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A Mark-Recapture Experiment to Estimate the Escapement of Chinook Salmon in the Keta River, 1999

by

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December 2000

Alaska Department of Fish and Game

Division of Sport Fish

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
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
Ampere	A
Calorie	cal
direct current	DC
Hertz	Hz
Horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
Volts	V
Watts	W

General

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

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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ABSTRACT

The Division of Sport Fish conducted a study of chinook salmon *Oncorhynchus tschawytscha* in 1999 on the Keta River for a second consecutive year to estimate the number of large (≥660 mm mideye to tail fork) spawning salmon, to determine expansion factors for aerial survey counts, and to obtain age, sex and length composition of the population. Escapement of chinook salmon was estimated using a two-event mark-recapture method. Fish were captured with rod and reel gear, and were marked with uniquely numbered spaghetti tags as the primary mark and were batch marked with an opercle punch in concert with removal of the left axillary appendage. Spawning and pre-spawning fish were captured later with angling gear and sampled for marks, and biological data were also collected to complete the experiment. The estimated escapement of large chinook salmon was 968 (SE = 116) in the Keta River in 1999, up from 446 (SE = 50) in 1998. The expansion factor, calculated from dividing the estimated escapement by the peak aerial survey count for large fish was 3.5 (SE = 0.42). A factor of 2.5 (SE = 0.28) was calculated in 1998. The dominant age classes for large spawners were age-1.2 (24.4%), -1.3 (53.0%), and -1.4 (14.0%) for the two sexes combined. Brood years from 1992 through 1996 were represented, with 10 age classes for all fish sampled. Age-0. fish composed 7.4% of all fish sampled.

Key words: chinook salmon, *Oncorhynchus tschawytscha*, spawning abundance, Keta River, mark-recapture, Petersen model, peak survey count, expansion factor, age, sex, length composition, Behm Canal

INTRODUCTION

The Keta River enters Boca de Quadra Inlet in the Misty Fjords National Monument about 56 km east of Ketchikan, Alaska (Figure 1). This is one of four key Behm Canal river systems monitored annually for escapements of chinook salmon *Oncorhynchus tschawytscha*. The Keta River has been surveyed annually by helicopter with standard counting areas and methods since 1975 (Pahlke 1997). Previous to 1975 the Keta River was surveyed on an occasional basis by various methods including foot, boat and fixed-wing aircraft. Indices of escapement consist of peak single day counts of large chinook salmon (≥660 mm mideye to tail fork (MEF)), generally fish saltwater-age-3 or older in most chinook-producing rivers in Southeast Alaska.

Peak counts of chinook salmon in the Keta River have increased from the average during the base period (1975-1980), but remain near the low end of the revised escapement index count (EIC) range (Pahlke 1997). General patterns of abundance are consistent among Behm Canal index rivers. A series of high abundance years beginning in 1982 and ending after 1989 is reflected in counts from the Unuk, Chickamin, Blossom, and Keta rivers. Relative to the revised EIC range, Chickamin River index counts are currently low, Unuk River escapements are currently within, and Blossom and Keta stocks are near the lower end.

The ADF&G Division of Sport Fish obtained funding, as part of the State of Alaska's commitment to a coast-wide rebuilding program, to conduct projects on the Blossom and Keta rivers beginning in 1998 to estimate abundance and age, sex and length composition of spawners. Funding for this program was approved by the Chinook Technical Committee (CTC) using monies from the U.S. Congress to implement abundance-based management of chinook salmon as detailed in a 1996 U.S. Letter of Agreement. Using two-event, mark-recapture methodology, the estimated escapements of large chinook salmon were 364 (SE = 77) in the Blossom River and 446 (SE = 50) in the Keta River (Brownlee et al. 1999). No previous chinook salmon abundance studies had been conducted on the Blossom or Keta rivers. Budget limitations precluded continuing stock assessment work at the Blossom River in 1999. The objectives of this project in 1999 were to estimate the abundance and age, sex and length composition of large chinook salmon in the escapement to the Keta River.

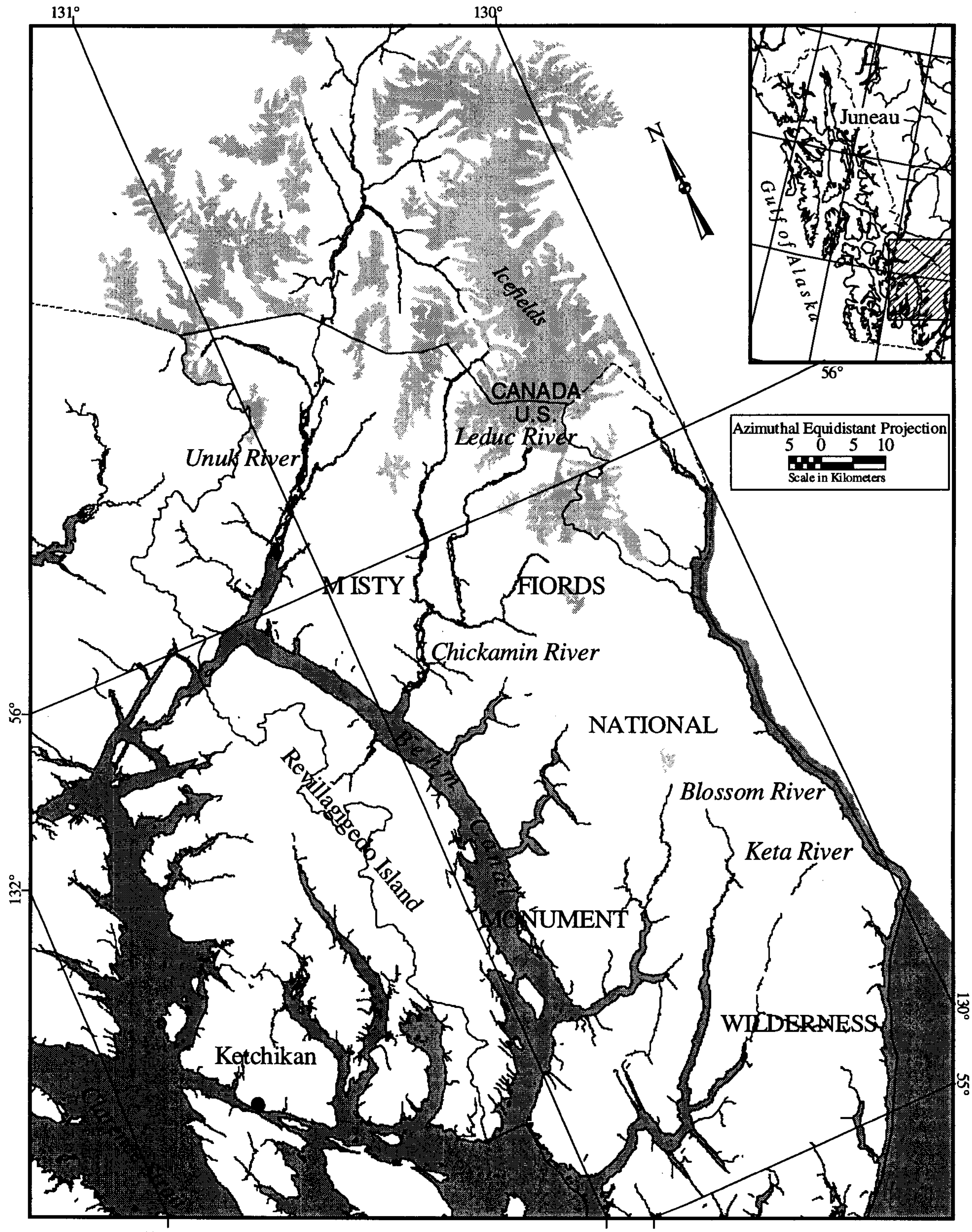

Figure 1.–Behm Canal and Misty Fjords National Monument in Southeast Alaska and location of major chinook salmon producing river systems.

An estimate of escapement in 1999 will allow us to calculate an expansion factor for a second consecutive year, and an improvement in stock assessment. Peak counts of large fish for individual systems are generally expanded to account for the proportion of spawners observed in index surveys relative to the entire escapement. Results of mark-recapture studies to estimate spawner abundance on the Unuk River (Pahlke et al. 1996; Jones et al. 1998) and Chickamin River (Pahlke 1997) were used to derive expansion factors for survey areas on these rivers (Pahlke 1998). Pahlke applied knowledge from these and other rivers to Keta River peak counts. Individual estimates of spawning abundance, coupled with survey counts, will provide the necessary validation of the expansion factor for the Keta River. Given harvest rate information, total escapement is necessary for estimating population parameters including total production and stock specific spawner-recruit relationships. Abundance estimates for the Keta River will contribute to the goal established by the Chinook Technical Committee to revise escapement goals based upon stock-specific scientific analyses. Estimates of length and age distributions of fish will provide information on general life history patterns.

STUDY AREA

The Keta River is tributary to Boca de Quadra Inlet (Figure 2), draining an area of 193 km^2. The river is confined within a narrow, steep-sided, glacier-carved valley, and has an overall mainstem gradient of about 1%. Large cobble riverbed sediments, exposed bars, steep riffles, and very large, bedrock controlled pools characterize the river channel. Large logjam complexes occur near river km 4 and near river km 7. The pool:riffle:glide ratio is about 25:35:40 (Hafele 1983).

The exposed bars, large pools, logjams, and large sediment size probably reflect the high peak flows (flood events) which occurred on the Keta River. The U.S. Geological Survey (USGS) maintained gage stations on the Blossom and Keta rivers between 1977 and 1984 (Bigelow et al. 1985). The flood of record for the Keta River was 30,300 ft^3 s^{-1} Oct. 31, 1978. Peak flows ranging from 10,900 to 21,000 ft^3 s^{-1} were recorded over the period of record. The average discharge for the system was 764 ft^3 s^{-1}.

Hafele (1983) estimated that 52% of spawning habitat on the Keta River was between the mouth and km 4.0, 22% between km 4.0 and the confluence with Hill Creek (km 7.0), and 26% was upstream of Hill Creek. Though not measured in 1998, spawning occurred mostly upstream of Hill Creek.

METHODS

A two-event mark-recapture experiment for a closed population (Seber 1982) was conducted on the Keta River in 1999. Rod and reel angling with bait and lures was the method of capture for the first event of the experiment. Rod and reel snagging and carcass recovery were employed for the second event.

CAPTURE OF CHINOOK SALMON

Rod and reel angling was used exclusively to capture fish in the first event. Terminal gear on the line was borax-cured salmon roe on a single hook. Set gillnetting was not attempted because of a lack of suitable sites in the lower river and because angling was much more effective in capturing fish. The lower river from the mouth (km 0) to km 5 was fished. Effort was concentrated at several sites where fish rested after entering the river. The river was accessed from the lower camp by boat downstream to the mouth and on foot above km 4, where a large logjam precluded boat passage.

MARKING AND SAMPLING

All fish captured were sampled for scales, length to the nearest 5 mm MEF, sex, presence of external parasitic copepods (an indicator of stream life), color, presence or absence of the adipose fin (indicating coded wire tagged fish), and condition. Five scales were taken from each captured fish (Welander 1940). Scales were mounted onto gum cards, which each held scales from 10 fish. The age of each fish was determined later from annual growth patterns of circuli (Olsen 1992) on images of scales impressed onto acetate magnified 70× (Clutter and Whitesel 1956). During the marking phase, a uniquely numbered spaghetti tag was applied to each fish in good condition ≥660 mm MEF. The tags consisted of a 5.7-cm section of

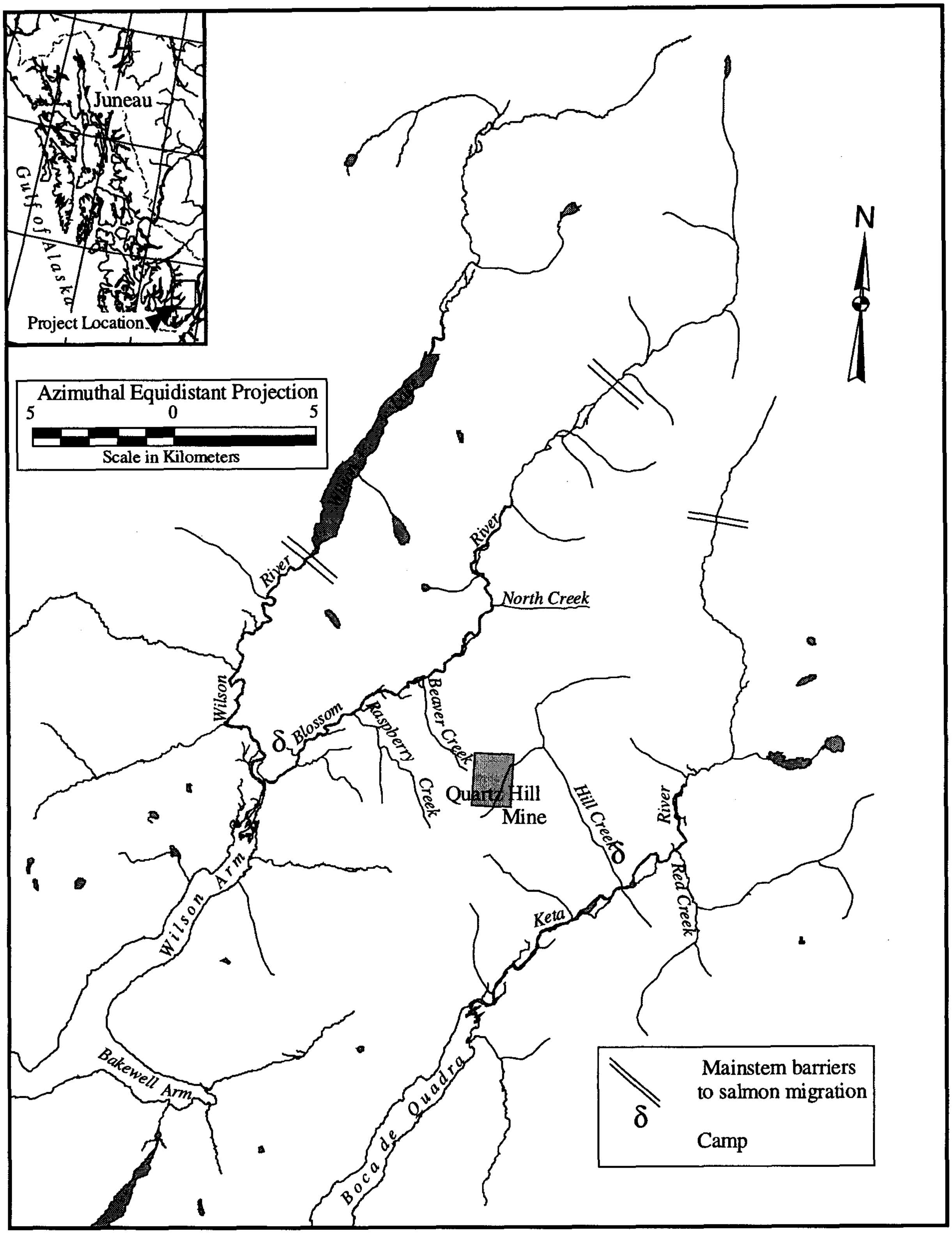

Figure 2.–Blossom and Keta river drainage area in Southeast Alaska, showing location of major tributaries, barriers to fish migration and ADF&G research sites.

blue or clear, laminated Floy™ tubing shrunk onto a 38-cm piece of 80 lb-test (36.3 kg) monofilament fishing line. The tag was applied by first punching the tip portion of a hollow needle through the fish approximately 1.5 cm below and anterior to the posterior insertion of the dorsal fin. The tag was pushed through the needle, then the needle withdrawn. A wire crimp was used to secure the ends of the tag line across the fish, below the dorsal fin. The trailing end of the line was cut 0.5 cm above the crimp. Each tag was uniquely numbered and stamped with an ADF&G contact address and phone number. Secondary marks applied included a 0.6-cm punch in the left upper operculum (LUOP) and a left axillary appendage clip (LAA).

SAMPLING ON THE SPAWNING GROUNDS

Fish were captured and sampled during Event 2 from km 1 upstream to km 17. All sampled fish were given a left lower operculum punch (LLOP) to prevent double sampling later. Fish were closely examined for the presence of the primary tag, LUOP, LLOP, and LAA, for the absence of their adipose fin, and sampled for length and scales using the same techniques employed during the marking event.

ABUNDANCE ESTIMATE

Conditions which must be met for use of Chapman's modification of the Petersen estimator (Seber 1982) include:

(a) every fish has an equal probability of being marked in the first sample, or that every fish has an equal probability of being captured in the second sample, or that marked fish mix completely with unmarked fish; and

(b) recruitment and mortality do not occur between samples; and

(c) marking does not affect the catchability of an animal; and

(d) animals do not lose their marks in the time between the two samples; and

(e) all marks are reported on recovery in the second sample; and

(f) double sampling does not occur.

Two chi-square tests were used to determine if assumption (*a*) was met. The null hypotheses ($\alpha = 0.1$) tested were that the fractions of marked fish were constant across Event 2 spatial strata and that the probability of recovering a fish was independent of its initial (temporal) strata in Event 1. Failure to confirm one of these hypotheses would require a spatially or temporally stratified estimate of abundance (Arnason et al. 1996); otherwise, a Petersen model could be used.

Assumption (*a*) may also be violated if length or sex selective sampling occurs. Two Kolmogorov-Smirnov (K-S) 2-sample tests were used to test the hypothesis that fish of different lengths were captured with equal probability ($\alpha = 0.1$) (Appendix A3). Sex selection was tested using two chi-square tests. In the first test, selectivity during the second sampling event is determined by comparing the number of fish marked in Event 1 and recaptured in Event 2 to the number marked and not recaptured. In the second test, the numbers of fish marked in Event 1 and inspected for marks in Event 2 are compared to determine if size selectivity occurred in the first sampling event. The population was assumed closed to recruitment because sampling spanned the entire immigration. Marking is assumed to have little effect on behavior of released fish or the catchability of fish on the spawning grounds since only fish in good condition were tagged and released. The use of multiple marks, careful inspection of all fish captured on the spawning grounds, and additional marking of all fish inspected helps to insure that assumptions *d*, *e*, and *f* were met.

Abundance of large chinook salmon on the spawning grounds was estimated with Chapman's modified Petersen mark-recapture estimator (Seber 1982, p. 60). Estimated abundance was calculated as

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1 \qquad (1)$$

where M is the estimated number of marked fish that survived to spawn, C is the number of fish inspected for marks on spawning grounds, and R is the number of these inspected fish with marks. Variance, bias, and confidence intervals for the abundance estimator were estimated using a bootstrap procedure, modified from Buckland and Garthwaite (1991). McPherson et al. (1997) contains an example of application of the procedure.

The expansion factor for Keta River was calculated as the ratio of the estimate of abundance of large chinook salmon to the peak aerial survey count.

AGE AND SEX COMPOSITION

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \quad (2)$$

$$\text{var}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \quad (3)$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age j in length group i, n_{ij} is the number of fish of age j of length group i, and n_i is the number of fish in the sample n of length group i (note: $\sum_j \hat{p}_j = 1$). Age and sex composition for the entire spawning population and its associated variances were also estimated by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes gender (male or female), such that $\sum_k \hat{p}_k = 1$, and by age-sex $\hat{p}_{jk}$, such that $\sum_{jk} \hat{p}_{jk} = 1$.

RESULTS

TAGGING, RECOVERY AND ABUNDANCE

Between 27 June and 1 August, 196 chinook salmon were captured, sampled and released with spaghetti tags, secondary and tertiary marks in the Keta River. Of these fish, 19 were medium (440-659 mm MEF) and 177 were large (Table 1). No small fish (<440 mm MEF) were marked.

From 6 August through 2 September, 10 medium and 244 large fish were captured and inspected for marks (Appendix A1). Of these, one medium and 44 large fish were observed with marks. Six of the 44 (or 14%) large fish were recovered with lost primary tags.

Table 1.–Numbers of chinook salmon marked in the Keta River and inspected for marks on the spawning grounds in 1999, by length group.

	440–659 mm	≥660 mm	Total
A. Released in Event 1 with marks (*M*)	19	177	**196**
B. Event 2:			
Captured (C)	9	244	**253**
Recaptured (*R*)	1	44	**45**
R/C (%)	11.1	18.0	**17.8**

The capture history information summary for large fish sampled in 1999 is shown in Table 2. Length frequencies of large fish did not differ significantly between fish marked in Event 1 and those recaptured on the spawning grounds in Event 2 (K-S test , P = 0.37, Figure 3). Similarly, length frequency distributions did not differ significantly for large fish between fish marked in Event 1 and fish inspected for marks in Event 2 (K-S test , P = 0.11, Figure 4); therefore length stratification of the experiment was not needed to estimate abundance of large fish (Appendix A3). Also, sex selectivity did not occur during either sampling event, based on frequencies of sexes recovered and not recovered in Event 2 (χ^2 = 0.04, P = 0.85, df = 1), and fish marked in Event 1 and examined in Event 2 (χ^2 = 1.12, P = 0.29, df = 1). Thus, samples from large fish for events 1 and 2 were pooled and used to estimate abundance by sex and age (Table 3; Appendix A4).

Because of the small sample sizes, abundance was not estimated for medium fish. All 28 medium sized fish sampled during the two events were males.

Table 2.–Capture histories for large (≥660 mm MEF) chinook salmon spawning in the Keta River in 1999.

Capture history	LARGE ≥660 mm	Source of statistics
Marked and not sampled	133	$M_i - R_i$
Marked and recaptured	44	R_i
Not marked, but captured	200	$C_i - R_i$
Not marked and not sampled	591	$\hat{N}_i - M_i - C_i + R_i$
Effective population for simulations	968	$\hat{N}_i$

A chi-square test of the hypothesis that marked and unmarked fractions of large fish were constant across spatial recovery strata was applied and found nonsignificant, as shown below:

	km 1-8	Km 9-17
Number:		
Marked	16	27
Unmarked	97	103
	$\chi^2 = 1.81$	
	df = 1	
	P = 0.18	

Another chi-square test of the hypothesis that the probability of recapture of large marked fish were independent of their marking strata (by time) was significant (failed), as shown below:

	Date marked	
	4 July–18 July	19 July–1 August
Recaptured	17	20
Not recaptured	35	105
	$\chi^2 = 6.19$	
	df = 1	
	P = 0.01	

Passing one of the two tests (above) is sufficient to allow use of the Petersen estimator (Arnason et al. 1996). Of 177 (M_{large}) large fish tagged in the first event, 44 (R_{large}) were recaptured out of 244 (C_{large}) total captured in the second event (Table 1). The abundance of large fish was estimated as $\hat{N}_{large} = 968$ (SE = 116) fish. The escapement expansion factor for the Keta River was calculated at 3.5 (SE = 0.42) (Table 4).

Estimates of Age and Sex Composition

The freshwater ages of fish sampled from the Keta River ranged from age-0. to age-2., with age-1. fish dominant for both females and males. Saltwater ages ranged from 1 to 5 years. The predominant age-classes for large males, estimated from fish sampled in both events, were 22.6% (SE = 2.3%) age-1.2 fish and 24.7% (SE = 2.4%) age-1.3 fish (Table 3). Large females composed an estimated 28.3% (SE = 2.5%) age-1.3 fish and 10.4% (SE = 1.7%) age-1.4 fish of the escapement. There were an estimated 435 (SE = 58) large female spawners in the Keta River escapement in 1999. For the combined sexes of large fish, 24.4% (SE = 2.3%) were age-1.2, 53.0% (SE = 2.7%) were age-1.3 and 14.0% (SE = 1.9%) were age-1.4.

An estimated 7.4% (SE = 1.4%) of the large chinook salmon return to Keta River were freshwater-age-0. fish (from under-yearling smolt). In addition, one large fish sampled (0.3%) was age-2.

DISCUSSION

The success of the population experiment on the Keta River relies on satisfying the conditions for use of the closed population estimator. Findings from the 1998 study enhanced our understanding of run timing, and identified a need to construct a field camp in the lower river. Constant sampling during event 1 in 1999 was thereby facilitated through easier boat access. Proportional sampling effort was also promoted during Event 2, by sampling over a long period from early August through early September. Event 2 sampling was also extended both upstream and downstream in 1999 relative to 1998.

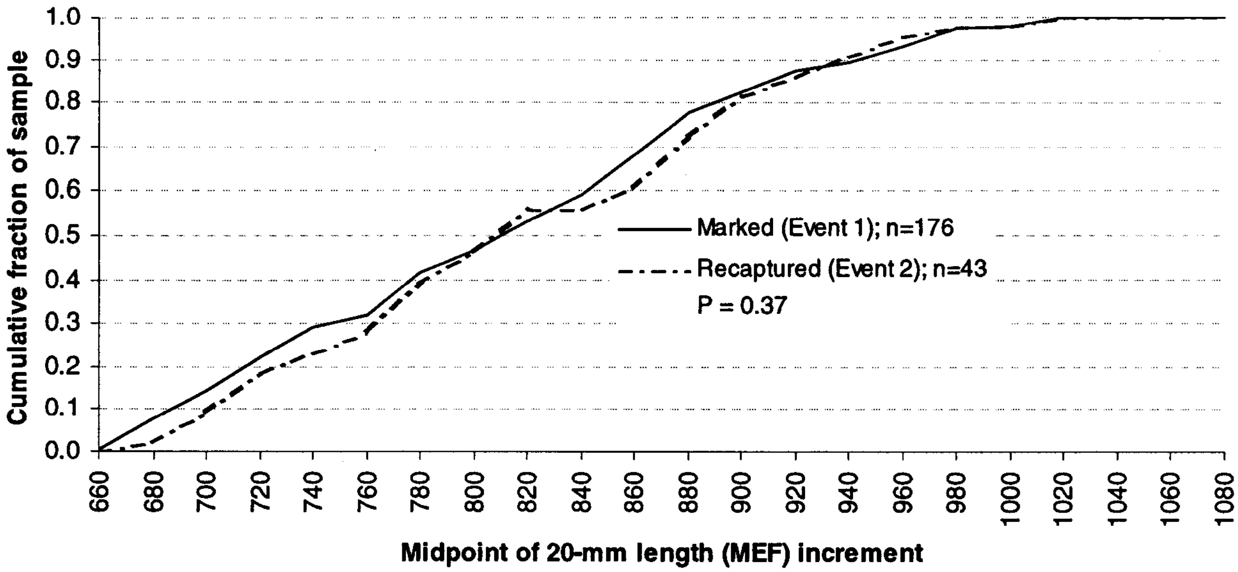

Figure 3.–Cumulative fractions of large (≥660 mm MEF) chinook salmon marked vs. recaptured in the Keta River in 1999.

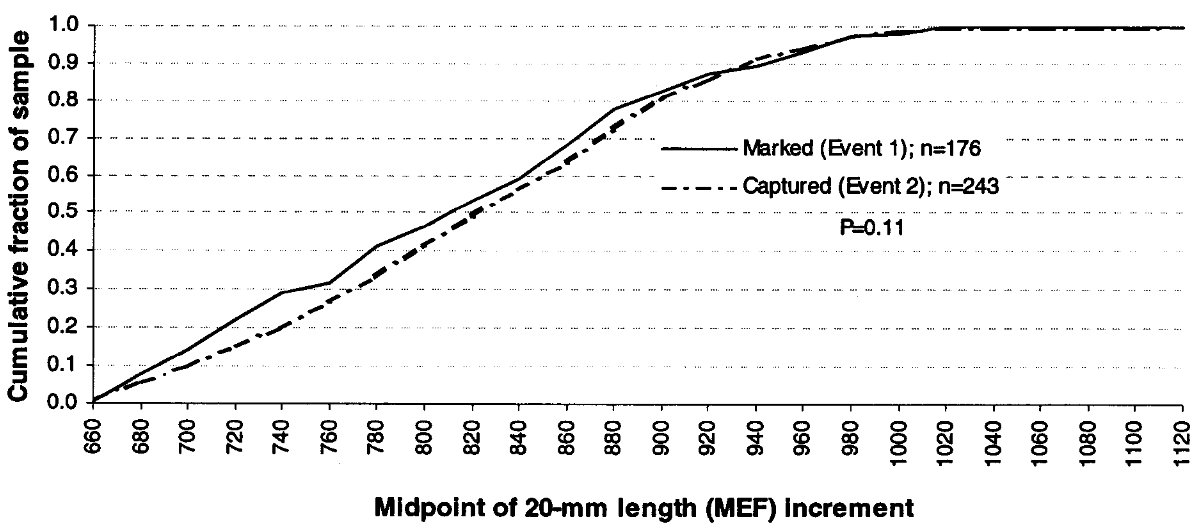

Figure 4.–Cumulative fractions of large (≥660 mm MEF) chinook salmon marked vs. captured in the Keta River in 1999.

Table 3.–Estimated abundance of the escapement, by age and sex, of large (≥660 mm MEF) chinook salmon in the Keta River in 1999.

		Brood year and age class									
		1996	1995	1995	1994	1994	1993	1993	1993	1992	
		0.2	1.2	0.3	1.3	0.4	1.4	2.3	0.5	1.5	Total
Males	Number sampled	2	76	6	83	4	12			2	185
	Percent	0.6	22.6	1.8	24.7	1.2	3.6			0.6	55.1
	SE of percent	0.4	2.3	0.7	2.4	0.6	1.0			0.4	2.7
	Escapement	6	219	17	239	12	35			6	533
	SE of esc.	4	34	7	37	6	11			4	69
Females	Number sampled		6	4	95	6	35	1	3	1	151
	Percent		1.8	1.2	28.3	1.8	10.4	0.3	0.9	0.3	44.9
	SE of percent		0.7	0.6	2.5	0.7	1.7	0.3	0.5	0.3	2.7
	Escapement		17	12	274	17	101	3	9	3	435
	SE of esc.		7	6	40	7	20	3	5	3	58
Total	Number sampled	2	82	10	178	10	47	1	3	3	336
	Percent	0.6	24.4	3.0	53.0	3.0	14.0	0.3	0.9	0.9	100.0
	SE of percent	0.4	2.3	0.9	2.7	0.9	1.9	0.3	0.5	0.5	0.0
	Escapement	6	236	29	513	29	135	3	9	9	968
	SE of esc.	4	36	10	67	10	24	3	5	5	116

Table 4.–Peak survey count compared to mark-recapture estimate of abundance for large (≥660 mm MEF) chinook salmon in the Keta River in 1999.

Location	Keta River
Survey count	276
Mark-recapture estimate (M-R)	968
M-R standard error	116
M-R 95% relative precision	23.5
M-R lower 95% C.I.	784
M-R upper 95% C.I.	1,231
Survey count / (M-R)	28.5%
Expansion factor	3.5
SE [expansion factor]	0.42

The isolated location of Keta River at the head of Boca de Quadra Inlet, away from other large rivers in the area leads us to believe the system was closed with respect to fish emigrating after tagging. Though short-term backing-down of tagged chinook salmon has been documented in other studies (Milligan et al. 1984; Johnson et al. 1992; Bendock and Alexandersdottir 1993; Johnson 1993; McPherson et al. 1997), we think that fish were unlikely to leave the river once tagged. Marked fish were not recaptured downstream of their respective marking sites. Also, immigrating strays from other systems were captured at the low rate of one fish each in 1998 and 1999. In 1999, the single stray captured was a 785 mm MEF female, aged 1.2, with a missing adipose fin, captured on 21 July; it was sacrificed and sampled for a coded wire tag. The tag was recovered and decoded at the ADF&G Coded Wire Tag Processing Lab in Juneau. The tag code indicated the fish was tagged and released at the Tamgas Hatchery on Annette Island, near Ketchikan in 1997; the original brood source was Unuk River.

Evidence of mortality of fish after marking and prior to spawning was low. Fish were released with tags only when in good condition. One pre-spawn, marked carcass was recovered during the second event in 1999 and none were recovered in 1998. Mortality of tagged fish by predators such as harbor seals *Phoca vitulina*, brown bears *Ursus arctos*, black bears *U. americana*, bald eagles *Haliaeetus leucocephalus*, and river otters *Lutra canadensis* was presumed low. The Keta River is a relatively large stream when compared with tributaries of the Unuk River or other chinook salmon spawning streams in the area. Though stream discharge was not measured, deep snow pack and above average rainfall resulted in mostly higher water conditions during the 1999 study. The use of blue or clear tags was assumed to minimize selective capture of tagged chinook by predators.

Even though the white tails of actively spawning or post-spawn females are easier to see during Event 2, there was no evidence of sex-selectivity for large fish in Event 2. Sex-selectivity may have been overcome because males were often captured near females. Kissner and Hubartt (1986) found that post-spawn females generally hold positions and defend redds while spawned-out males drift downstream. Because most sampling for the second event was conducted directly prior to or during active spawning, little sex-related bias should have been introduced during the second event as a result of post-spawning behavior of the fish.

A problem occasionally encountered in similar mark-recapture studies is the inaccurate determination of sex shortly after the fish enter freshwater. A check of all 38 fish recaptured with tags confirmed that each fish was assigned the same sex in the two events. Based on experience of the field crew and physical features of the fish, the sex of Keta River chinook was deemed easier to determine than at other area systems.

In most chinook streams studied by ADF&G in Southeast Alaska, fish ≥660 mm MEF are primarily saltwater-age-.3 fish or older. However, this assumption was not valid for the Keta River in 1999, or in 1998 (Brownlee et al. 1999). Eighty-four (84), or 25%, of the 335 large fish aged over both sampling events were saltwater-age-.2, and all but 6 of those were males (Table 5). This skewed the distribution by sex of large fish sampled to about 55% males and 45% females (Table 3). Mean lengths by age class from the Keta River (Table 5) for combined samples (both sexes and both events) are larger

Table 5.–Average length by sex and age of large (≥660 mm MEF) chinook salmon sampled in the Keta River in 1999.

		Brood year and age class								
		1996	1995	1995	1994	1994	1993	1993	1993	1992
		0.2	1.2	0.3	1.3	0.4	1.4	2.3	0.5	1.5
Males	n	2	76	6	83	4	12			2
	Avg. length	708	711	785	828	926	929			888
	SD	46.0	33.4	85.1	75.1	81.4	93.6			95.5
	SE	32.5	3.8	34.8	8.2	40.7	27.0			95.5
Females	n		6	4	94	6	35	1	3	1
	Avg. length		730	771	849	873	921	800	980	1000
	SD		48.2	42.7	45.3	48.1	47.9		5.0	
	SE		19.7	21.3	4.7	19.7	8.1		2.9	
Sexes combined	n	2	82	10	177	10	47	1	3	3
	Avg. length	708	712	780	840	894	923	800	980	925
	SD	46.0	34.6	68.5	61.8	65.3	61.7		5.0	93.7
	SE	32.5	3.8	21.6	4.6	20.7	9.0		2.9	93.7

than chinook salmon sampled from the spawning grounds than in all other rivers sampled in Southeast Alaska (Jones and McPherson 1999; Pahlke *In prep.*).

In addition, length-at-age information suggests that differences exist between environmental regimes influencing growth and (or) genotype heterogeneity among populations. Validation, however, requires sampling across multiple years to demonstrate consistency in age and length differences.

CONCLUSIONS AND RECOMMENDATIONS

The project goals of producing accurate and precise estimates of abundance and sex, length and age composition of large chinook salmon in the Keta River in 1998 and 1999 were accomplished. Capturing adequate numbers of small and medium chinook salmon to permit us to estimate abundance has, however, been challenging. In attempting to improve capture success of small and medium fish, we recommend extending Event 2 sampling until mid-September (through the spawning cycle) and angling with bait.

Expansion factors (total escapement to survey count ratios) were also estimated successfully in 1998 and 1999. The expansion factors derived from this study can replace expansion factors previously applied from results of studies of other Behm Canal chinook stocks. Since we have only two estimates for the Keta River, interannual variation in the estimates remains unclear. Continuation of this project should provide more accurate estimates of the expansion factor. Estimating total abundance annually is necessary to estimate escapement goals and to track population trends based on age-class strength.

Ten age classes of fish, across five brood years, were represented in the Keta River escapement samples. We do not know whether this apparent plasticity in life history pattern is a result of environmental factors or heritable traits. The response of this population to environmental conditions and fisheries pressure may be different from other stocks. The implication to managers may be that the Keta River and other Behm Canal chinook populations require particular attention in terms of longer-term stock assessment programs. Interannual variability in age and length composition should be examined and compared, by concurrent runs, among populations in order to confirm the unique character of these stocks with respect to other stocks used to represent common stock groupings.

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APPENDIX A

Appendix A1.-Sex, length, age, capture and recovery data for chinook salmon caught in the Keta River in 1999.

Capture site (km)	Fish number	Marking date	Sex	Length MEF (mm)	Comments[a]	Color	Age	Spaghetti tag no.	Sea lice	Recovery site (km)	Recovery date
3.75	1	4-Jul	F	785		Bright	1.3	00241	Y	15	12-Aug
3.75	2	4-Jul	F	835		Bright-gray	1.3	00242	N		
3.75	3	4-Jul	M	960		Pink-gray	0.4	00243	N		
3.75	4	4-Jul	M	630		Bright	1.2	00245	Y		
3.75	5	5-Jul	F	1010		Gray-bright	1.4	00246	Y		
4	6	5-Jul	F	1005		Bright	1.4	00247	Y	7	12-Aug
3.75	7	5-Jul	F	900		Bright	1.4	00248	Y	9	31-Aug
3.75	8	7-Jul	M	605		Bright	1.2	00249	N		
3.75	9	8-Jul	M	830		Gray	1.4	00250	Y		
3.75	10	8-Jul	M	620		Bright	1.2	00251	Y		
3.75	11	9-Jul	M	785		Gray	1.3	00252	Y		
3.75	12	9-Jul	M	830		Bright	1.3	00253	Y		
3.75	13	9-Jul	F	895	Hook scar	Bright	1.3	00254	Y	10	31-Aug
3.75	14	10-Jul	M	685		Bright	1.2	00255	N		
3.75	15	10-Jul	M	615		Bright	1.2	00256	Y		
3.75	16	11-Jul	F	985		Bright	0.5	00257	Y		
3.75	17	11-Jul	F	870		Bright	1.3	00258	Y	9	9-Aug
3.75	18	12-Jul	M	650		Bright	1.2	00259	Y	15	12-Aug
3.75	19	12-Jul	M	465		Bright	1.1	00260	Y		
3.75	20	12-Jul	M	630		Bright	1.2	00261	N		
3	21	12-Jul	F	860		Bright	R.4	00262	Y		
3.75	22	12-Jul	M	830		Gray	1.4	00263	Y		
3.75	23	12-Jul	F	880		Rose	R.3	00264	Y		
3.75	24	12-Jul	M	735		Gray-pink	1.2	00265	Y		
3.75	25	13-Jul	M	740		Gray	1.2	00266	Y		
4.25	26	13-Jul	F	855		Gray	1.3	00267	N	9	11-Aug
3	27	13-Jul	M	445		Bright	1.1	00268	Y		
3.75	28	15-Jul	M	760		Gray	1.3	00269	Y		
3.75	29	15-Jul	M	440		Bright	1.1	00270	Y		
3.75	30	15-Jul	M	775		Gray	1.2	00271	Y	11	31-Aug
3.75	31	15-Jul	F	910		Gray-pink	1.3	00272	N		
3.75	32	15-Jul	M	770		Brown	1.3	00273	Y	9	9-Aug
4.25	33	15-Jul	M	695		Bright	1.2	00274	Y		
4.25	34	15-Jul	M	635		Gray	1.2	00275	N		
4.25	35	15-Jul	M	725		Bright	1.2	00276	N		
4.25	36	15-Jul	F	945		Pink	1.4	00277	Y		
4.25	37	15-Jul	M	845		Brown	0.3	00278	N		
4.25	38	15-Jul	M	955		Gray	1.4	00279	Y	9	9-Aug
4.25	39	15-Jul	F	795		Bright	R.3	00280	Y		
2.5	40	15-Jul	M	855		Gray	1.3	00281	N		
2.5	41	15-Jul	F	890		Gray	1.3	00282	Y		
2.5	42	15-Jul	F	930		Gray	1.4	00283	Y	9	2-Sep
2.5	43	15-Jul	M	695		Bright	1.2	00284	Y		
2.5	44	16-Jul	M	635		Bright	1.2	00285	Y		
2.5	45	16-Jul	F	835		Bright	R.3	00286	Y		
2.5	46	16-Jul	M	715		Gray	1.2	00287	Y	2	26-Aug

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Capture site (km)	Fish number	Marking date	Sex	Length MEF (mm)	Comments[a]	Color	Age	Spaghetti tag no.	Sea lice	Recovery site (km)	Recovery date
3	47	16-Jul	M	765		Gray	R.3	00288	Y	9	2-Sep
3	48	16-Jul	M	980		Dark	0.4	00289	Y	8	6-Aug
3	49	16-Jul	M	735		Gray	1.2	00290	N	8	2-Sep
3	50	16-Jul	F	805		Bright	1.3	00291	Y	11	31-Aug
3	51	16-Jul	M	770		Bright	1.2	00292	Y		
3.75	52	17-Jul	M	710		Gray-pink	1.2	00293	Y		
3.75	53	17-Jul	F	860		Dark	1.3	00294	Y		
3	54	17-Jul	M	725		Bright	1.2	00295	Y		
3	55	17-Jul	M	745		Pink	1.2	00296	Y	8	2-Sep
3.75	56	18-Jul	M	1010		Dark	1.3	00297	Y		
3.75	57	18-Jul	M	705		Bright	1.2	00298	Y		
3.75	58	18-Jul	M	885		Pink-gray	R.3	00299	Y		
3.75	59	18-Jul	M	700		Bright	1.2	00300	N		
3.75	60	18-Jul	M	780		Gray-pink	1.3	00301	Y		
3.75	61	18-Jul	F	920		Gray	R.4	00302	Y		
3.75	62	18-Jul	F	870		Gray-bright	1.3	00303	Y		
3.75	63	18-Jul	M	955		Gray-pink	1.3	00304	Y	15	12-Aug
0.5	64	19-Jul	M	685		Bright	1.2	00305	Y		
0.5	65	19-Jul	F	795		Bright	R.2	00307	Y	9	2-Sep
0.5	66	19-Jul	M	675		Bright-gray	1.2	00308	Y		
0.5	67	19-Jul	F	855		Bright	1.3	00309	Y		
0.5	68	19-Jul	M	865		Pink	1.4	00310	Y		
0.5	69	19-Jul	M	565		Bright	R.2	00311	Y		
0.5	70	19-Jul	F	975		Dark	0.5	00312	Y		
0.5	71	19-Jul	M	430		Bright	1.1	00313	N		
0.5	72	19-Jul	M	440		Green	1.1	00314	N		
0.5	73	19-Jul	M	670		Bright	1.2	00315	Y		
0.5	74	19-Jul	M	900		Dark	1.3	00316	Y		
0.5	75	19-Jul	F	815		Bright	1.3	00317	Y		
0.5	76	19-Jul	M	790		Green	1.3	00318	Y		
0.5	77	19-Jul	F	815		Pink	1.3	00319	Y	9	11-Aug
2.5	78	19-Jul	M	885		Dark	1.3	00320	Y		
2.5	79	19-Jul	M	850		Pink	1.3	00321	Y		
2.5	80	19-Jul	M	770		Pink	1.3	00322	Y	9	2-Sep
2.5	81	19-Jul	M	745		Bright	1.2	00323	Y		
2.5	82	19-Jul	M	730		Bright	1.2	00324	Y		
2.5	83	19-Jul	F	875		Gray	1.4	00325	Y	8	1-Sep
2.5	84	19-Jul	F	880		Bronze	0.4	00306	Y		
3	85	19-Jul	M	665		Bright	R.2	00326	Y		
3	86	19-Jul	M	710		Bright-gray	1.2	00327	Y		
3	87	19-Jul	M	510		Bright	1.1	00328	N		
3	88	19-Jul	F	865		Bright	R.3	00329	Y		
3	89	19-Jul	F	835		Bright	1.3	00330	Y		
3	90	19-Jul	M	670		Bright	1.2	00331	N		
3	91	19-Jul	M	685		Pink	1.2	00332	Y		
3	92	19-Jul	F	870		Brown	1.3	00333	Y		

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Capture site (km)	Fish number	Marking date	Sex	Length MEF (mm)	Comments[a]	Color	Age	Spaghetti tag no.	Sea lice	Recovery site (km)	Recovery date
3 '	93	19-Jul	F	790		Bright	1.3	00334	Y		
3	94	19-Jul	M	675		Bright	1.2	00335	Y	13	31-Aug
3	95	19-Jul	M	710		Bright	1.3	00336	Y		
3	96	19-Jul	F	805		Bright-pink	1.3	00337	Y		
3.75	97	20-Jul	F	970		Bright	1.4	00338	N		
4.25	98	20-Jul	F	830		Bright	1.3	00339	Y	8	1-Sep
4.25	99	20-Jul	M	665		Gray	1.2	00340	N		
4.25	100	20-Jul	M	795		Dark	1.3	00341	Y	9	11-Aug
4.25	101	20-Jul	M	440		Bright	1.1	00342	N		
0.5	102	20-Jul	F	785		Bright	R.3	00343	Y		
0.5	103	20-Jul	M	465		Bright	1.1	00344	Y		
0.5	104	20-Jul	M	725		Pink-gray	1.3	00345	N		
2.5	105	20-Jul	F	700		Bright	1.2	00346	Y		
2.5	106	20-Jul	F	725		Gray	0.3	00347	Y		
2.5	107	20-Jul	M	780		Pink-gray	1.3	00348	Y		
2.5	108	20-Jul	F	855		Brown	1.4	00349	Y		
3	109	20-Jul	M	670		Pink-green	1.2	00350	Y	7	1-Sep
1.5	110	21-Jul	F	865		Bright	1.3	00351	Y		
0.5	111	21-Jul	F	865		Bright	1.4	00352	Y		
0.5	112	21-Jul	F	910		Bright	1.4	00353	Y	2	26-Aug
0.5	113	21-Jul	M	635		Bright	1.2	00354	Y		
0.5	114	21-Jul	M	680		Bright	1.2	00355	Y		
0.5	115	21-Jul	M	765		Bright	1.3	00356	Y		
0.5	116	21-Jul	M	655		Bright	R.2	00357	Y		
0.5	117	21-Jul	M	725		Bright	0.3	00358	Y		
0.5	118	21-Jul	F	805		Bright	1.3	00359	Y		
0.5	119	21-Jul	F	720		Bright	1.2	00360	Y		
0.5	120	21-Jul	M	970		Pink-bright	1.3	00361	Y		
0.5	121	21-Jul	M	675		Gray	1.2	00362	N		
0.5	122	21-Jul	F	660		Bright	1.2	00363	N		
2.5	123	21-Jul	M	720		Bright	1.2	00364	Y		
2.5	124	21-Jul	F	845		Pink-green	1.3	00365	N	8	1-Sep
0.5	125	22-Jul	M	810		Gray	1.3	00366	Y		
0.5	126	22-Jul	F	875		Bright	1.3	00367	Y	9	31-Aug
0.5	127	22-Jul	F	920		Bronze	1.3	00368	Y		
0.5	128	22-Jul	M	790		Pink-green	R.	00369	N		
0.5	129	22-Jul	F	777		Gray	R.3	00370	Y		
3	130	22-Jul	F	860		Bright	1.3	00371	N		
3	131	22-Jul	M	675		Bright	1.2	00372	N		
0.5	132	23-Jul	M	910		Red	1.3	00373	Y	9	2-Sep
0.5	133	23-Jul	F	860		Dark	1.3	00374	Y		
0.5	134	23-Jul	F	770		Bright	R.3	00375	Y		
0.5	135	23-Jul	M	725		Bright	1.2	00376	Y		
0.5	136	23-Jul	M	675		Bright-pink	1.2	00377	Y		
2.5	137	23-Jul	F	910		Brown	1.3	00378	Y	9	7-Aug
2.5	138	23-Jul	M	700		Bright	1.2	00379	Y	8	11-Aug

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Appendix A1.–Page 4 of 5.

Capture site (km)	Fish number	Marking date	Sex	Length MEF (mm)	Comments[a]	Color	Age	Spaghetti tag no.	Sea lice	Recovery site (km)	Recovery date
0.5	139	24-Jul	M	780		Bright-green	1.2	00380	Y		
0.5	140	24-Jul	F	860		Bright	0.4	00381	Y	4	26-Aug
0.5	141	24-Jul	F		No length	Dark	1.3	00382	N		
0.5	142	24-Jul	M	715		Bright	0.3	00384	Y		
0.5	143	24-Jul	M	870		Dark	1.3	00383	N	9	2-Sep
0.5	144	24-Jul	M	960		Dark	1.3	00385	Y	7	1-Sep
0.5	145	24-Jul	F	880		Bright	1.3	00386	Y		
0.5	146	24-Jul	M	770		Green-pink	1.2	00387	Y		
0.5	147	26-Jul	F	860		Bright-gray	1.3	00388	N		
0.5	148	26-Jul	M	860		Red	1.3	00389	N		
2.5	149	26-Jul	M	975		Dark	1.3	00390	N		
2.5	150	26-Jul	M	725	Hook scar	Gold	R.3	00391	N		
2.5	151	26-Jul	F	860		Bright	1.3	00392	Y		
2.5	152	26-Jul	F	1005		Pink-gray	1.4	00393	Y		
2.5	153	26-Jul	M	700		Pink-gray	R.2	00394	Y		
2.5	154	26-Jul	M	675		Green-pink	0.2	00395	N		
2.5	155	26-Jul	F	835		Dark	1.3	00396	N		
0.5	156	27-Jul	M	680		Bright	R.2	00397	N		
0.5	157	27-Jul	M	705		Bright	1.2	00398	N		
0.5	158	27-Jul	F	805		Dark	1.3	00399	N		
0.5	159	27-Jul	F	915		Gray-bright	1.4	00400	Y	9	31-Aug
0.5	160	29-Jul	M	975		Gray	1.3	00464	Y		
2.5	161	29-Jul	M	745		Green-pink	1.3	00465	Y		
2.5	162	29-Jul	F	895		Bright	1.3	00466	Y		
2.5	163	29-Jul	M	705		Bright	1.2	00467	N	9	2-Sep
2.5	164	29-Jul	M	690		Pink-green	1.2	00468	N	10	31-Aug
2.5	165	29-Jul	F	880		Bright	1.3	00469	Y		
2.5	166	29-Jul	M	805		Dark	1.3	00470	Y		
2.5	167	30-Jul	M	710		Gray	1.2	00471	N		
2.5	168	30-Jul	M	740		Gray	0.2	00472	Y		
2.5	169	30-Jul	M	765		Gray	1.2	00473	N		
2.5	170	30-Jul	M	770		Red	R.3	00474	N		
2.5	171	30-Jul	F	865		Gray	0.4	00475	N		
2.5	172	30-Jul	M	685		Dark	1.2	00476	N		
2.5	173	30-Jul	F	765		Bright	R.3	00477	Y		
0.5	174	30-Jul	F	900		Gray-bright	1.3	00478	Y		
0.5	175	30-Jul	M	940		Dark	1.3	00479	Y		
0.5	176	30-Jul	M	980		Dark	1.3	00480	Y		
0.5	177	30-Jul	F	820		Gray-green	R.3	00481	Y		
0.5	178	30-Jul	M	955		Dark	R.3	00482	N		
0.5	179	31-Jul	M	810		Pink	1.3	00483	Y		
0.5	180	31-Jul	F	835		Gray	1.3	00484	N		
0.5	181	31-Jul	F	860		Gray	1.3	00485	Y		
0.5	182	31-Jul	F	915		Bright-gray	1.4	00486	Y		
0.5	183	31-Jul	M	780		Pink-red	1.3	00487	N	8	1-Sep
0.5	184	31-Jul	M	770		Pink-green	R.4	00488	Y		

-continued-

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Capture site (km)	Fish number	Marking date	Sex	Length MEF (mm)	Comments[a]	Color	Age	Spaghetti tag no.	Sea lice	Recovery site (km)	Recovery date
0.5	185	31-Jul	F	875		Pink-bright	1.3	00489	Y		
0.5	186	31-Jul	M	705		Red	1.3	00490	N		
0.5	187	1-Aug	F	750		Bright	1.2	00491	Y		
0.5	188	1-Aug	M	865		Red	1.3	00492	Y		
0.5	189	1-Aug	M	810		Chum color	1.3	00493	Y		
0.5	190	1-Aug	M	950		Gray	1.3	00494	Y		
0.5	191	1-Aug	M	710		Gray	1.2	00495	N		
0.5	192	1-Aug	F	940		Dark	1.4	00496	N		
0.5	193	1-Aug	F	830		Gray	1.3	00497	Y		
0.5	194	1-Aug	M	805		Olive	0.4	00498	N		
2.5	195	1-Aug	M	915		Dark	1.3	00499	Y		
2.5	196	1-Aug	M	710		Gray	1.2	00500	N		

[a] Fish were in good condition unless otherwise noted.

Appendix A2.–Age composition by length class and sex for chinook salmon sampled in the Keta River in 1999.

EVENT 1 SAMPLE

		1996	1996	1995	1995	1994	1994	1993	1993	1993	1992	
		1.1	0.2	1.2	0.3	1.3	0.4	1.4	2.3	0.5	1.5	Total
Medium chinook salmon (440-659 mm MEF)												
Male	Number sampled	8		9								17
	Percent	47.1		52.9								100.0
	SE of percent	12.5		12.5								
Large chinook salmon (≥660 mm MEF)												
Male	Number sampled		2	43	3	37	3	4				92
	Percent		2.2	46.7	3.3	40.2	3.3	4.3				59.7
	SE of percent		1.2	4.0	1.4	4.0	1.4	1.6				4.0
Female	Number sampled			4	1	38	3	14		2		62
	Percent			6.5	1.6	61.3	4.8	22.6		3.2		40.3
	SE of percent			6.1	3.1	12.2	5.4	10.5		4.4		12.3
Total	Number sampled		2	47	4	75	6	18		2		154
	Percent		1.3	30.5	2.6	48.7	3.9	11.7		1.3		100.0
	SE of percent		0.9	3.7	1.3	4.0	1.6	2.6		0.9		

EVENT 2 SAMPLE

		1996	1996	1995	1995	1994	1994	1993	1993	1993	1992	
		1.1	0.2	1.2	0.3	1.3	0.4	1.4	2.3	0.5	1.5	Total
Medium chinook salmon (440-659 mm MEF)												
Male	Number sampled	2		8								10
	Percent	20.0		80.0								100.0
	SE of percent	13.3		13.3								
Large chinook salmon (≥660 mm MEF)												
Male	Number sampled			45	4	55	2	9			2	117
	Percent			20.2	1.8	24.7	0.9	4.0			0.9	52.5
	SE of percent			2.7	0.9	2.9	0.6	1.3			0.6	3.4
Female	Number sampled			2	3	66	5	27	1	1	1	106
	Percent			0.9	1.3	29.6	2.2	12.1	0.4	0.4	0.4	47.5
	SE of percent			0.6	0.8	3.1	1.0	2.2	0.4	0.4	0.4	3.4
Total	Number sampled			47	7	121	7	36	1	1	3	223
	Percent			21.1	3.1	54.3	3.1	16.1	0.4	0.4	1.3	100.0
	SE of percent			2.7	1.2	3.3	1.2	2.5	0.4	0.4	0.8	

Appendix A3.–Detection of length-selectivity in sampling and its effects on estimation of length composition.

Results of Hypothesis Tests (K-S and χ^2) on Lengths of Fish MARKED during the First Event and RECAPTURED during the Second Event	Results of Hypothesis Tests (K-S) on Lengths of Fish CAPTURED during the First Event and CAPTURED during the Second Event
Case I:	
"Accept" H_O	"Accept" H_O
There is no length-selectivity during either sampling event.	
Case II:	
"Accept" H_O	Reject H_O
There is no length-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_O	"Accept" H_O
There is length-selectivity during both sampling events.	
Case IV:	
Reject H_O	Reject H_O
There is length-selectivity during the second sampling event; the status of length-selectivity during the first event is unknown.	

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

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

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

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

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

Appendix A4.–Computer files used to estimate the spawning abundance of chinook salmon in the Keta River in 1999.

File name	Description
99Ketam-r.xls	Spreadsheets containing mark-recapture data, summary tables, age and sex composition data.
Ksketa99.xls	Spreadsheets containing chi-square test results and Kolmogorov-Smirnov (K-S) 2-sample test results.
Keta99calc.xls	Spreadsheets containing statistical length at age and sex tables and charts, abundance estimates, and related calculations.