational DE	Ketchikan	2005	1	2	12	4	693	1,561	619	50	44	43	43	1	16	15
Recreational MB	Ketchikan	2005	1	2	11	4	451	23,189	42	5	5	5	5	1	131	130
Recreational MB	Ketchikan	2005	1	2	13	4	2,843	158,780	541	39	37	34	34	3	203	119
Recreational DE	Sitka	2005	1	2	11	4	1,175	19,521	1,175	67	67	59	59	1	12	12

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\text{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Recreational MB	Sitka	2005	1	2	12	4	5,280	194,636	1,628	84	83	73	73	1	40	40
Traditional troll	NE Quadrant	2005	1	7	1	3	2,184	0	515	40	40	37	37	1	52	51
Traditional troll	NE Quadrant	2005	1	7	4	3	3,717	0	688	153	143	127	127	1	70	70
Traditional troll	NE Quadrant	2005	1	7	6	3	1,802	0	654	203	203	193	192	1	34	33
Traditional troll	NW Quadrant	2005	1	7	1	3	28,349	0	5,803	615	608	345	345	4	241	120
Traditional troll	NW Quadrant	2005	1	7	3	3	97,209	0	28,826	1,530	1,474	1,238	1,235	5	214	95
Traditional troll	NW Quadrant	2005	1	7	6	3	10,030	0	3,095	331	317	227	226	1	41	41
Traditional troll	SE Quadrant	2005	1	7	3	3	10,208	0	2,707	149	141	104	104	1	49	48
Traditional troll	SW Quadrant	2005	1	7	3	3	23,066	0	8,841	369	354	282	282	2	66	46
Drift gillnet	District 106	2006	1	7	26	4	398	0	159	11	11	8	8	1	31	30
Drift gillnet	District 108	2006	1	7	22	4	4,369	0	2,126	44	43	37	37	1	26	25
Drift gillnet	District 108	2006	1	7	23	4	5,337	0	2,735	46	46	45	45	1	24	23
Drift gillnet	District 108	2006	1	7	24	4	5,766	0	2,645	61	60	56	56	2	54	38
Drift gillnet	District 108	2006	1	7	25	4	4,538	0	2,888	119	119	114	114	1	19	19
Drift gillnet	District 101 MIC	2006	1	7	26	4	114	0	32	5	5	4	4	1	43	43
Experimental troll	District 101-29	2006	1	7	21	5	620	0	523	32	32	25	25	1	14	14
Experimental troll	District 105-41	2006	1	7	23	5	160	0	44	1	1	1	1	1	44	44
Experimental troll	District 107-10	2006	1	7	26	5	29	0	29	2	2	1	1	1	12	12
Experimental troll	District 112-12	2006	1	7	25	5	1,579	0	734	132	129	123	122	1	27	27
Experimental troll	District 113-01	2006	1	7	25	5	175	0	104	5	5	4	4	1	21	20
Experimental troll	District 113-31	2006	1	7	24	5	978	0	436	22	22	21	21	1	27	27
Experimental troll	District 113-95	2006	1	7	25	5	423	0	337	17	17	16	16	1	15	15
Experimental troll	District 114-50	2006	1	7	25	5	450	0	262	15	15	13	13	1	21	20
Recreational DE	Ketchikan	2006	1	2	11	4	625	0	533	41	39	36	36	1	15	15
Recreational DE	Ketchikan	2006	1	2	12	4	337	0	295	18	18	18	18	1	14	13
Recreational MB	Ketchikan	2006	1	2	11	4	235	10,824	32	3	3	3	3	1	90	89
Recreational MB	Ketchikan	2006	1	2	13	4	1,654	99,566	365	22	21	21	21	2	58	57
Recreational MB	Sitka	2006	1	2	11	4	1,939	354,983	638	30	30	29	29	2	74	54
Recreational MB	Sitka	2006	1	2	13	4	4,658	226,907	1,683	72	71	62	62	1	34	34
Traditional troll	NE Quadrant	2006	1	7	1	3	2,377	0	885	105	104	101	101	2	66	46
Traditional troll	SE Quadrant	2006	1	7	1	3	4,891	0	2,476	142	141	117	117	1	24	24

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Traditional troll	Area 001 CDFO	2006	1	7	24	3	7,461	0	4,653	175	173	154	154	1	21	20
2000 brood year total							283,910	1,098,261	101,719	6,164	6,026	4,922	4,913	105	3,481	415
PANEL J: 2001 BROOD																
Test fishery	District 113	2004	1	7	45	4	8	0	8	2	2	1	1	1	11	10
Traditional purse seine	District 110	2004	1	7	30	4	126	0	126	28	28	27	27	1	11	10
Drift gillnet	District 101 MIC	2005	1	7	26	4	359	0	191	6	6	6	6	1	20	20
Experimental troll	District 101-29	2005	1	7	26	5	1,395	0	680	56	55	48	48	1	22	22
Recreational DE	Ketchikan	2005	1	2	12	4	693	1,561	619	50	44	43	43	1	14	13
Test fishery	District 105-41	2005	1	7	35	4	6	0	6	1	1	1	1	1	11	10
Traditional troll	NW Quadrant	2005	1	7	6	3	10,030	0	3,095	331	317	227	226	1	36	36
Traditional troll	SE Quadrant	2005	1	7	6	3	1,962	0	641	53	53	48	48	1	33	32
Drift gillnet	District 101	2006	1	7	26	4	513	0	221	9	9	7	7	1	25	24
Drift gillnet	District 108	2006	1	7	19	4	934	0	484	4	4	2	2	1	21	20
Experimental troll	District 101-29	2006	1	7	25	5	1,570	0	622	40	40	37	37	1	27	27
Experimental troll	District 101-29	2006	1	7	26	5	534	0	136	7	7	6	6	1	42	42
Experimental troll	District 107-10	2006	1	7	25	5	26	0	23	2	2	1	1	1	12	12
Recreational DE	Ketchikan	2006	1	2	11	4	625	0	533	41	39	36	36	1	13	13
Recreational MB	Ketchikan	2006	1	2	13	4	1,654	99,566	365	22	21	21	21	1	51	50
Recreational DE	Sitka	2006	1	2	11	4	846	0	846	41	40	33	33	1	11	10
Recreational MB	Sitka	2006	1	2	12	4	4,105	296,983	2,254	50	49	45	45	1	20	19
Traditional purse seine	District 101	2006	1	7	29	4	209	0	73	7	7	5	5	1	31	30
Traditional purse seine	District 107	2006	1	7	28	4	440	0	132	4	3	3	3	1	48	47
Traditional troll	NW Quadrant	2006	1	7	3	3	96,526	0	27,048	1,274	1,225	910	909	4	159	80
Traditional troll	SE Quadrant	2006	1	7	3	3	4,100	0	1,682	68	67	48	48	1	26	26
Traditional troll	Area 001 CDFO	2006	1	7	26	3	19,955	0	12,544	326	326	302	302	1	18	17
Experimental troll	District 101-29	2007	1	7	20	5	139	0	46	4	4	3	3	1	32	32
Experimental troll	District 105-41	2007	1	7	22	5	210	0	177	9	9	9	9	1	13	12
Experimental troll	District 105-41	2007	1	7	24	5	431	0	138	5	5	5	5	1	33	33
Experimental troll	District 106-30	2007	1	7	24	5	543	0	214	15	15	14	14	1	27	27
Experimental troll	District 106-30	2007	1	7	25	5	1,277	0	391	35	35	34	34	1	35	34
Experimental troll	District 109-62	2007	1	7	21	5	1,443	0	1,036	98	98	94	94	1	15	14
Recreational MB	Ketchikan	2007	1	2	13	4	2,262	11,603	356	23	22	20	20	2	142	100

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Recreational MB	Sitka	2007	1	2	14	4	2,432	110,816	729	36	36	32	32	1	36	35
Traditional troll	NW Quadrant	2007	1	7	1	3	29,540	0	9,788	620	615	408	407	2	65	46
Traditional troll	NW Quadrant	2007	1	7	3	3	103,464	0	32,704	1,529	1,426	1,098	1,093	1	36	36
Traditional troll	SW Quadrant	2007	1	7	3	3	24,807	0	10,193	316	311	224	223	1	27	26
2001 brood year total							313,164	520,529	108,101	5,112	4,921	3,798	3,789	38	1,123	202
PANEL L: 2002 BROOD																
Trad. purse seine, jack	District 101	2005	1	7	28	4	17	0	17	5	5	3	3	1	15	15
Drift gillnet	District 108	2006	1	7	38	4	16	0	5	3	3	3	3	1	48	48
Drift gillnet, jack	District 108	2006	1	7	30	4	22	0	7	1	1	1	1	1	48	47
Experimental troll	District 101-29	2006	1	7	23	5	1,141	0	482	27	24	21	20	1	42	42
Recreational MB	Ketchikan	2006	1	2	16	4	544	97,141	167	14	14	10	10	1	49	49
Recreational MB	Ketchikan	2006	1	2	17	4	196	1,777	76	3	3	3	3	1	39	39
Recreational MB, jack	Ketchikan	2006	1	2	13	4	56	568	19	2	2	1	1	1	45	44
Recreational DE	Sitka	2006	1	2	11	4	846	0	846	41	40	33	33	1	16	15
Traditional purse seine	District 102	2006	1	7	27	4	296	0	70	9	9	7	7	1	64	64
Traditional purse seine	District 104	2006	1	7	27	4	343	0	143	7	7	5	5	1	36	36
Traditional purse seine	District 104	2006	1	7	29	4	901	0	367	6	6	4	4	1	37	37
Traditional troll	NE Quadrant	2006	1	7	5	3	1,575	0	908	214	214	204	204	2	53	37
Traditional troll	NW Quadrant	2006	1	7	3	3	96,526	0	27,048	1,274	1,225	910	909	2	113	79
Traditional troll	NW Quadrant	2006	1	7	4	3	42,231	0	13,226	591	558	408	407	1	51	51
Traditional troll	SE Quadrant	2006	1	7	4	3	5,651	0	1,906	146	144	102	102	1	46	45
Traditional troll	SW Quadrant	2006	1	7	4	3	13,435	0	4,338	215	213	158	157	1	48	47
Traditional troll	Area 001 CDFO	2006	1	7	25	3	24,177	0	11,778	348	348	314	313	1	31	31
Mixed net and seine	Area 000 CDFO	2007	1	7	25	3	3,679	0	863	17	17	17	17	1	65	64
Drift gillnet	District 106	2007	1	7	25	4	634	0	198	14	14	11	11	1	48	48
Drift gillnet	District 106	2007	1	7	29	4	85	0	20	3	3	3	3	1	64	64
Drift gillnet	District 106	2007	1	7	30	4	50	0	29	4	4	4	4	1	26	26
Drift gillnet	District 108	2007	1	7	25	4	1,265	0	316	20	19	16	16	1	64	63
Experimental troll	District 101-29	2007	1	7	22	5	202	0	113	5	5	5	5	1	27	27
Experimental troll	District 101-29	2007	1	7	23	5	423	0	239	22	22	14	14	1	27	26
Experimental troll	District 101-29	2007	1	7	24	5	1,165	0	516	20	20	13	13	1	34	34
Experimental troll	District 101-29	2007	1	7	25	5	2,151	0	737	33	32	23	23	1	46	45

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
Experimental troll	District 101-29	2007	1	7	26	5	1,908	0	623	39	39	31	31	1	46	46
Experimental troll	District 105-41	2007	1	7	21	5	78	0	68	8	8	8	8	1	17	17
Experimental troll	District 105-41	2007	1	7	26	5	442	0	188	8	8	7	7	1	36	35
Experimental troll	District 106-20	2007	1	7	24	5	33	0	33	4	4	4	4	1	15	15
Experimental troll	District 106-30	2007	1	7	24	5	543	0	214	15	15	14	14	1	38	38
Experimental troll	District 108-41	2007	1	7	20	5	298	0	135	8	8	8	8	1	33	33
Experimental troll	District 108-41	2007	1	7	23	5	464	0	260	8	8	8	8	1	27	27
Experimental troll	District 108-41	2007	1	7	24	5	384	0	171	10	10	9	9	1	34	34
Experimental troll	District 109-62	2007	1	7	21	5	1,443	0	1,036	98	98	94	94	2	42	29
Experimental troll	District 112-12	2007	1	7	25	5	1,242	0	796	189	189	178	178	1	24	23
Recreational MB	Craig	2007	1	2	13	4	398	0	366	11	11	11	11	1	16	16
Recreational DE	Ketchikan	2007	1	2	12	4	322	0	188	26	26	23	23	1	26	25
Recreational DE	Sitka	2007	1	2	11	4	809	0	809	43	43	36	36	1	15	15
Recreational MB	Sitka	2007	1	2	10	4	2,261	567,179	467	12	12	11	11	1	73	73
Traditional troll	NE Quadrant	2007	1	7	3	3	4,921	0	2,009	192	185	173	173	1	39	38
Traditional troll	NW Quadrant	2007	1	7	3	3	103,464	0	32,704	1,529	1,426	1,098	1,093	7	361	139
Traditional troll	SE Quadrant	2007	1	7	3	3	7,357	0	3,459	185	180	127	127	2	66	46
Traditional troll	SW Quadrant	2007	1	7	1	3	3,477	0	2,483	116	116	73	72	2	43	30
Traditional troll	SW Quadrant	2007	1	7	3	3	24,807	0	10,193	316	311	224	223	4	150	75
Traditional troll	Area 001 CDFO	2007	1	7	25	3	18,076	0	7,710	167	167	144	144	1	36	35
Drift gillnet	District 101	2008	1	7	28	4	182	0	98	8	8	6	6	1	28	28
Drift gillnet	District 106	2008	1	7	26	4	175	0	100	10	10	10	10	1	27	26
Drift gillnet	District 108	2008	1	7	21	4	1,591	0	1,041	40	40	39	39	1	23	23
Drift gillnet	District 108	2008	1	7	24	4	1,267	0	655	29	29	29	29	1	29	29
Experimental troll	District 108-41	2008	1	7	24	5	331	0	222	15	15	15	15	1	23	22
Experimental troll	District 112-12	2008	1	7	19	5	356	0	232	34	34	32	32	1	23	23
Recreational DE	Ketchikan	2008	1	2	11	4	358	0	286	22	21	20	20	1	20	19
Recreational MB	Yakutat	2008	1	2	10	4	79	0	74	2	2	2	2	1	16	16
Traditional troll	NW Quadrant	2008	1	7	1	3	10,799	0	3,854	241	238	173	172	3	130	75
Traditional troll	NW Quadrant	2008	1	7	3	3	48,029	0	18,729	1,286	1,258	906	900	1	40	39
Traditional troll	SW Quadrant	2008	1	7	3	3	10,064	0	6,137	284	278	195	195	1	25	25
2002 brood year total							443,585	666,665	159,774	7,999	7,749	6,001	5,982	73	2,705	336

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Fishery	Fishery location	Year	Sample type	Sampling period type	Sampling period	Estimation level	H_u	$\mathrm{var}(H_u)$	n_u	a_u	a'_u	t_u	t'_u	m_{uj}	$\hat{r}_{uj}$	$SE(\hat{r}_{uj})$
PANEL K: 2003 BROOD																
Terminal purse seine, jack	District 112-22	2006	1	7	28	5	207	0	157	26	26	24	24	1	16	15
Drift gillnet	District 108	2007	1	7	27	4	731	0	731	62	61	59	59	1	12	12
Recreational DE	Ketchikan	2007	1	2	12	4	322	0	188	26	26	23	23	1	21	20
Trad. purse seine, jack	District 107	2007	1	7	28	4	64	0	64	1	1	1	1	1	12	12
Experimental troll	District 101-29	2008	1	7	21	5	175	0	85	7	7	6	5	1	30	29
Experimental troll	District 101-29	2008	1	7	23	5	315	0	173	12	12	12	12	2	44	31
Experimental troll	District 101-45	2008	1	7	23	5	13	0	13	2	2	2	2	1	12	12
Experimental troll	District 105-41	2008	1	7	23	5	217	0	159	10	10	10	10	1	16	16
Experimental troll	District 106-30	2008	1	7	26	5	107	0	20	2	2	2	2	1	64	64
Experimental troll	District 109-62	2008	1	7	21	5	698	0	595	91	91	87	87	1	14	14
Experimental troll	District 109-62	2008	1	7	24	5	1,854	0	983	186	185	170	170	1	23	22
Recreational DE	Ketchikan	2008	1	2	11	4	358	0	286	22	21	20	20	1	16	15
Traditional troll	NE Quadrant	2008	1	7	1	3	1,455	0	863	95	95	83	83	1	20	20
Traditional troll	NW Quadrant	2008	1	7	3	3	48,029	0	18,729	1,286	1,258	906	900	2	63	45
Traditional troll	NW Quadrant	2008	1	7	4	3	24,386	0	8,788	813	806	506	502	1	34	33
Traditional troll	SE Quadrant	2008	1	7	1	3	3,319	0	1,872	75	74	66	66	1	22	21
2003 brood year total							82,250	0	33,706	2,716	2,677	1,977	1,966	18	419	110
PANEL L: 2004 BROOD																
Drift gillnet	District 106	2008	1	7	27	4	318	0	206	17	17	14	14	1	25	25
Drift gillnet, jack	District 108	2008	1	7	22	4	67	0	60	3	3	3	3	1	18	18
Private non-profit	District 101-95	2008	1	7	28	5	2,511	0	1,080	95	95	91	91	1	38	37
Trad. purse seine, jack	District 107	2008	1	2	30	4	7	0	7	2	2	2	2	1	16	16
2004 brood year total							2,903	0	1,353	117	117	110	110	4	97	51

Appendix B7.–Voluntary recoveries of Chinook salmon possessing a valid Unuk River Chinook salmon CWT from 1995 to 2008. CDFO = Canadian Department of Fisheries and Oceans.

Fishery	Fishery location	Year	Recovery date	Tag code	Brood year
Recreational	CDFO Area 001	1999	05/21/1999	44213	1993
Recreational	CDFO Area 002	2000	05/21/2000	43829	1995
Recreational	CDFO Area 001	2000	06/09/2000	44712	1995
Recreational	Ketchikan	2001	06/17/2001	44712	1995
Recreational	Ketchikan	2001	06/21/2001	44236	1995
Recreational	Ketchikan	2001	10/10/2001	44713	1996
Recreational	CDFO Area 000	2002	05/18/2002	44339	1996
Recreational	Homer	2003	06/17/2003	40256	1998
Recreational	Ketchikan	2004	06/24/2004	40142	1998
Recreational	Ketchikan	2004	06/29/2004	40142	1998
Recreational	Ketchikan	2004	07/01/2004	40256	1998
Recreational, sublegal research	District 101-85	2005	05/27/2005	40810	2002
Recreational	CDFO Area 009	2005	06/21/2005	40145	1999
Recreational, sublegal research	District 101-85	2005	07/25/2005	40810	2002
Recreational, sublegal research	District 101-90	2005	08/07/2005	40842	2002

APPENDIX C

Appendix C1.–Computer files used in the creation of this manuscript that are archived by ADF&G, Research Technical Services.

File name	Description
UNUK41Theta08F.xls	Tables 3, 9, 10-20, B1, B5, and B6.
08UNUK41AF.xls	Tables 7, 8, A4, and A7 and Figures 13 and 17.
07UNUK41AF.xls	Tables 5, 6, and A5 and Figure 9.
08UNUK41ASLF.xls	2008 Mark-recapture data file.
07UNUK41ASLF.xls	2007 Mark-recapture data file.
07KS41UNUK.7s	2007 K-S test data input and output for Figures 10–12 and 14–16.
08KS41UNUK.7s	2008 K-S test data input and output for Figures 18–23.
41Migration08.xls	Table 4.
08UNUK41SMOLT.xls	Tables B2-B4.