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A Mark-Recapture Experiment to Estimate the Escapement of Chinook Salmon in the Blossom River, 2004

by

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and

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December 2005

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

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ABSTRACT

The second year of a planned 3 year study of Chinook salmon *Oncorhynchus tshawytscha* on the Blossom River was completed in 2004 by the Division of Sport Fish. The study estimated the number of large (≥660 mm MEF) spawning salmon, estimated expansion factors for aerial survey counts, and estimated age, sex and length composition of the population. Escapement was estimated using a two-event mark-recapture experiment. Fish were captured with rod and reel gear, marked with uniquely numbered spaghetti tags and batch marked with two secondary marks. Spawning and pre-spawning fish were captured later with angling gear and dip nets, sampled for marks, age (scales), sex and length. The estimated escapement of Chinook salmon was 869 fish (SE = 89), consisting of 734 large (SE = 76) and 135 (SE = 47) medium-sized (590–659 mm MEF) fish. The sex composition of these fish was 247 female spawners. Age-.2 fish composed an estimated 41% of the combined escapement estimate, followed by age-.3 fish (33%), and age-.4 fish (19%). Brood years from 1998 through 2002 were represented, with eight age classes present. Age-0. fish returning from subyearling smolt accounted for an estimated 8% of the escapement. The calendar year expansion factor for the peak aerial survey count in 2004 was 2.2 (SE = 0.23), compared to 4.0 (SE = 0.85) calculated in 1998.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, spawning abundance, escapement, Blossom River, mark-recapture, Petersen model, peak survey count, expansion factor, age, sex, length composition, Behm Canal, Southeast Alaska

INTRODUCTION

The Blossom River enters the Wilson Arm of Smeaton Bay in the Misty Fjords National Monument about 75 km east of Ketchikan, Alaska (Figure 1). The Blossom River is one of four Behm Canal river systems in which the number of Chinook salmon *Oncorhynchus tshawytscha* has been counted annually by the Alaska Department of Fish and Game (ADF&G) using aerial surveys (Pahlke 1997). Previous to 1975, the Blossom River was surveyed on an occasional basis by various methods including foot, boat and fixed-wing aircraft. Indices of escapement for these systems are obtained from the peak (highest) of several, single day counts, of "large" Chinook salmon (≥660 mm mideye to tail fork (MEF). These large-sized Chinook salmon are generally fish age-.3 (saltwater-age-3) or older in most Chinook-producing rivers in Southeast Alaska.

Peak counts of Chinook salmon in the Blossom River have increased from the average during the base period (1975–1980), but remain near the low end of the revised escapement goal index count range (McPherson and Carlile 1997). Temporal trends in the peak counts are reasonably consistent among Behm Canal index rivers, the Unuk, Chickamin, Blossom, and Keta rivers (Figure 2). Relatively low survey counts were observed for 1975–1981 and 1990–1999, with higher counts in between (1982–1989). Since 1999, counts have increased in the larger Unuk and Chickamin Rivers versus those in the Blossom and Keta Rivers. The survey counts in the Blossom River have been quite stable from 1988 to 2004, with a mean of 230 and a SD of 77. All four of these Behm Canal systems are among the 50 escapement indicator stocks, whose data is used to evaluate escapement and management performance and used in modeling population dynamics, by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC).

The ADF&G Division of Sport Fish obtained funding, as part of the State of Alaska's commitment to a coast wide rebuilding and improved stock assessment program for Chinook salmon, 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 recommended by the U.S. members of the Chinook Technical Committee and approved by the U.S. Commissioners of the PSC, using monies from the U.S. Congress to implement abundance-based management of Chinook salmon from Oregon to Alaska, as detailed in "The 1996 U.S. Letter of Agreement." As determined by two-event, mark-recapture methodology, the estimated escapements of large Chinook salmon in 1988 were 364 (SE = 77) in the Blossom River and 446

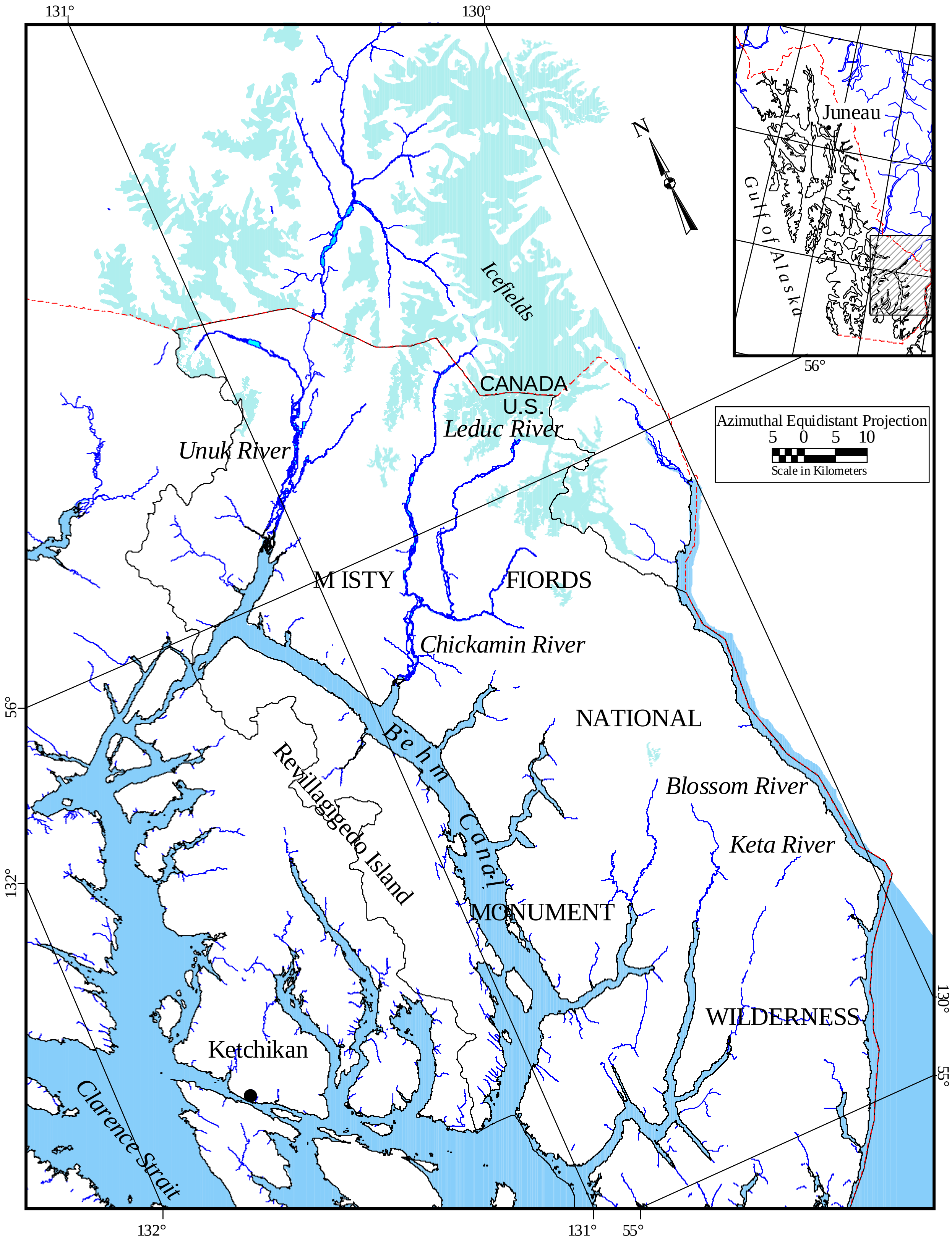

Figure 1.–Behm Canal and Misty Fjords National Monument in Southeast Alaska and location of major Chinook salmon-producing river systems.

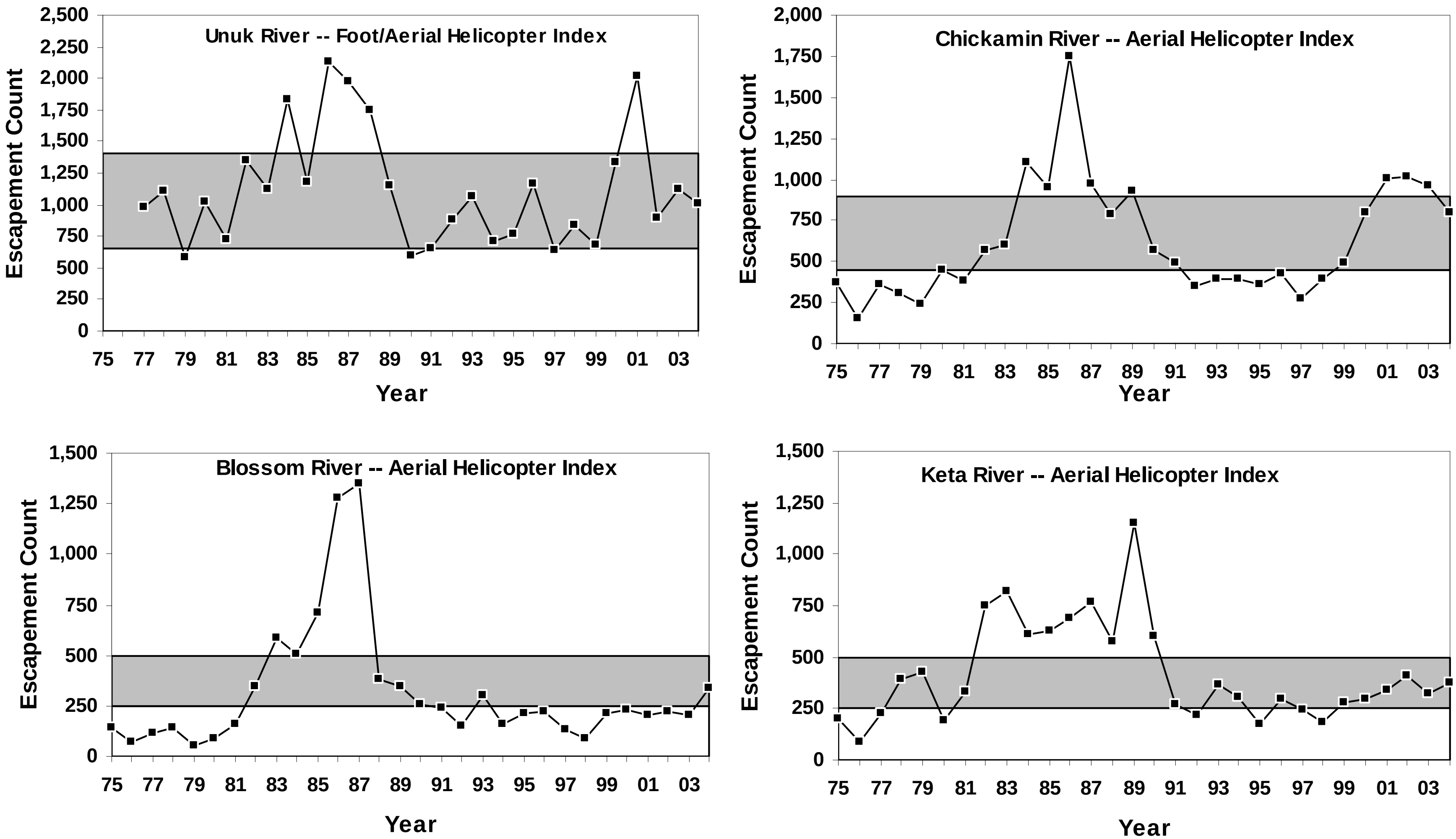

Figure 2.–Peak survey escapement counts of large Chinook in four Behm Canal rivers, 1975–2004, versus escapement goal ranges. Shaded area is escapement goal range.

(SE = 50) in the Keta River (Brownlee et al. 1999). These were the first Chinook salmon abundance studies conducted on the Blossom or Keta rivers. Budget limitations precluded continuing stock assessment work at the Blossom River until 2004. The objectives of this project were to estimate abundance and age, sex and length composition of large Chinook salmon spawning in the Blossom River in 2004.

An estimate of escapement in 2004, along with the annual peak survey count, allows calculation of an expansion factor for a second year, provides data to determine if U.S. CTC escapement data standards (PSC 1997) are met, and provides a valid technical basis to revise estimated total escapements from expanded aerial survey counts. Peak counts of large fish for individual systems can be expanded to account for the proportion of spawners observed in index surveys relative to the entire escapement if a technically valid river specific expansion factor has been estimated for three or more years (PSC 1997). Results of mark-recapture studies to estimate spawner abundance on the Unuk (Pahlke et al. 1996; Jones III et al. 1998), Chickamin (Pahlke 1997), and Keta rivers (Freeman et al. 2001) were used to derive expansion factors for survey areas on these rivers (Pahlke 1998). Initially, Pahlke (2000) applied knowledge from these rivers to the Blossom River peak counts to obtain an approximation of the total escapements. Three years of specific estimates of spawning abundance on the Blossom River, coupled with survey counts, will provide the initial data for technical evaluation of an appropriate expansion factor for the Blossom River Chinook salmon population. Given harvest rate information, total escapement is necessary for estimating population parameters including total production. Age composition is needed to estimate and model stock specific spawner-recruit relationships, maturation rates and forecasting of future returns. Estimates of length at age provide additional information on comparative growth rates, age of recruitment and general life history patterns.

STUDY AREA

The Blossom River is tributary to the Wilson Arm of Smeaton Bay, off Behm Canal (Figure 3), draining an area of 176 km^2. The river is confined within a narrow, steep-sided, glacier-carved valley, and has an overall mainstem gradient of about 1%. 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 October 31, 1978. Peak flows ranging from 10,900 to 21,000 ft^3/s were recorded over the period of record. The average discharge for the system was 764 ft^3/s. The Blossom River is characterized by less extreme peak flows and a generally more confined and stable channel morphology. The extreme flow for the Blossom River during the period of record was 10,600 ft^3/s Oct. 8, 1982. Average flow for the system is 638 ft^3/s. The system is defined by short glides, moderate riffles with small cobble and gravel sediments, and long, deep pools. There are two large logjam complexes at about km 2 and km 10, upstream from salt water. The pool:riffle:glide ratio is about 45:25:30 (Hafele 1983).

Available spawning habitat differs between the two rivers. On the Blossom River, 25% of available spawning habitat is below Raspberry Creek (km 5.5, with km 0.0 at the confluence with the Wilson River), 44% is between Raspberry Creek and North Creek (km 14), and 31% is above North Creek. On the Keta River, 52% of spawning habitat is between the mouth and km 4.0, 22% is between km 4.0 and the confluence with Hill Creek (km 7.0), and 26% is upstream of Hill Creek (Hafele 1983).

Not all of the Blossom River drainage is accessible to Chinook salmon. An apparent velocity block is present at km 17. This blockage cuts off 53% of the drainage to salmon, leaving approximately 90 km^2 of the drainage accessible to Chinook salmon (Brian Frenette, ADF&G, Douglas, *personal communication.*)

METHODS

A two-event mark-recapture experiment for a closed population (Seber 1982) was conducted on the Blossom River in 2004. Rod and reel angling with bait and lures was the method of capture for the first (capture) event of the experiment in the lower river. Rod and reel snagging, dipnetting and carcass recovery were employed for the second (recapture) event. Studies in 1998 showed this to be an effective means for estimating spawning

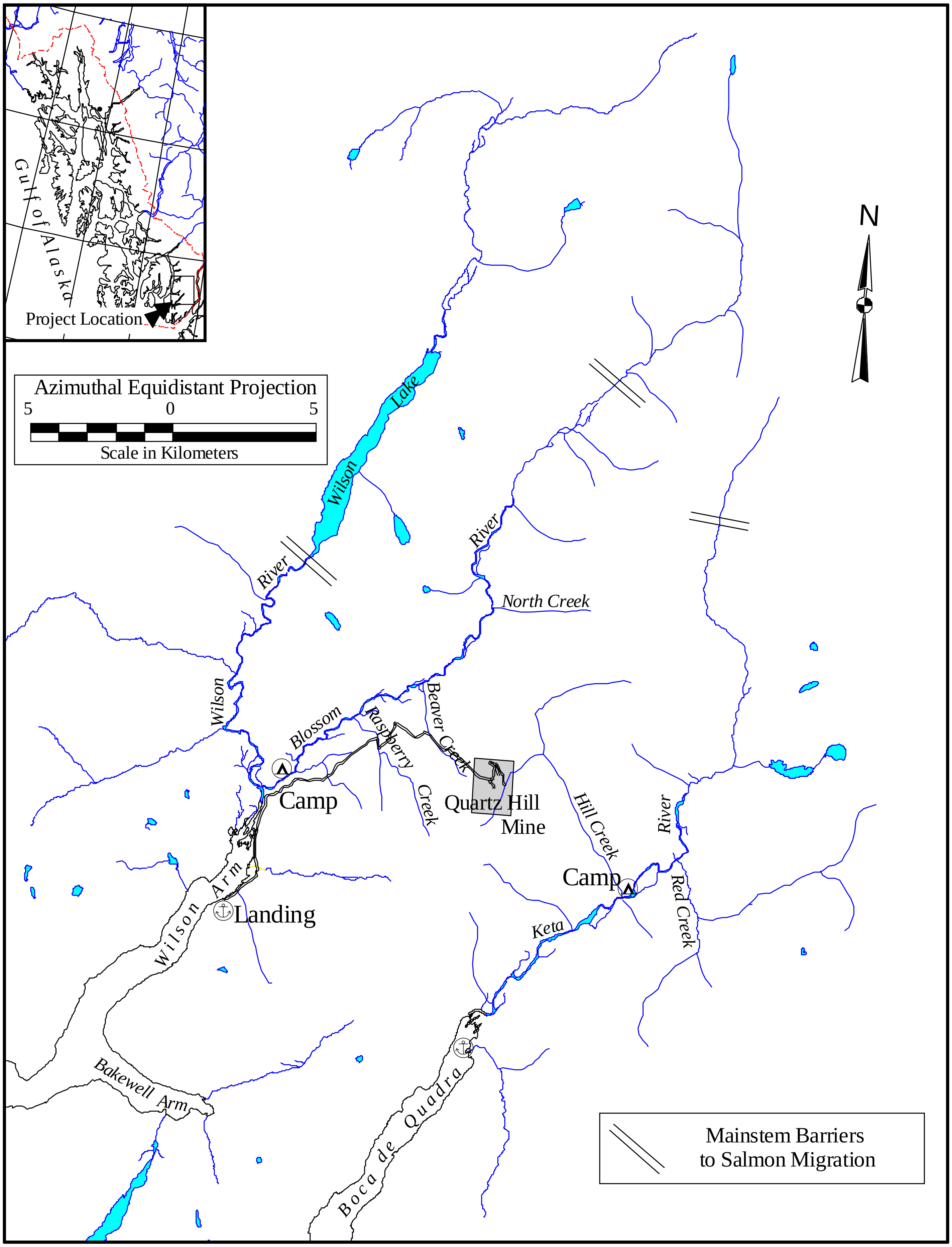

Figure 3.–Blossom and Keta river drainage area in Southeast Alaska, showing location of major tributaries and barriers to fish migration.

population parameters in the Blossom River (Brownlee et al. 1999).

CAPTURE OF CHINOOK SALMON

Rod and reel angling using bait and artificial lures was used exclusively to capture fish during Event 1. In 1998, the project was conducted from a camp located below the lower logjam, which made it very difficult for the crew to access concentrations of Chinook salmon. We addressed this problem in 2004 by constructing a new camp just above the mouth of Raspberry Creek, and the river was accessed by boat between the two large logjam complexes near km 2 and 10. The lower river from about km 3 to km 8.5 was fished throughout the Chinook salmon immigration. Effort was concentrated at several sites where fish rested after entering the river.

MARKING AND SAMPLING

All fish captured in the lower river were sampled for scales, length to the nearest 5 mm MEF, sex, presence of external parasitic copepods (an indicator of stream life), external color, presence or absence of the adipose fin (indicating the fish was marked with a coded wire tag), and condition. Five scales were taken from each captured fish (Welander 1940). Scales were mounted onto gum cards which each held scales from up to 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 solid-core spaghetti tag was applied to each fish in good condition, $\geq$ 590 mm MEF length. The tags consisted of a 5.7-cm section of blue, laminated Floy™[1] tubing shrunk onto a 38-cm piece of 80 lb-test (36.3 kg) monofilament fishing line, modified from a tag design developed and described in Johnson et al (1992). 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 insertion of the dorsal fin, so as to be embedded within the last fins rays of the dorsal fin. The tag was pushed into the needle, then the needle withdrawn. A metal leader sleeve was used to secure the ends of the tag line across the fish, below the posterior portion of the dorsal fin. The trailing end of the line was cut 0.5 cm above the crimp. Two secondary (batch) marks were a 0.6-cm punch in the left upper operculum (LUOP) and excision of the left auxiliary appendage (LAA).

SAMPLING ON THE SPAWNING GROUNDS

Fish were captured and sampled during Event 2 from river km 6 upstream to approximately river km 18. 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, sex and scales using the same techniques employed during Event 1.

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, <u>or</u> that every fish has an equal probability of being captured in the second sample, <u>or</u> that marked fish mix completely with unmarked fish; <u>and</u>

(b) Recruitment and mortality do not occur between samples; <u>and</u>

(c) Marking does not affect the catchability of an animal; <u>and</u>

(d) Animals do not lose their marks in the time between the two samples; <u>and</u>

(e) All marks are reported on recovery in the second sample; <u>and</u>

(f) Double sampling does not occur.

Three consistency tests described by Seber (1982) were used to test for temporal and/or spatial violations of condition (a). Contingency table analyses were used to test three null hypotheses: 1) the probability that a marked fish is recovered during Event 2 is independent of when it was marked; 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) for all marked fish recovered during

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

Event 2, time of marking is independent of when/where recovery occurs. If all three hypotheses are rejected, a "partially" stratified abundance estimator such as a Darroch (Arnason et al. 1996) will be used. Failure to reject at least one of these three hypotheses is sufficient to conclude that condition (a) is satisfied.

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 (α = 0.1) (Appendix A1). 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 of each sex marked in Event 1 and recaptured in Event 2 to the number marked and not recaptured. In the second test, the numbers of fish of each sex marked in Event 1 and inspected for marks in Event 2 are compared to determine if size selectivity occurred in the first sampling event. Use of these tests assumes sex is accurately determined in each event. To test this assumption, the sex of each recaptured fish is compared to sex assigned in Event 1. If sex is assigned the same in Event 1 and Event 2, we presume there was no bias in assigning sex.

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. Radio telemetry studies conducted concurrent with capture-recapture studies on six other rivers in the region for Chinook salmon have shown that little (a maximum of 5–9%) tag-induced mortality occurs in the marking event (e.g., Pahlke et al. 1996). 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 the application of the procedure.

EXPANSION FACTOR

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

$$\hat{\pi}_i = \hat{N}_i / C_i \qquad (2)$$

$$v(\hat{\pi}_i) = v(\hat{N}_i) / C_i^2 \qquad (3)$$

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

The estimated mean expansion factor ($\bar{\pi}$) is

$$\bar{\pi} = \sum_{i=1}^{k} \hat{\pi}_i \, / \, k \qquad (4)$$

$$v(\hat{\pi}) = \sum_{i=1}^{k} \left(\hat{\pi}_i - \bar{\pi}\right)^2 \, / \, (k-1) \qquad (5)$$

where k is the number of years with mark-recapture experiments.

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

$$\hat{N}_t = \bar{\pi} \, C_t \qquad (6)$$

$$v(\hat{N}_t) = C_t^2 \, v(\hat{\pi}) \qquad (7)$$

The peak survey count program on the Blossom River has been standardized in time and area since 1975. The surveys are done multiple times during the peak spawning period of Aug 21 to Aug 31. All surveys have essentially been done with two surveyors since the inception, with overlap between them to validate observer efficiency. This consistency and standardization is done to ensure that the peak survey counts capture trends in relative spawning abundance. Ideally, the same fraction is counted annually; however, atypical weather and flow patterns can increase or decrease the fraction counted in an individual year (Pahlke 2003).

AGE AND SEX COMPOSITION

Age and sex composition of the Blossom River Chinook salmon escapement was estimated as:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \qquad (8)$$

$$v(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \qquad (9)$$

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 7 July and 27 July of 2004, 217 Chinook salmon were captured, sampled and released with spaghetti tags, secondary and tertiary marks in the Blossom River. Also, 30 small (<440 mm MEF), 42 medium (440-659mm MEF), and 5 large fish were captured but not tagged because they were not in "good" condition or they were <590 mm. Of the 217 marked fish, 1 ranged from 440–585 mm (MEF), 34 were medium sized (590–659 mm MEF) and 182 were large sized (Table 1). Fish less than 590 mm (MEF) were not used in abundance or age calculations because only 4 fish <590 mm were captured in Event 2.

From 18 August through 1 September of 2004, 1 small, 33 medium and 220 large fish were captured and inspected for marks (Appendix A2). Of these, 7 medium and 54 large fish were observed with marks (Table 1). Two (3%) of the recaptured fish had lost their primary tags.

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 = 0.99; Figure 4). 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 = 0.31; Figure 4). Therefore, length stratification of the experiment was not needed to estimate abundance of large fish (Appendix A1). We also determined that sex selectivity did not occur during either sampling event, on the basis of frequencies of sexes recovered and not recovered in Event 2 (χ^2 = 0.027, P = 0.87, df = 1), and fish marked in Event 1 and examined in Event 2 (χ^2 = 0.538, P = 0.46, df = 1). The sex assigned to all 59 recaptured fish was the same as assigned in event 1. Thus, samples from large fish for events 1 and 2 were pooled and used for estimating abundance by sex and age (Table 2; Appendix A3).

A chi-square test of the hypothesis that marked and unmarked fractions of large fish were independent of spatial recovery strata yielded a non-significant result (χ^2 = 0.371, df = 1, P = 0.54) (Table 3). Another chi-square test of the hypothesis that the probability of recapture of large marked fish was independent of the marking strata was also non-significant (χ^2 = 0.964, df = 1, P = 0.326) (Table 3). Failure to reject the null hypothesis for either of these two tests is sufficient to allow use of a Petersen-type estimator (Arnason et al. 1996).

Of 182 (M_{large}) large fish tagged in the first event, 54 (R_{large}) were recaptured out of 220 (C_{large}) total captured in the second event (Table 1). The abundance of large fish was estimated as $\hat{N}_{large}$ = 734 fish (SE = 76; bias = 0.64%; 95% CI: 609 to 908)

Table 1.–Numbers of Chinook salmon marked in the Blossom River and inspected for marks on the spawning grounds in 2004, by length group.

	590–659 mm	**≥ 660 mm**	**Total**
Event 1:			
Released with marks (*M*)	34	182	216
Event 2:			
Captured (*C*)	30	220	250
Recaptured (*R*)	7	54	61
R/C	23.3%	24.5%	24.4%

Capture history information for medium fish sampled and used in abundance estimates is shown in Table 5. Length frequencies did not differ significantly between fish marked and fish recaptured (K-S test, P = 0.56; Figure 5), nor between fish marked and fish captured in Event 2 (K-S test, P = 0.66; Figure 5). The small numbers of fish smaller than 590 mm MEF sampled during both events clearly indicates that our sampling techniques were biased against collection of small fish and smaller medium-sized fish in Event 2. Medium fish were thus censored to estimate the abundance of fish 590–659 mm MEF; only 1 medium fish between 440 and 590 mm MEF was culled from the marking event, and four from Event 2. Because there were only seven recaptures, the tests for temporal or spatial violations of condition (a) were not attempted, and data were pooled across marking and recovery strata. The abundance of medium fish was estimated as $\hat{N}_{medium}$ = 135 fish (SE = 34; bias = 4.11%; 95% CI: 84 to 259).

The estimated abundance of $\hat{N}_{large}$ + $\hat{N}_{medium}$ was 869 Chinook salmon. The estimated bias was 1.18% and the 95% CI was 732 to 1,072 fish, for this estimate.

ESTIMATES OF AGE, SEX AND LENGTH COMPOSITION

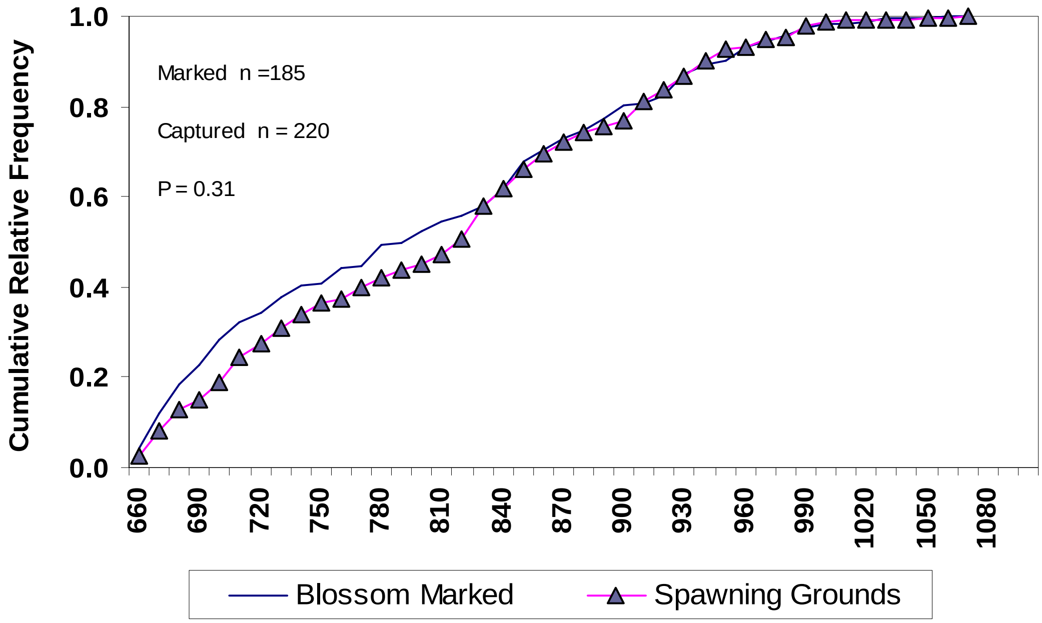
The estimated freshwater ages of fish sampled from both events on the Blossom River were age-0. and age-1., with age-1. fish dominant for both females and males. Saltwater ages ranged from 1 to 4 years (Figure 6). The predominant age class in medium (590-659 mm) fish was age-1.2 (96.3% SE = 2.6%) and all medium fish were males (Table 2). Amongst large fish, age-1.2 fish comprised 30.9% (SE = 2.7%) and age-1.3 fish comprised 37.8% (SE = 2.8%) of the estimated total. Age-1.2 fish dominated the combined escapement estimate of 869 fish (41.1% SE = 3.9%), with age-1.3 fish (32.5% SE = 2.9%) and age-1.4 fish (18.9% SE = 2.3%) accounting for most of the remainder. There were an estimated 487 (SE = 54) large males and 247 (SE = 33) large female spawners in the Blossom River escapement in 2004. An estimated 8.9% (SE 1.7%) of the large Chinook salmon return to the Blossom River were freshwater-age-0. fish (from subyearling smolt).

EXPANSION FACTOR

The expansion factor for the Blossom River Chinook salmon aerial surveys was calculated as the annual ratio of the estimate of abundance of large Chinook salmon to the peak aerial survey count for the individual year. The estimated expansion factor in 2004 was 2.2 (SE = 0.23), compared to 4.0 in the 1998 study (Table 4). The estimated mean expansion factor was 3.1 (SE = 0.87). The summer of 2004 was one of the warmest and driest summers on record in Southeast Alaska, and resulted in very low water conditions in many coastal rivers including the Blossom and Keta. Conditions for counting and sampling Chinook salmon were exceptionally good. We believe that the counting conditions were exceptional in the Blossom River in 2004 and that the 1998 expansion factor may be more representative of normal counting efficiency.

DISCUSSION

Success of the population estimate experiment on the Blossom River required that conditions for use of the closed population estimator were satisfied.



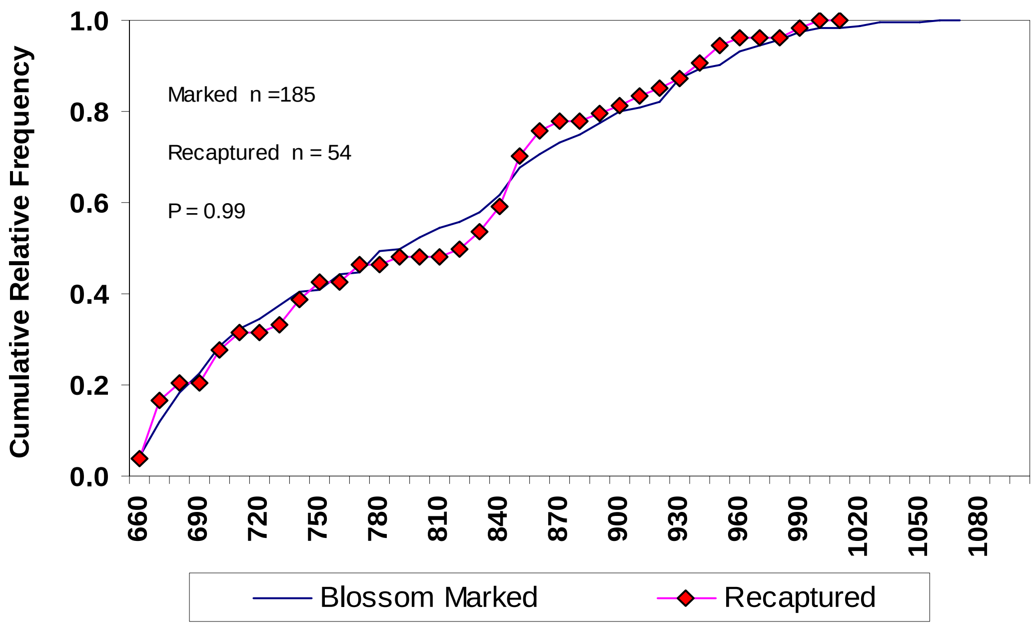


Figure 4.–Cumulative fractions of large (≥660 mm MEF) Chinook salmon marked vs. captured (top) and marked vs. recaptured in event 2 (bottom) in the Blossom River in 2004.

Table 2.–Estimated abundance of the escapement, by age and sex, of medium (590–659 mm MEF) and large (≥660 mm MEF) Chinook salmon in the Blossom River in 2004.

		Brood year and age class						
		2001	**2000**	**2000**	**1999**	**1999**	**1998**	
		0.2	**1.2**	**0.3**	**1.3**	**0.4**	**1.4**	**Total**
PANEL A: Medium Chinook salmon (590-659 mm MEF, event 1 and 2 samples)								
Males	Sample size		52		2			54
	Percent		96.3		3.7			100.0
	SE of percent		2.6		2.6			0.0
	Escapement		130		5			135
	SE of esc.		45		4			47
Total	Sample size		52		2			54
	Percent		96.3		3.7			100.0
	SE of percent		2.6		2.6			0.0
	Escapement		130		5			135
	SE of esc.		45		4			47
PANEL B: Large Chinook salmon (≥660 mm MEF, event 1 and 2 samples)								
Males	Sample size	7	89	9	59	4	25	193
	Percent	2.4	30.6	3.1	20.3	1.4	8.6	66.3
	SE of percent	0.9	2.7	1.0	2.4	0.7	1.6	2.8
	Escapement	18	224	23	149	10	63	487
	SE of esc.	7	31	8	23	5	14	54
Females	Sample size		1	3	51	3	40	98
	Percent		0.3	1.0	17.5	1.0	13.7	33.7
	SE of percent		0.3	0.6	2.2	0.6	2.0	2.8
	Escapement		3	8	129	8	101	247
	SE of esc.		3	4	21	4	18	33
Total	Sample size	7	90	12	110	7	65	291
	Percent	2.4	30.9	4.1	37.8	2.4	22.3	100.0
	SE of percent	0.9	2.7	1.2	2.8	0.9	2.4	0.0
	Escapement	18	227	30	277	18	164	734
	SE of esc.	7	31	9	35	7	25	76
PANEL C: Medium and large Chinook salmon								
Males	Sample size	7	141	9	61	4	25	247
	Percent	2.0	40.8	2.6	17.7	1.2	7.3	71.6
	SE of percent	0.8	3.9	0.9	2.2	0.6	1.4	2.8
	Escapement	18	354	23	154	10	63	622
	SE of esc.	7	55	8	23	5	14	72
Females	Sample size		1	3	51	3	40	98
	Percent		0.3	0.9	14.8	0.9	11.6	28.4
	SE of percent		0.3	0.5	2.1	0.5	1.8	2.8
	Escapement		3	8	129	8	101	247
	SE of esc.		3	4	21	4	18	33
Total	Sample size	7	142	12	112	7	65	345
	Percent	2.0	41.1	3.5	32.5	2.0	18.9	100.0
	SE of percent	0.8	3.9	1.0	2.9	0.8	2.3	
	Escapement	18	357	30	282	18	164	869
	SE of esc.	7	55	9	36	7	25	89

Table 3.–Number of marked large Chinook salmon released in the Blossom River and recaptured by marking period and recovery location, and number examined for marks by recovery area, 2004.

Marking dates	Number marked	Fraction recovered	Recovery area km 6–9	km 10+	Total
7/7 to 7/21	86	0.24	3	18	21
7/22 to 7/29	96	0.33	20	12	32
Total/average	182	0.29	24[a]	30	54
		Number inspected	104	116	220
		Fraction marked	0.23	0.26	0.25

[a] Includes one large marked fish missing its numbered tag.

Table 4.–Peak survey counts, mark-recapture estimates of abundance and estimated expansion factors for large (≥660 mm MEF) Chinook salmon in the Blossom River, 1998 and 2004.

Parameter	Year 1998	2004	Average
Survey count	91	333	212
Mark-recapture estimate	364	734	549
M-R standard error	77	76	76
95% relative precision	41.5	20.3	30.9
M-R lower 95% C.I.	292	609	
M-R upper 95% C.I.	597	908	
Survey count/(M-R)	0.25	0.45	0.35
Expansion factor	4.0	2.2	3.1
SE [expansion factor]	0.85	0.23	0.87

Experience gained in 1998 on the Blossom and 1998–2000 on the Keta rivers facilitated our realization of project objectives. The location of the new camp allowed good access and sampling effort remained constant in the lower river throughout the Chinook salmon immigration. Contingency table analysis indicates that sampling was conducted throughout the immigration.

Sampling during Event 2 was more successful than anticipated, because very low rainfall in August resulted in exceptional visibility and improved efficiency of sampling on the spawning grounds. The exceptional visibility in 2004 also resulted in the peak aerial survey count representing over 45% of the estimated escapement of large fish, compared to the estimate in 1998 of 25% on the Blossom River and the three year average on the Keta River of about 34%. We believe that the total escapement in 2004 in the Blossom River was similar to levels since 1989, but that the survey count was higher due to exceptional counting conditions.

The data standards developed by the U.S. section of the CTC (PSC 1997) require that expansion factors be estimated a minimum of three times. We intend to continue this study again in 2005 which will provide a third estimate. The USCTC also suggests that if the expansion factors have moderate to large amounts of variability (a coefficient of variation of more than 20%) they should be monitored annually. The proximity of the Blossom River some 30 km up and at the head of Smeaton Bay isolates it from other large rivers in the area, with the exception of the Wilson River. Most of the fish tagged in 2004 did not have sea lice on them, indicating that they had been in fresh water for some time (McLean et al. 1990). These features support our contention that fish were unlikely to leave the river once tagged. One Chinook salmon with a missing adipose fin was found in the Blossom River in 2004. The 645-mm MEF male, was sacrificed and sampled for a coded wire tag. The ADF&G Coded Wire Tag Processing Lab in Juneau found no tag. In the 1998 study, one fish with a missing adipose fin was encountered. The fish was released from the Kitimat Hatchery in British Columbia.

Mean lengths by age class for Chinook from the Blossom River (Table 5) were, in most cases, greater than those for Chinook salmon sampled from other rivers sampled in Southeast Alaska (Appendix A4). This trend has been observed in Southeast Alaska stocks since 1998, with the largest fish at age occurring in the Chickamin, Keta and Blossom rivers and average size decreasing towards the north (Pahlke 2003). This

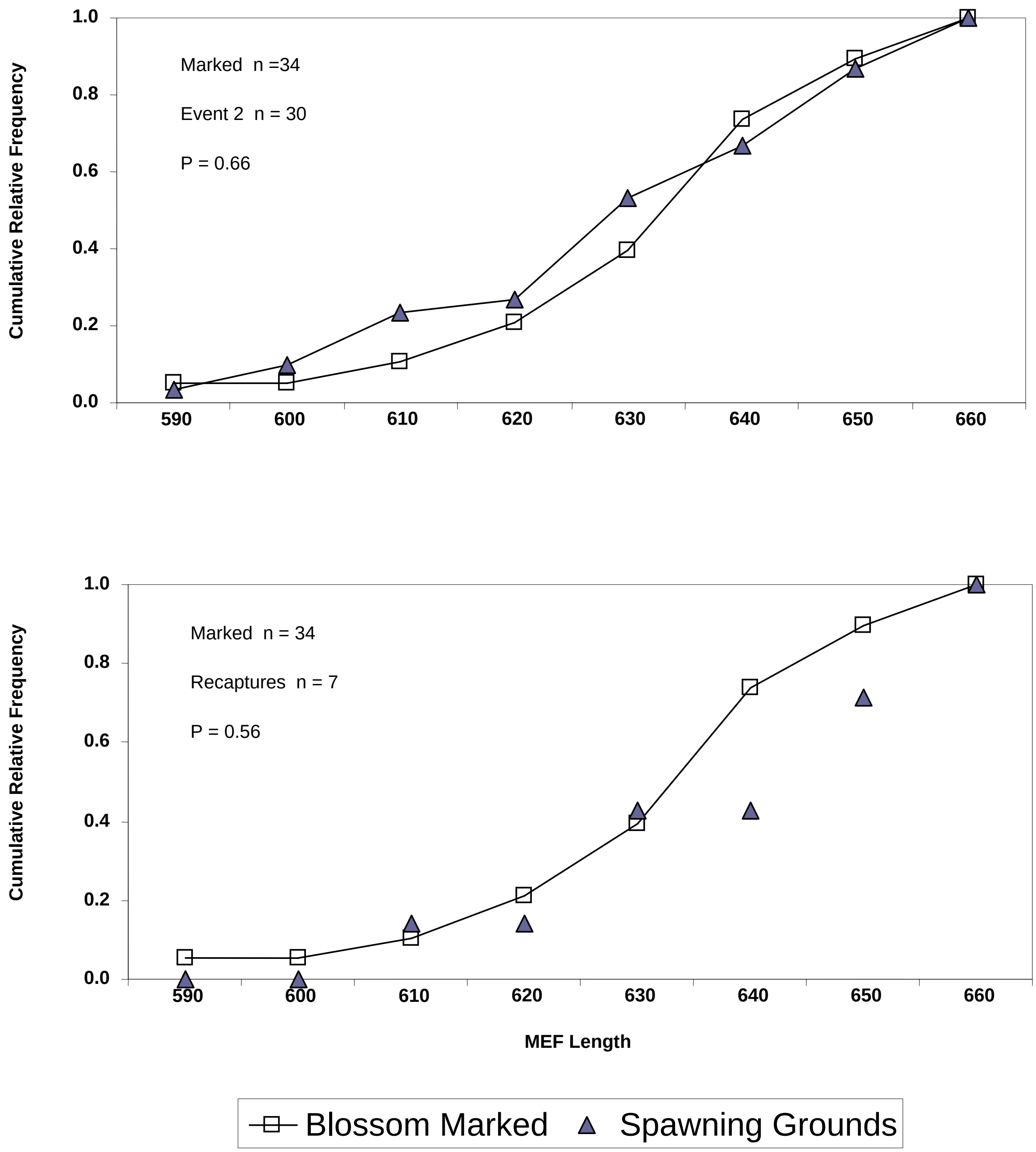


Figure 5.–Cumulative fractions of medium (590–659 mm MEF) Chinook salmon marked vs. captured (top) and marked vs. recaptured in event 2 (bottom) in the Blossom River in 2004.

large size phenomenon may occur because of inherent genetic traits or in combination with environmental conditions. The Blossom and Keta Rivers are clear water systems (not glacially influenced), and water temperatures are presumed warmer than in most other Chinook-producing systems in the Southeast Alaska region, with the exception of the Situk River near Yakutat. There are extensive tidal flats fronting the rivers, and the associated long inlets may serve as an extended estuary that promotes favorable growth in the early marine life stage. The nearby Chickamin and Wilson rivers also produce some of the largest Chinook salmon in the region. All are the most southerly Chinook stocks in the Southeast Alaska region, and only the Chickamin is a glacial system.

Evidence of mortality of fish after marking and prior to spawning was low. Fish were released with tags only when in good condition. No pre-spawn, marked carcasses were recovered during the second event. Mortality of tagged fish by predators was presumed low. The Blossom River is a relatively large stream when compared with tributaries of the Unuk River or other Chinook salmon spawning streams in the area. Blue tags were used to minimize visibility and predation of tagged Chinook salmon.

The behavior of immigrating Chinook salmon may have been affected by the presence of harbor seals *Phoca vitulina*, in the Blossom River. Seals occupied the lower river continuously during the project period. The crew observed seals traveling between reaches and aggregating in pools. Seals also were consistently observed during boat and foot surveys up to 10 km above the Wilson River confluence. Few seals were observed in the Keta River during the period of the marking phases of that project

The presence of seals in the lower river may account for some of the difference in immigration pattern observed between the two systems. Fish did not utilize holding water on the lower Blossom River during the immigration phase of the spawning run. On the Keta River, fish were captured in most pools between tidewater and the lower limits of spawning reaches. Spawning habitat on the Blossom River is distributed relatively high in the system compared to the Keta River. Immigrating Chinook salmon may have

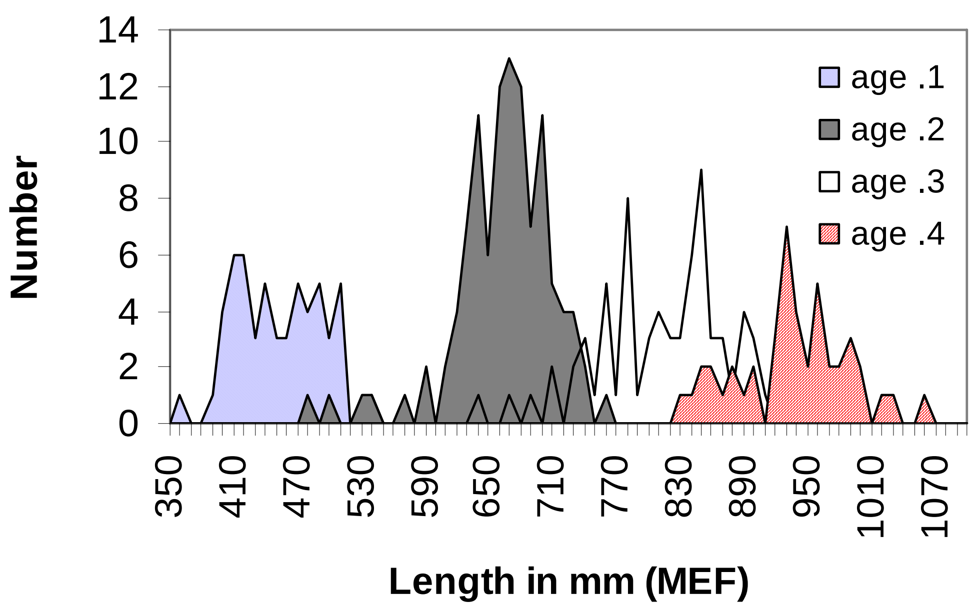


Figure 6.–Numbers of Chinook Salmon by ocean age and length from samples taken on the Blossom River, 2004.

Table 5.–Average length by sex and age of Chinook salmon sampled in the Blossom River in 2004. Estimates include all Chinook encountered in events 1 and 2.

Panel A. Large (≥660 mm mef) Chinook salmon										
		Brood year and age class								
		2000	**2001**	**2001**	**2000**	**2000**	**1999**	**1999**	**1998**	**1998**
		0.1	**1.1**	**0.2**	**1.2**	**0.3**	**1.3**	**0.4**	**1.4**	**0.5**
Males	n	0	0	7	89	9	59	4	25	0
	Avg. length			731	690	802	800	969	964	
	SD			63	28	117	62	33	58	
	SE			24	3	39	8	16	12	
Females	n	0	0	0	1	3	51	3	40	0
	Avg. length				710	837	835	888	921	
	SD					73	48	38	39	
	SE					72	7	22	6	
Sexes	n			7	90	12	110	7	65	
combined	Avg. length			731	690	811	817	934	937	
	SD			63	28	105	59	53	52	
	SE			24	3	30	6	20	6	
Panel B. All sizes of Chinook salmon encountered										
		Brood year and age class								
		2000	**2001**	**2001**	**2000**	**2000**	**1999**	**1999**	**1998**	**1998**
		0.1	**1.1**	**0.2**	**1.2**	**0.3**	**1.3**	**0.4**	**1.4**	**0.5**
Males	n	2	44	7	147	9	61	4	25	0
	Avg. length	378	458	731	661	802	795	969	964	
	SD	25	38	63	50	117	68	33	58	
	SE	18	6	24	4	39	9	16	12	
Females	n	0	0	0	1	3	51	3	40	0
	Avg. length				710	837	835	888	921	
	SD					73	48	38	39	
	SE					42	7	22	6	
Sexes	n	2	44	7	148	12	112	7	65	0
combined	Avg. length	378	458	731	662	811	813	934	937	
	SD	25	38	63	50	105	63	53	52	
	SE	18	6	24	4	30	6	20	6	

moved more rapidly through the lower river to access holding water below spawning areas in the Blossom River. The extremely low water conditions in 2004 may have also affected the spawning distribution by increasing their vulnerability to predation by seals in the lower river. Even though the white tails of actively spawning or post-spawn females are easier to see, there was no evidence of sex-selectivity for large fish in Event 2. Both samples were heavily skewed towards males due to the large number of age-1.2 fish, which were all males. 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 Event 2 as a result of post-spawning behavior of the fish. Also when pursuing active fish in event 2, the size of the river limited singling out individual fish in many cases.

A problem occasionally encountered in similar mark-recapture studies is the inaccurate determination of sex shortly after the fish enter freshwater. This typically occurs on large glacial rivers like the Taku and Stikine, where Chinook enter the lower river in bright condition and then spend 1–3 months inriver before spawning. A check of all 59 fish recaptured with tags confirmed that all fish were assigned the same sex in the two events. For the three years combined on the Keta River, 113 of 115 (98.3%) recaptured fish were assigned the same sex in each event. Based on experience of the field crew and advanced physical maturation characteristics of the fish, sex of Blossom and Keta River Chinook was generally deemed easier to determine than at other area systems. However, the larger age-.2 males often proved challenging to identify by sex.

CONCLUSIONS AND RECOMMENDATIONS

Continuation of annual peak abundance counts in surveys, coupled with escapement sampling for age-sex-length composition, is recommended to estimate spawner-recruit relationships and to refine escapement goal ranges for improved stock assessment and fishery management. The mean expansion factor can be used to estimate total escapement of large Chinook, and this expansion factor estimate is relatively precise.

The Blossom River is manageable with current levels of logistical support, in that a crew of two proved effective in completing the mark-recapture experiment, especially during Event 1 sampling. A crew of two also proved adequate during Event 2 when stream levels were low. However, any future studies should plan to incorporate additional staff as needed for short time periods following extended high water events during Event 2.

The estimated escapement of fish <590 mm MEF remains unknown. Methodology used during Event 2 of this study proved unsuccessful at capturing fish smaller than 590 mm in length. Incorporation of such methods as hook and line with bait, or extending Event 2 by a couple of weeks may be required.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1.–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 A1.–Sex, length (MEF in mm), age, capture and recovery data for Chinook salmon caught in the Blossom River in 2004.

Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
1	7-Jul	M	875	I.4	6501	Bright	Good	NL	6	
2	7-Jul	F	930	1.4	6502	Bright	Good	NL	6	
3	7-Jul	M	465	1.1	NT	Bright	Good	LP	6	
4	7-Jul	M	685	1.2	6503	Bright	Good	LP	6	
5	8-Jul	M	1025	R.4	6504	Bright	Good	LP	7.5	
6	8-Jul	M	635	1.2	6505	Bright	Good	LP	7.5	
7	8-Jul	M	955	R.4	6506	Bright	Good		7.5	13.5
8	8-Jul	M	615	1.2	6507	Bright	Good	LP	6	
9	9-Jul	M	680	1.2	6508	Bright	Good	LP	6	15
10	9-Jul	M	485	1.1	NT	Bright	Good	NL	6	
11	9-Jul	M	480	1.1	NT	Bright	Good	NL	6	
12	10-Jul	F	835	1.3	6509	Gray	Good	NL	6	
13	10-Jul	F	845	1.3	6510	Gray	Good	LP	6	
14	10-Jul	M	630	1.2	6511	Bright	Good	LP	6	
15	10-Jul	M	755	1.3	6512	Gray	Good	NL	6	
16	10-Jul	M	720	R.2	6513	Bright	Good	NL	6	
17	10-Jul	M	660	R.2	6514	Bright	Good	LP	6	
18	10-Jul	F	985	1.4	6515	Bright	Good	LP	6	
19	10-Jul	M	645	1.2	6516	Bright	Good	LP	5.5	
20	10-Jul	M	720	1.2	6517	Bright	Good	NL	5.5	10
21	10-Jul	F	890	1.4	6518	Bright	Good	LP	5.5	
22	10-Jul	M	885	1.3	6519	Gray	Good	LP	5.5	9
23	11-Jul	M	980	0.4	6520	Gray	Good		5.5	9
24	11-Jul	M	640	1.3	6521	Gray	Good	LP	5.5	
25	11-Jul	M	855	R.4	6522	Bright	Good	LP	5.5	
26	11-Jul	M	840	R.4	6523	Bright	Good	LP	5.5	
27	11-Jul	M	470	1.1	NT	Bright	Good	LP	6.0	
28	11-Jul	M	480	R.R	NT	Bright	Good		7.0	
29	11-Jul	M	625	1.2	6524	Bright	Good	LP	7.0	
30	11-Jul	M	400	1.1	NT	Bright	Good	LP	7.0	
31	11-Jul	M	635	1.2	6525	Bright	Good	LP	7.0	
32	11-Jul	F	780	1.3	6526	Bright	Good	LP	7.5	
33	11-Jul	F	830	1.3	6527	Bright	Good	NL	7.5	
34	11-Jul	M	640	1.2	6528	Bright	Good	NL	5.5	
35	12-Jul	M	695	R.2	NT	Brown	Mort	LP	5.5	
36	12-Jul	M	425	R.R	NT	Bright	Good	LP	5.5	
37	12-Jul	M	450	1.1	NT	Bright	Good	NL	8.5	
38	12-Jul	F	890	1.3	6529	Bright	Good	LP	8.5	
39	12-Jul	F	950	1.4	6530	Bright	Good	NL	8.5	
40	12-Jul	M	780		NT	Brown	Mort	NL	8.5	
41	12-Jul	F	930	R.4	6531	Brown	Good	NL	7.5	
42	12-Jul	M	710	1.3	6532	Gray	Bleeder	NL	7.5	
43	12-Jul	F	855	R.3	6533	Gray	Good	NL	7.5	
44	12-Jul	M	690	1.2	NT	Gray	Good	NL	7.5	
45	12-Jul	M	850	R.3	6534	Red	Good	NL	7.5	
46	12-Jul	F	830	R.4	6535	Bright	Good	LP	7.5	

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Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
47	12-Jul	M	495	1.2	NT	Bright	Good	NL	7 .0	
48	12-Jul	F	860	R.3	6536	Bright	Good	LP	7 .0	
49	13-Jul	F	930	1.4	6537	Pink	Good	LP	8 .5	
50	13-Jul	M	1015	1.4	6538	Dark	Good	NL	8 .5	
51	13-Jul	F	955	1.4	6539	Gray	Good	NL	8 .5	
52	13-Jul	M	420	1.1	NT	Bright	Good		7 .0	
53	13-Jul	F	845	1.3	6540	Gray	Good	NL	5 .5	10
54	13-Jul	M	535	1.1	NT	Bright	Good	NL	5 .5	
55	13-Jul	M	540	1.2	NT	Bright	Good	NL	5 .5	
56	13-Jul	M	900	R.3	6541	Red	Good	NL	5 .5	
57	13-Jul	M	620	R.2	6542	Bright	Good	LP	5 .5	
58	13-Jul	F	740	1.3	6543	Bright	Good	LP	6 .0	
59	14-Jul	M	405	1.1	NT	Bright	Good	NL	5 .5	
60	14-Jul	M	435	R.R	NT	Bright	Good	NL	6	
61	17-Jul	M	660	1.2	6544	Gray	Good	LP	8 .5	
62	18-Jul	M	665	R.2	6545	Dark	Good		5 .5	13 .5
63	18-Jul	M	760	R.3	6546	Dark	Good	LP	5 .5	12
64	18-Jul	M	755	1.3	6547	Gray	Good	NL	5 .5	
65	18-Jul	M	730	R.2	6548	Bright	Good	LP	6 .0	15
66	18-Jul	M	405	R.1	NT	Bright	Good	NL	8 .5	
67	18-Jul	F	950	1.4	6549	Gray	Good	NL	8 .5	
68	18-Jul	M	615	1.2	6550	Bright	Good	LP	8 .5	
69	18-Jul	M	645	1.2	6551	Bright	Good	LP	7 .5	
70	18-Jul	M	705	R.2	6552	Bright	Good	NL	6	
71	18-Jul	F	800	R.3	6553	Gray	Bleeder	NL	6 .0	
72	18-Jul	F	840	R.3	6554	Bright	Good	LP	6 .0	12 .5
73	18-Jul	M	700	1.2	6555	Gray	Good	NL	6 .0	
74	18-Jul	M	500	1.1	NT	Bright	Good	LP	6 .0	
75	19-Jul	F	850	1.3	6556	Bright	Good	LP	8 .5	12 .5
76	19-Jul	M	680	1.2	6557	Pink	Good	LP	8 .5	
77	19-Jul	M	675	R.2	6558	Gray	Good	NL	8 .5	
78	19-Jul	M	990	1.4	6559	Brown	Good	NL	8 .5	
79	19-Jul	M	370		NT	Bright	Good	NL	8 .5	
80	19-Jul	M	760	0.3	6560	Brown	Good	LP	8 .5	
81	19-Jul	M	655	1.2	6561	Brown	Good	NL	7 .5	
82	19-Jul	M	725	0.3	6562	Brown	Good	NL	7 .5	
83	19-Jul	F	840	1.3	6563	Gray	Good	NL	7 .5	17
84	19-Jul	M	605	1.2	NT	Bright	Bleeder	NL	7 .5	
85	19-Jul	M	500	1.1	NT	Bright	Good	NL	7 .5	
86	19-Jul	M	395	R.1	NT	Bright	Good	NL	7 .5	
87	19-Jul	M	680	R.2	6564	Bright	Good	NL	7 .5	
88	19-Jul	F	780	R.3	6565	Brown	Good	LP	7 .0	
89	19-Jul	M	670	1.2	6566	Brown	Good	NL	7 .0	
90	19-Jul	M	665	1.2	6567	Brown	Good	LP	7	12 .5
91	19-Jul	F	940	1.4	6568	Gray	Good	LP	7 .0	
92	19-Jul	M	570	R.R	NT	Bright	Good	LP	5 .5	
93	19-Jul	M	675	1.2	6569	Brown	Good	NL	5 .5	
94	19-Jul	M	460	1.2	NT	Bright	Good	LP	5 .5	
95	19-Jul	M	665	R.2	6570	Brown	Good	NL	6 .0	10

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Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
96	19-Jul	M	465	1.1	NT	Bright	Bleeder	NL	6 .0	
97	19-Jul	M	510	1.1	NT	Bright	Good	NL	6 .0	
98	19-Jul	M	725	1.3	6571	Brown	Good	NL	6 .0	10
99	19-Jul	M	865	R.R	6572	Red	Good	NL	6 .0	
100	19-Jul	M	775	1.3	6573	Bright	Good	LP	6	
101	19-Jul	M	410	1.1	NT	Bright	Good	NL	6 .0	
102	20-Jul	M	655	1.2	6574	Bright	Good	NL	3 .0	
103	20-Jul	M	710	1.2	6575	Bright	Good	NL	3 .0	
104	20-Jul	M	900	1.3	6576	Pink	Good	LP	3 .0	
105	20-Jul	M	435	R.1	NT	Bright	Good	NL	3 .0	
106	20-Jul	M	630	R.2	6577	Gray	Good	LP	3 .0	
107	20-Jul	M	390	1.1	NT	Bright	Good	NL	3 .0	
108	20-Jul	M	685	R.3	6578	Bright	Good	LP	4 .0	
109	20-Jul	M	645	R.2	Ad Clip	Bright	Killed		4 .0	
110	20-Jul	M	965	R.4	6579	Red	Good	LP	8 .5	
111	20-Jul	F	920	1.4	6580	Brown	Good	NL	8 .5	
112	20-Jul	M	635	1.2	6581	Gray	Good	NL	7 .0	7
113	20-Jul	M	640	1.2	6582	Bright	Good	NL	7 .0	
114	20-Jul	F	885	R.3	6583	Bright	Good	LP	6 .0	
115	20-Jul	M	800	1.3	6584	Pink	Good	LP	6 .0	12 .5
116	20-Jul	M	590	1.2	6585	Brown	Good	NL	6 .0	
117	20-Jul	M	675	1.2	6586	Bright	Good	NL	6 .0	
118	20-Jul	M	625	1.2	6587	Brown	Good	NL	6 .0	
119	20-Jul	M	685	1.2	6588	Brown	Good	NL	6 .0	
120	20-Jul	M	665	1.2	6589	Gray	Good	NL	6	
121	20-Jul	M	815	R.3	6590	Red	Good	NL	6 .0	
122	20-Jul	M	635	1.2	6591	Bright	Good	NL	6 .0	
123	20-Jul	M	435	R.1	NT	Bright	Good	NL	6 .0	
124	20-Jul	M	655	R.2	6592	Bright	Good	LP	6 .0	7
125	20-Jul	M	680	1.2	6593	Bright	Good	NL	6 .0	
126	21-Jul	M	685	1.2	6594	Bright	Good	NL	3 .5	
127	21-Jul	M	775	R.3	NT	Red	Bleeder	NL	3 .5	
128	21-Jul	F	925	1.4	6595	Gray	Good	NL	8 .5	
129	21-Jul	F	780	1.3	6596	Brown	Good	LP	8 .5	
130	21-Jul	M	850	1.3	6597	Pink	Good	LP	8 .5	
131	21-Jul	M	650	1.2	6598	Bright	Good	NL	7 .5	
132	21-Jul	M	835	1.3	6599	Red	Good	LP	7 .5	12 .5
133	21-Jul	M	425	1.1	NT	Bright	Good	NL	7 .5	
134	21-Jul	M	430	1.1	NT	Bright	Good	NL	7 .5	
135	21-Jul	M	965	1.4	6600	Red	Good	NL	7 .5	10
136	21-Jul	M	420	1.1	NT	Bright	Bleeder	NL	7 .5	
137	21-Jul	F	895	R.4	6601	Pink	Good	NL	5 .5	
138	21-Jul	F	940	1.4	6602	Bright	Good	NL	5 .5	
139	21-Jul	M	680	1.2	6603	Pink	Good	NL	6 .0	13 .5
140	21-Jul	M	450	1.1	NT	Bright	Good	NL	6	
141	21-Jul	M	695	R.2	6604	Gray	Good	NL	6 .0	

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Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
142	21-Jul	M	405	R.1	NT	Bright	Good	NL	6 .0	
143	21-Jul	M	695	0.2	6605	Bright	Good	NL	6 .0	
144	21-Jul	M	700	1.2	6606	Pink	Good	LP	6 .0	10
145	21-Jul	F	920	R.4	6607	Bright	Good	LP	6 .0	
146	21-Jul	M	395	1.1	NT	Bright	Bleeder	NL	6 .0	
147	21-Jul	M	465	R.R	NT	Bright	Good	NL	6 .0	
148	22-Jul	M	700	R.2	6608	Brown	Good	NL	4 .0	8 .5
149	22-Jul	M	660	1.2	6609	Gray	Good	NL	4 .5	16
150	22-Jul	M	645	R.2	6610	Bright	Good	LP	4	
151	22-Jul	F	880	1.4	6611	Bright	Good	LP	4 .5	7 .5
152	22-Jul	M	705	1.2	6612	Bright	Good	NL	4 .5	
153	22-Jul	M	435	R.R	NT	Bright	Mort	NL	4 .5	
154	22-Jul	F	845	0.4	6613	Brown	Good	NL	5 .5	
155	22-Jul	M	475	R.1	NT	Bright	Poor	NL	6 .0	
156	22-Jul	M	495	1.1	NT	Bright	Bleeder	NL	6 .0	
157	22-Jul	M	635	R.2	6614	Bright	Good	NL	6 .0	7
158	22-Jul	F	755	R.2	6615	Bright	Good	NL	6 .0	
159	22-Jul	F	930	1.4	6616	Gray	Good	NL	6 .0	
160	22-Jul	F	750	1.3	6617	Gray	Good	NL	6	
161	22-Jul	M	475	1.1	NT	Gray	Tired	NL	6 .0	
162	22-Jul	M	670	1.2	6618	Brown	Good	NL	6 .0	
163	22-Jul	F	910	0.3	6619	Bright	Good	LP	6 .0	
164	22-Jul	M	760	0.3	6620	Brown	Good	NL	6 .0	8 .5
165	22-Jul	M	405	R.1	NT	Bright	Good	NL	6 .0	
166	23-Jul	M	635	1.2	6621	Brown	Good	NL	6 .0	
167	23-Jul	F	865	R.3	6622	Dark	Good	NL	6 .0	8 .5
168	23-Jul	M	675	1.2	6623	Brown	Good	NL	6 .0	
169	23-Jul	M	695	1.2	6624	Brown	Good	NL	5 .5	
170	23-Jul	F	700	R.2	6625	Gray	Good	NL	5 .5	
171	23-Jul	M	705	1.2	6626	Bright	Tired	NL	4 .5	
172	23-Jul	M	725	R.2	6627	Gray	Good	NL	4 .5	
173	23-Jul	M	465	1.1	NT	Bright	Good	NL	6 .0	
174	23-Jul	M	690	1.2	6628	Bright	Good	NL	6 .0	7
175	23-Jul	M	360	0.1	NT	Bright	Good	NL	6 .0	
176	23-Jul	M	665	1.2	6629	Brown	Good	NL	6 .0	14
177	23-Jul	M	445	1.1	NT	Bright	Good	LP	6 .0	
178	23-Jul	M	415	1.1	NT	Bright	Good	NL	6 .0	
179	24-Jul	F	935	1.4	6630	Brown	Good	NL	6 .0	7
180	24-Jul	F	920	1.4	6631	Gray	Good		6	
181	24-Jul	M	730	R.2	6632	Red	Good	NL	7 .0	
182	24-Jul	M	735	0.2	6633	Brown	Good	NL	7 .0	
183	24-Jul	M	465	R.R	NT	Bright	Good	NL	7 .0	
184	24-Jul	M	395	0.1	NT	Bright	Bleeder	NL	7 .0	
185	24-Jul	F	835	0.3	6634	Gray	Good	NL	7 .5	
186	24-Jul	M	735	1.2	6635	Brown	Good	NL	7 .5	
187	24-Jul	F	810	1.3	6636	Brown	Good	NL	8 .5	

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Appendix A2.–page 5 of 7

Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
188	24-Jul	M	780	1.3	6637	Brown	Good	NL	8.5	
189	24-Jul	F	955	R.4	6638	Brown	Good	NL	8.5	
190	24-Jul	M	670	0.3	6639	Brown	Good	NL	7.5	
191	24-Jul	M	435	1.1	NT	Bright	Good	NL	7.5	
192	24-Jul	F	800	1.3	NT	Brown	Mort	LP	7.5	
193	24-Jul	M	640	1.2	6641	Bright	Good	NL	7.5	
194	24-Jul	M	660	1.2	6642	Red	Good	NL	7.5	
195	24-Jul	M	925	0.3	6643	Brown	Good	NL	7.5	11
196	24-Jul	F	885	1.3	6644	Bright	Good	LP	4.5	
197	24-Jul	F	845	1.3	6645	Bright	Good	NL	4.5	
198	24-Jul	F	810	1.3	6646	Brown	Good	NL	5.5	
199	24-Jul	M	420	1.1	NT	Bright	Good	NL	5.5	
200	24-Jul	M	625	1.2	NT	Bright	Bleeder	NL	5.5	
201	24-Jul	M	780	1.3	6647	Brown	Good	NL	5.5	
202	25-Jul	M	820	1.3	6648	Bright	Good	LP	3.0	10
203	25-Jul	M	825	1.3	6649	Red	Good	NL	3.0	
204	25-Jul	F	845	1.3	6650	Semi	Good	NL	3.0	9.5
205	25-Jul	F	955	R.4	6651	Semi	Good	LP	3.0	
206	25-Jul	M	670	R.2	6653	Pink	Good	NL	3.0	15
207	25-Jul	F	865	1.3	6654	Red	Good	NL	6.0	
208	25-Jul	M	740	1.3	6655	Brown	Good	LP	6.0	8.5
209	25-Jul	M	695	1.2	6656	Bright	Good	NL	6.0	
210	25-Jul	F	850	1.3	6657	Bright	Good	NL	6	10
211	25-Jul	F	925	ill.4	6658	Gray	Good	NL	6.0	8.5
212	25-Jul	F	805	1.3	6659	Gray	Good	LP	6.0	
213	25-Jul	M	705	0.3	6660	Dark	Good	NL	7.0	
214	25-Jul	M	505	1.1	6661	Brown	Good	NL	7.5	
215	25-Jul	M	620	R.2	6662	Bright	Good	NL	7.5	
216	25-Jul	F	925	1.3	6663	Dark	Good	NL	7.5	
217	25-Jul	M	415	R.1	NT	Bright	Mort	NL	7.5	
218	25-Jul	M	405	1.1	NT	Bright	Good	NL	7.5	
219	25-Jul	F	995	1.4	6664	Gray	Good	NL	5.5	
220	25-Jul	M	980	1.4	6665	Red	Good	NL	5.5	
221	25-Jul	F	870	1.4	6666	Pink	Good	NL	6.0	
222	26-Jul	M	860	1.3	6667	Brown	Good	NL	6.0	
223	26-Jul	M	725	1.2	6668	Bright	Good	NL	6.0	
224	26-Jul	M	685	1.2	6669	Brown	Good	NL	6.0	
225	26-Jul	M	525	1.2	NT	Bright	Good	LP	3.0	
226	26-Jul	M	435	1.1	NT	Bright	Good	NL	3.0	
227	26-Jul	M	675	1.2	6670	Semi	Good	NL	3.5	
228	26-Jul	M	635	1.2	6671	Bright	Good	NL	4.0	
229	26-Jul	M	590	1.2	6672	Gray	Good	NL	4.5	
230	26-Jul	M	505	1.1	NT	Bright	Good	LP	4.5	
231	26-Jul	M	490	1.1	NT	Bright	Good	NL	4.5	
232	26-Jul	M	695	0.2	6673	Bright	Good	NL	4.5	7.5
233	26-Jul	M	660	1.2	6674	Brown	Good	NL	5.5	
234	26-Jul	M	435	1.1	NT	Bright	Good	NL	5.5	

-continued-

Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
235	26-Jul	M	485	1.1	NT	Bright	Good	NL	5.5	
236	26-Jul	M	795		6675	Red	Good	NL	5.5	
237	26-Jul	M	660	1.2	6676	Brown	Good	NL	7.5	15
238	26-Jul	M	485	1.1	NT	Bright	Good	NL	7.5	
239	26-Jul	F	845	R.3	6677	Brown	Good	NL	7.5	
240	26-Jul	F	740	R.3	6678	Brown	Good	NL	7.5	8.5
241	26-Jul	M	1060	1.4	6679	Pink	Good	NL	7.5	
242	26-Jul	M	640	R.2	6680	Pink	Good	NL	7.5	10
243	26-Jul	M	455	1.1	NT	Bright	Good	NL	7.5	
244	26-Jul	M	970	1.3	6681	Pink	Good	NL	8.5	
245	26-Jul	F	930	R.4	6682	Brown	Good	NL	8.5	9
246	26-Jul	F	860	1.4	6683	Gray	Good	NL	6.0	8.5
247	26-Jul	M	865	R.3	6684	Pink	Good	LP	6.0	7
248	27-Jul	M	655	R.2	6685	Semi-	Good	NL	6.0	10
249	27-Jul	M	505	1.1	NT	Bright	Good	NL	6.0	
250	27-Jul	M	665	1.2	6686	Bright	Good	NL	7	
251	27-Jul	M	775	1.3	6687	Brown	Good	NL	4.5	7
252	27-Jul	M	665	1.2	6688	Bright	Good	NL	3.0	
253	27-Jul	M	650	1.2	6689	Gray	Good	NL	6.0	10
254	27-Jul	M	835	1.3	6690	Dark	Good	NL	6.0	
255	27-Jul	M	715	R.2	6691	Red	Good	NL	6.0	15
256	27-Jul	M	465	1.1	NT	Bright	Good	NL	6.0	
257	28-Jul	M	705	1.2	6692	Brown	Good	LP	3.0	
258	28-Jul	F	895	R.4	6693	Bright	Good	LP	3.0	7
259	28-Jul	M	660	1.2	6694	Bright	Good	LP	3.0	
260	28-Jul	M	480	1.1	NT	Bright	Bleeder	NL	3	
261	28-Jul	M	480	1.2	NT	Bright	Bleeder	NL	3.5	
262	28-Jul	M	830	1.3	6695	Brown	Good	LP	3.5	
263	28-Jul	M	690	1.2	6696	Pink	Good	NL	3.5	8.5
264	28-Jul	M	670	1.2	6697	Brown	Good	NL	4.5	
265	28-Jul	F	990	1.4	6698	Brown	Good	NL	4.5	
266	28-Jul	M	635	R.R	NT	Bright	Mort	NL	5.5	
267	28-Jul	F	955	1.4	6699	Brown	Good	NL	8.5	11
268	28-Jul	F	785	1.3	6700	Pink	Good	NL	8.5	
269	28-Jul	M	820	R.3	6701	Red	Good	NL	7.5	11
270	28-Jul	M	680	1.2	6702	Bright	Good	NL	7.5	
271	28-Jul	M	Large		6703	Red	Good		7.5	
272	28-Jul	M	485	1.1	NT	Green	Good	NL	7.5	
273	28-Jul	F	895	1.3	6704	Brown	Good	NL	7.5	
274	28-Jul	M	660	1.2	6705	Brown	Good	NL	7.5	
275	28-Jul	M	510	1.1	NT	Bright	Poor	NL	7.5	
276	28-Jul	M	675	1.2	6706	Brown	Good	NL	7.5	9.5
277	28-Jul	F	940	1.4	6707	Brown	Good	NL	6.0	
278	28-Jul	M	565	R.2	NT	Brown	Good	NL	6.0	
279	28-Jul	M	415	R.1	NT	Bright	Good	NL	6.0	
280	28-Jul	F	875	1.3	6708	Brown	Good	NL	6	13.5

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Fish Number	Date	Sex	Length (mm)	Age	Tag #	Color	Condition	Sea Lice	Capture Site (km)	Recovery Site (km)
281	29-Jul	M	455	R.1	NT	Bright	Good	LP	3.0	
282	29-Jul	M	605	1.2	6709	Bright	Good	LP	3.0	
283	29-Jul	M	670	R.2	6710	Bright	Good	LP	3.0	
284	29-Jul	M	525	R.R	NT	Gray	Good	NL	3.5	
285	29-Jul	M	625	1.2	6711	Brown	Good	NL	3.5	
286	29-Jul	M	625	1.2	6712	Brown	Bleeder	NL	4.0	9
287	29-Jul	M	995	1.4	6713	Brown	Good	NL	5.5	7
288	29-Jul	M	425	R.1	NT	Bright	Good	NL	5.5	
289	29-Jul	F	850	R.4	6714	Bright	Good	NL	6	7
290	29-Jul	F	805	R.3	6715	Brown	Good	NL	6	7
291	29-Jul	M	720	1.2	6716	Brown	Good	NL	6	
292	29-Jul	F	765	1.3	6717	Bright	Good	LP	7.5	
293	29-Jul	M	700	1.2	6718	Semi-	Good	NL	7.5	
294	29-Jul	M	665	1.2	6719	Bright	Good	NL	8.5	

Appendix A2.–Age composition by length class and sex for Chinook salmon sampled in the Blossom River in 2004.

EVENT 1 SAMPLE		2002	2001	2001	2000	2000	1999	1999	1998	1998	
		0.1	1.1	0.2	1.2	0.3	1.3	0.4	1.4	0.5	Total
Small Chinook salmon (<440 mm MEF)											
Males	Number sampled	2	15								17
	Percent	11.8	88.2								100
	SE of percent	8.1	8.1								
Medium Chinook salmon (440-659 mm MEF)											
Males	Number sampled		26		32		1				59
	Percent		44.1		54.2		1.7				100
	SE of percent		6.5		6.5		1.7				
Large Chinook salmon (≥660 mm MEF)											
Males	Number sampled			3	46	6	20	1	6		82
	Percent			2.3	35.1	4.6	15.3	0.8	4.6		62.6
	SE of percent			1.3	4.2	1.8	3.2	0.8	1.8		4.2
Females	Number sampled					2	25	1	21		49
	Percent					1.5	19.1	0.8	16.0		37.4
	SE of percent					1.1	3.4	0.8	3.2		4.2
Total	Number sampled			3	46	8	45	2	27		131
	Percent			2.3	35.1	6.1	34.4	1.5	20.6		100
	SE of percent			1.3	4.2	2.1	4.2	1.1	3.5		

EVENT 2 SAMPLE		2002	2001	2001	2000	2000	1999	1999	1998	1998	
		0.1	1.1	0.2	1.2	0.3	1.3	0.4	1.4	0.5	Total
Small Chinook salmon (<440 mm MEF)											
Males	Number sampled		1								1
	Percent		100								100
	SE of percent										
Medium Chinook salmon (440-659 mm MEF)											
Males	Number sampled		2		26		1				29
	Percent		6.9		89.7		3.4				100
	SE of percent		4.8		5.8		3.4				
Large Chinook salmon (≥660 mm MEF)											
Males	Number sampled			4	43	3	39	3	19		111
	Percent			2.5	26.9	1.9	24.4	1.9	11.9		69.4
	SE of percent			1.2	3.5	1.1	3.4	1.1	2.6		3.7
Females	Number sampled				1	1	26	2	19		49
	Percent				0.6	0.6	16.3	1.3	11.9		30.6
	SE of percent				0.6	0.6	2.9	0.9	2.6		3.7
Total	Number sampled			4	44	4	65	5	38		160
	Percent			2.5	27.5	2.5	40.6	3.1	23.8		100
	SE of percent			1.2	3.5	1.2	3.9	1.4	3.4		

Appendix A3.–Estimated average length by sex and age of Chinook salmon sampled in escapements in 11 rivers in Southeast Alaska in 2000. Age classes with less than four fish sampled were not included in this summary.

	Brood year and age class													
	1998	1997	1996	1997	1996	1995	1996	1995	1994	1995	1994	1993	1994	1993
	0.1	1.1	2.1	0.2	1.2	2.2	0.3	1.3	2.3	0.4	1.4	2.4	0.5	1.5
PANEL A. MALE CHINOOK SALMON														
1. Keta		412		648	650		844	833			931			
2. Blossom					673			835						
3. Chickamin					667			793			930			
4. Unuk		370			642			789			910			
5. Stikine					628			778			889			912
6. Andrew Cr					590			739			846			
7. King Salmon					650			754						
8. Taku		349			584			754			876			
9. Chilkat		379			574			762			892			
10. Alsek					616	679		806			934			
11. Situk	351			573			769	805						
Averages		378			627			786			901			912
PANEL B. FEMALE CHINOOK SALMON														
1. Keta					728		852	844		907	914		960	
2. Blossom								871			896			
3. Chickamin								844			905			
4. Unuk					726			816			884			975
5. Stikine					635			784			839			870
6. Andrew Cr								779			829			935
7. King Salmon								787			817			
8. Taku					657			773			826			895
9. Chilkat								795			858			
10. Alsek					567			775			834			
11. Situk				612			780	806		844				
Averages					663			807			860			919
PANEL C. SEXES COMBINED														
1. Keta		412		648	651		847	839		908	921			
2. Blossom					673			844			903			
3. Chickamin					667			820			914			
4. Unuk		370			644			800			892			963
5. Stikine					629			781			858	858		896
6. Andrew Cr					606			760			833			
7. King Salmon					650			769			826			
8. Taku		349			586			764			845			
9. Chilkat		379			576			776			871			866
10. Alsek					605	679		783			883			
11. Situk	351			589			776	805		847				
Averages		378			629			795			875			908

Appendix A4.–Computer files used to estimate the spawning abundance and age, sex, length data for Chinook salmon in the Blossom River in 2004.

File name	Description
Kscharts04.xls	Spreadsheets containing mark-recapture data, summary tables, chi-square test results, Kolmogorov-Smirnov (K-S) 2-sample test results, and age and sex composition data.
Blossommarked04age.xls Blossomrecaps04age.xls	Spreadsheets containing Chinook salmon length at age data and charts.
Popest.xls agecomps.xls	Spreadsheets containing statistical length at age and sex tables and charts, abundance estimates and annual escapement summary data.