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A Mark-Recapture Experiment to Estimate the Escapement of Chinook Salmon in the Blossom River, 2005

by

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and

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December 2006

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 third year of a planned 3-year study of Chinook salmon *Oncorhynchus tshawytscha* on the Blossom River was completed in 2005 by the Alaska Department of Fish and Game, 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 1,247 fish (SE = 144), consisting of 926 large (SE = 99) and 321 (SE = 105) medium-sized (500–659 mm MEF) fish. The sex composition of these fish included 375 female spawners. Age-.3 fish composed an estimated 64% of the escapement estimate of large fish, followed by age-.2 fish (19%), and age-.4 fish (15%). Age-0. fish returning from subyearling smolt accounted for an estimated 4.3% of the escapement. The calendar year expansion factor for the peak aerial survey count in 2005 was 2.1 (SE = 0.22) compared to 2.2 (SE = 0.21) in 2004 and 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 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 have been reasonably consistent among the four Behm Canal index rivers (Figure 2). Relatively low survey counts were observed during 1975–1981 and 1990–1999, and higher counts were made between 1982 and 1989. The survey counts in the Blossom River were quite stable from 1988 to 2004 (mean = 230, SD = 77). All four of the Behm Canal systems are among the 50 escapement indicator stocks whose data are used to evaluate escapement and management performance in modeling population dynamics by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC).

Beginning in 1998, the ADF&G Division of Sport Fish has obtained funding as part of the State of Alaska's commitment to a coastwide rebuilding and improved stock assessment program for Chinook salmon. Funding for this program was recommended by the U.S. members of the CTC and approved by the U.S. Commissioners of the PSC using monies appropriated by 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.*" Projects were conducted on the Blossom and Keta rivers to estimate abundance and age, sex and length composition of spawners. As determined by two-event mark-recapture methodology, the estimated escapements of large Chinook salmon in 1998 were 364 (SE = 77) in the Blossom River and 446 (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 2005.

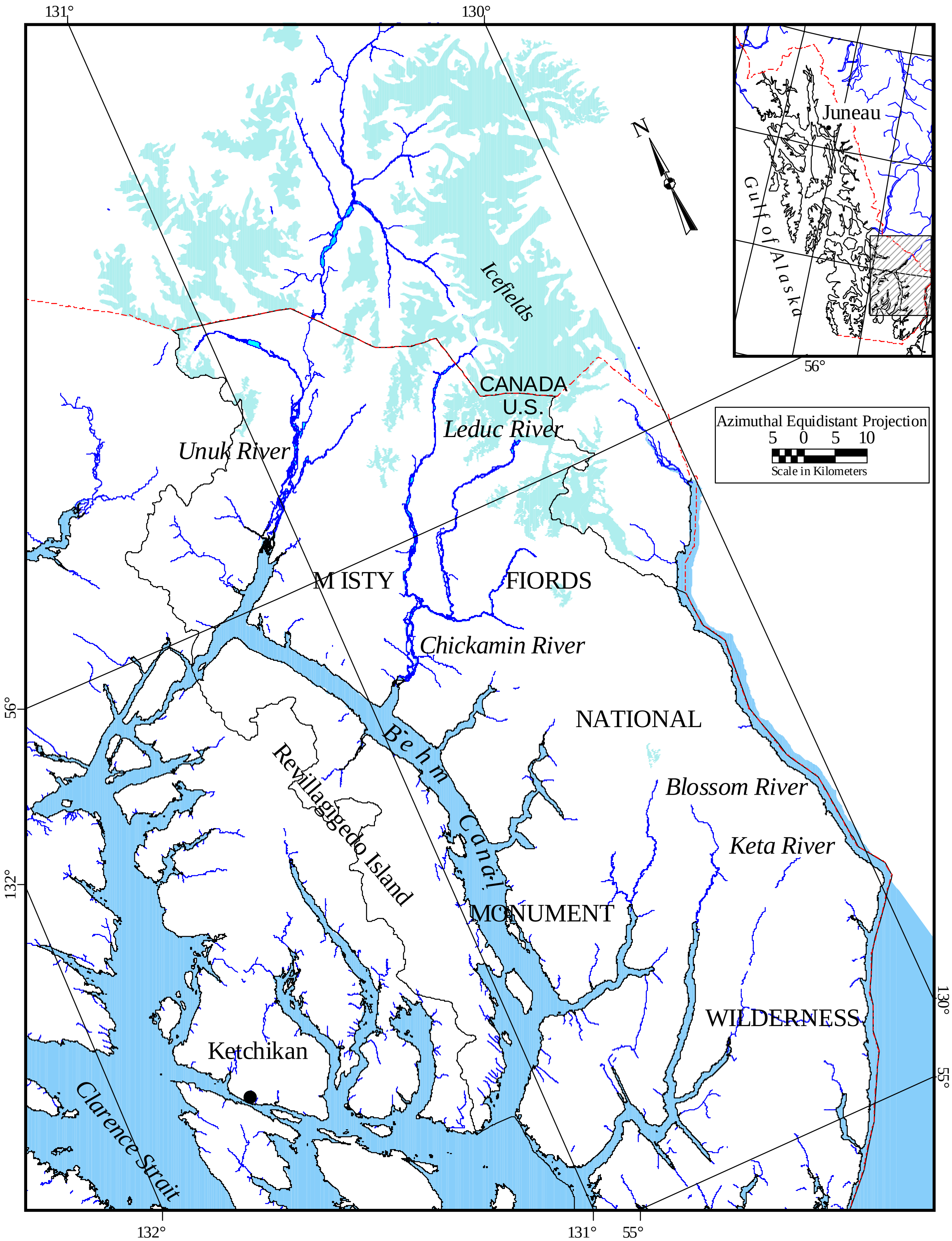


Figure 1.–Behm Canal and Misty Fjords National Monument in Southeast Alaska and location of major Chinook salmon-producing river systems.

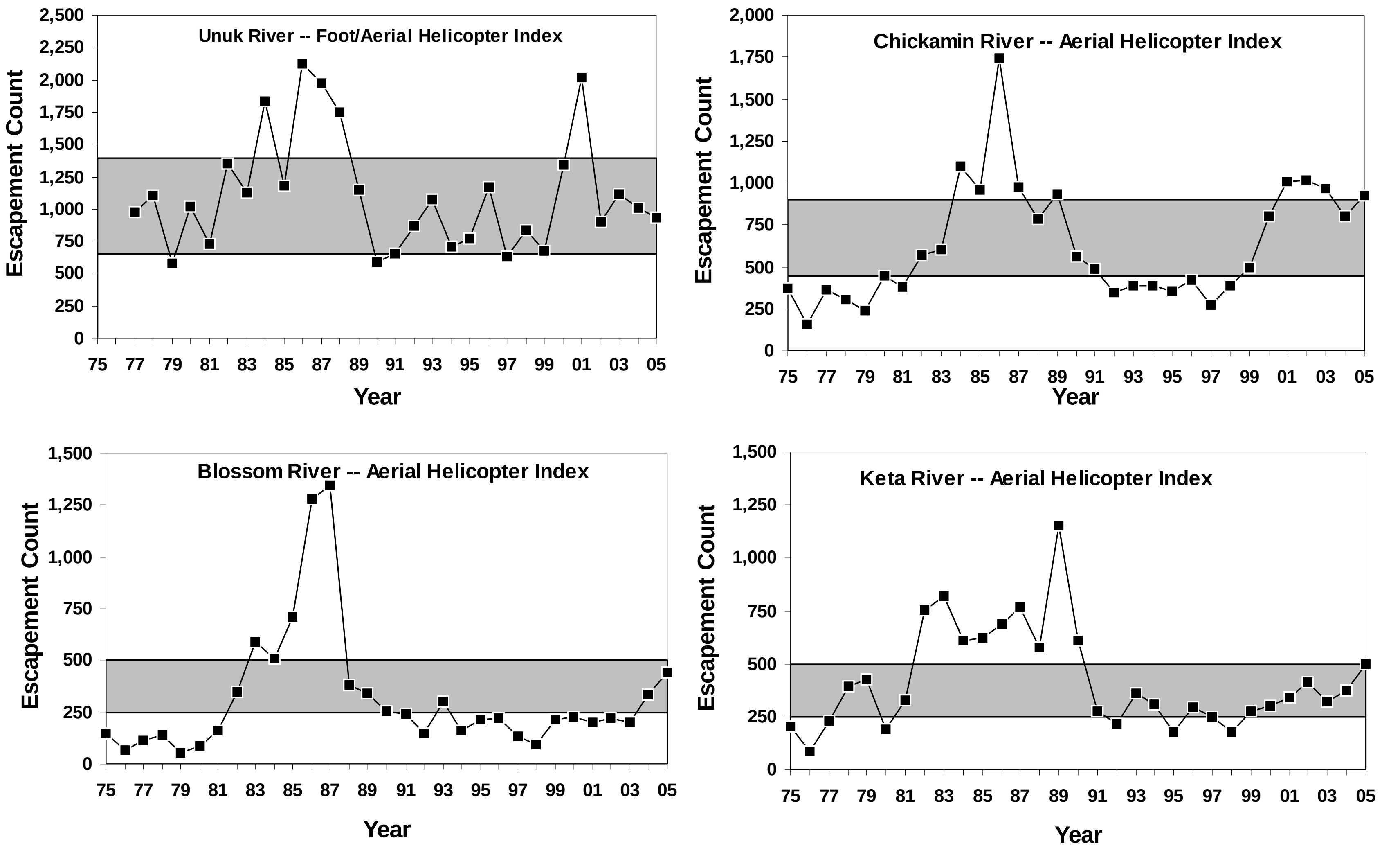


Figure 2.–Peak survey escapement counts of large Chinook in four Behm Canal rivers, 1975–2005, versus escapement goal ranges. Shaded area is escapement goal range.

An estimate of escapement in 2005, along with the annual peak survey count, allows calculation of an expansion factor for a third 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 (Jones III et al. 1998; Pahlke et al. 1996), 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 information is needed to estimate spawner-recruit relationships, maturation rates and future run size. 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 Keta River is just south of the Blossom and escapement survey methods and timing are similar. 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, October 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. The pool:riffle:glide ratio is about 45:25:30 (Hafele 1983).

There are two large logjam complexes upstream from salt water at about km 2 and km 10. The research camp is located at km 6, so all building materials, boat and motor, crew and camp supplies are flown in by helicopter. Areas above the logjam at river km 10 can be accessed on foot up to about km 15 during low river levels, but a helicopter is needed to get to the upper spawning areas when water levels are above normal.

Available spawning habitat differs between the two rivers. On the Blossom River, 25% of available spawning habitat is below Raspberry Creek (km 5.5), 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% 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 2005. Rod and reel angling with bait and lures was the method of capture during the first (capture) event. Rod and reel

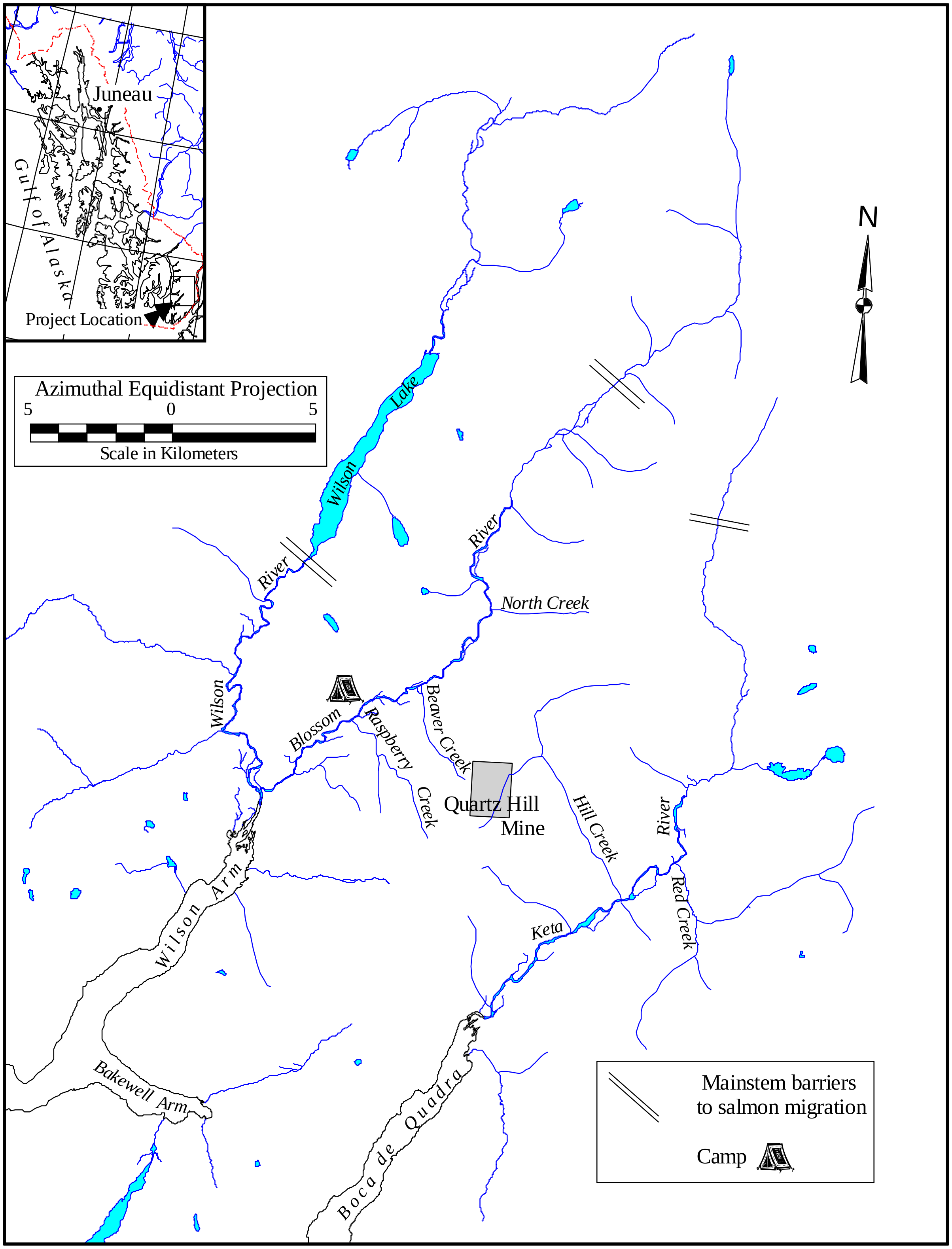


Figure 3.–Blossom and Keta river drainage area in Southeast Alaska, showing location of major tributaries, barriers to fish migration.

snagging, dip-netting and carcass recovery were employed during the second (recapture) event. Studies in 1998 showed this to be an effective means for estimating spawning population parameters in the Blossom River (Brownlee et al. 1999).

MARKING AND SAMPLING

Rod and reel angling using bait and lures was used exclusively to capture fish during event 1. All fish captured in event 1 were sampled for scales, length to the nearest 5 mm MEF, sex, presence of external parasitic copepods (an indicator of the length of freshwater residence), 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 that each held scales from up to 10 fish. Scale impressions were made on cellulose acetate (Clutter and Whitesel 1956), the images were magnified 70X, and each fish was aged according to the procedures in Olsen (1992). During the marking phase, a uniquely numbered solid-core spaghetti tag was applied to each fish $\geq$ 500 mm MEF in good condition. 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 monofilament was sewn through the musculature of the fish approximately 1.5 cm posterior and ventral to the dorsal fin and secured by crimping both ends in a metal crimp. The trailing end of the line was cut 0.5 cm above the crimp. Two secondary (batch) marks consisting of a 0.6-cm punch in the left upper operculum (LUOP) and a left axillary appendage clip (LAA) were also applied.

SAMPLING ON THE SPAWNING GROUNDS

Fish were captured and sampled during event 2 from river km 3 upstream to approximately river km 17. All sampled fish were given a left lower operculum punch (LLOP) to prevent double sampling. 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 event 2, time of marking is independent of when/where recovery occurs. If all three hypotheses are rejected, the "partially" stratified abundance estimator described by Darroch (1961) must be used (Arnason et al. 1996). 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 (Conover 1980) were used to test the hypothesis that fish of different lengths were captured with equal probability (P = 0.1; Appendix A1). Sex selection was tested using two chi-square tests. In the first

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

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 sex 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 because 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 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

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

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

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

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

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

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

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 21 to 31 Aug. 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 2006).

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

The estimated abundance of fish in sex/age category *j* in the entire population medium and large spawners is then:

$$\hat{N}_j = \sum_{i=1}^{s} \hat{p}_{ij} \hat{N}_i \qquad (10)$$

where $\hat{N}_i$ is the estimated abundance in size stratum *i*; and *s* is the number of size strata.

The variance for $\hat{N}_j$ in this case will be estimated using the formulation for the exact variance of the product of two independent random variables (Goodman 1960):

$$\hat{V}\left[\hat{N}_j\right] = \sum_{i=1}^{s}\left(\hat{V}\left[\hat{p}_{ij}\right]\hat{N}_i^2 + V\left[\hat{N}_i\right]\hat{p}_{ij}^2 - \hat{V}\left[\hat{p}_{ij}\right]V\left[\hat{N}_i\right]\right) \qquad (11)$$

The estimated proportion of the population in sex/age group *j* $(\hat{p}_j)$ is then:

$$\hat{p}_j = \hat{N}_j \big/ \hat{N} \qquad (12)$$

where $\hat{N} = \sum_{i=1}^{s} \hat{N}_i$.

Variance of the estimated proportion can be approximated with the delta method (Seber 1982):

$$\hat{V}\left[\hat{p}_j\right] \approx \sum_{i=1}^{s}\left\{\left(\frac{\hat{N}_i}{\hat{N}}\right)^2 \hat{V}\left[\hat{p}_{ij}\right]\right\} + \frac{\sum_{i=1}^{s}\left\{V\left[\hat{N}_i\right]\left(\hat{p}_{ij} - \hat{p}_j\right)^2\right\}}{\hat{N}^2} \qquad (13)$$

RESULTS

TAGGING, RECOVERY AND ABUNDANCE

Between 8 and 30 July of 2005, 215 Chinook salmon were captured, sampled and released with spaghetti tags and secondary marks in the Blossom River. Also, 7 small (<500 mm MEF), 31 medium (500–659mm MEF), and 8 large fish were captured but not tagged because they were not in "good" condition or they were <500 mm. Of the 215 marked fish, 45 were medium sized (500-659 mm MEF) and 170 were large sized (Table 1). Fish less than 500 mm (MEF) were not used in abundance or age calculations because only 3 fish <500 mm were captured in event 2.

Table 1.–Numbers of Chinook salmon marked in the Blossom River and inspected for marks on the spawning grounds in 2005, by length group.

	500–659 mm	≥660 mm	Total
Event 1:			
Released with marks (*M*)	45	17	2
Event 2:			
Captured (*C*)	41	27	3
Recaptured (*R*)	5	4	
R/C	12.2%	1 .2%	.4%

From 15 August through 29 August of 2005, 3 small, 41 medium (500–659mm) and 270 large fish were captured and inspected for marks (Appendix A2). Of these, 5 medium and 49 large fish were observed with marks (Table 1). One (2%) of the recaptured fish (a partial carcass) had lost its primary tag.

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 = 0.39; 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 = 0.56; Figure 4). Therefore, length stratification 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 = 1.017, P = 0.31, df = 1), and fish marked in event 1 and examined in event 2 (χ^2 = 1.352, P = 0.24, df = 1). The sex assigned to all 53 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 = 0.114, df = 1, P = 0.74; 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 = 0.758, df = 1, P = 0.38; 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 170 (M_{large}) large fish tagged in the first event, 49 (R_{large}) were recaptured out of 270 (C_{large}) total captured in the second event (Table 1). The abundance of large fish was estimated as $\hat{N}_{large}$ = 926 fish (SE = 99; bias = 1.5%; 95% CI: 791 to 1,148).

Capture history information for medium fish sampled and used in abundance estimates is shown in Table 1. Length frequencies of medium fish did not differ significantly between fish marked in event 1 and those recaptured on the spawning grounds in event 2 (K-S test, D = 0.52, P = 0.13; Figure 5). Similarly, length frequency distributions did not differ significantly for medium fish recaptured in event 2 and all fish inspected for marks in event 2 (K-S test, D = 0.31, P = 0.70). However, length frequencies did differ significantly between fish marked in event 1 and fish captured in event 2 (K-S test, D = 0.372, P = 0.003; Figure 5). While stratification by size is not necessary for estimating abundance, after considering the small number of recaptures and low power of the first two tests, these results suggest that size bias sampling might have occurred during the second sampling event (Case II, Appendix A1).

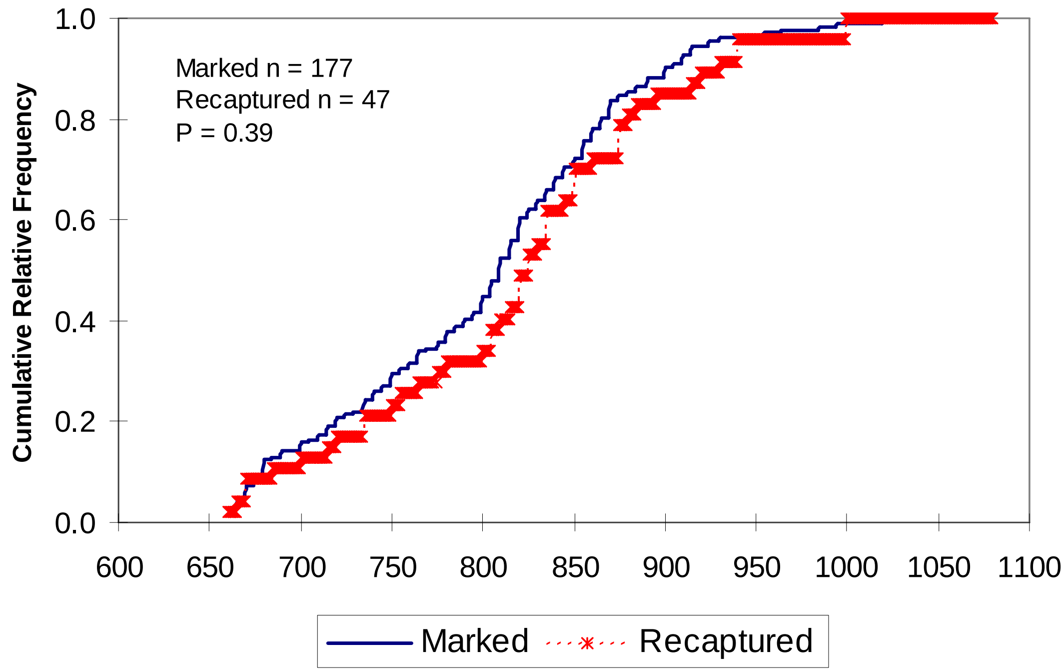
The small numbers of fish <500 mm MEF sampled during both events suggests that our sampling techniques were biased against collection of small fish. Only medium fish ≥500 mm MEF were tagged to estimate the abundance of fish 500–659 mm MEF. Because there were only five recaptures, the tests for temporal 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 $\hat{N}_{medium}$ = 321 fish (SE = 105 bias = 12.7%; 95% CI: 197 to 870).

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 -1.; females and males were predominately age-1. fish. Saltwater ages ranged from 1 to 5 years (Figure 6). The dominant age class among medium (500-659 mm) fish was age-1.2 (80.8%, SE = 4.6%). All medium fish were males (Table 2). Age-1.3 fish dominated the escapement estimate of 926 large fish (61.2% SE = 2.7%), with age-1.2 fish (18.8% SE = 2.2%) and age-1.4 fish (15.1% SE =2.0%) accounting for most of the remainder. There were an estimated 550 (SE =64) large males and 376 (SE =47) large female spawners in the Blossom River escapement in 2005. An estimated 4.6% (SE 1.2%) of the large Chinook salmon return to the Blossom River were freshwater-age-0. fish (from sub-yearling 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. The estimated expansion factor in 2005 was 2.1 (SE =0.22), compared to 2.2 in 2004 and 4.0 in the 1998 study (Table 4). The estimated mean expansion factor was 2.8 (SE =0.52).



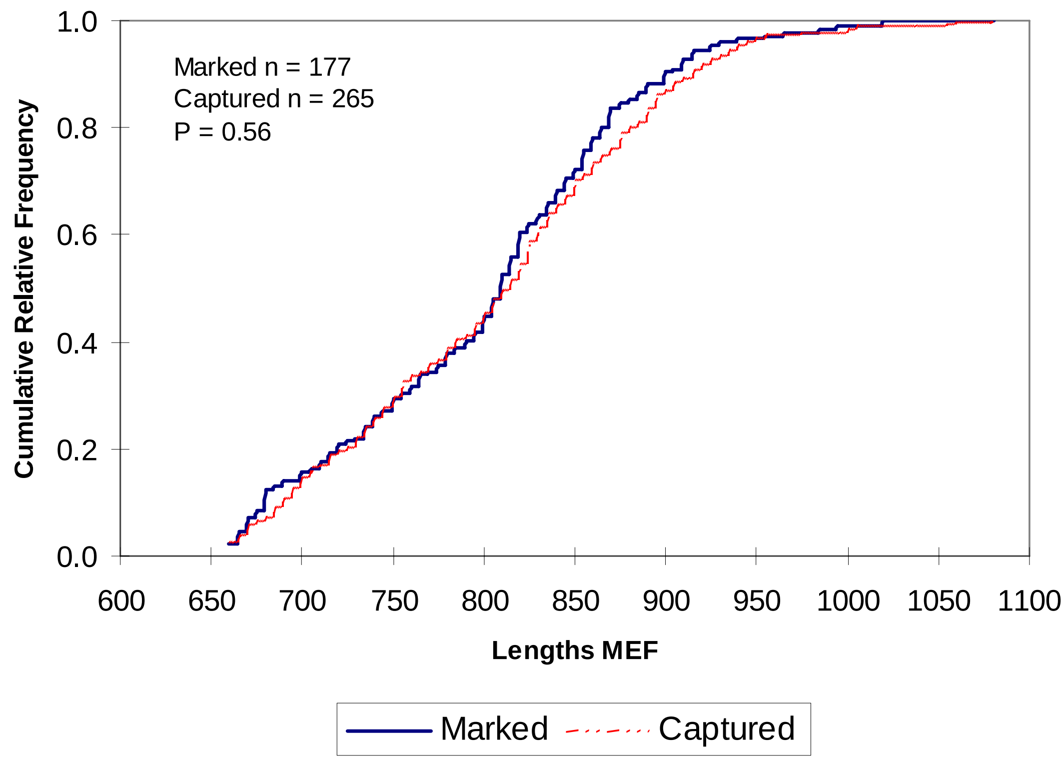


Figure 4.–Cumulative fractions of large Chinook salmon marked vs. recaptured (top) and marked vs. captured (bottom) in the Blossom River in 2005.

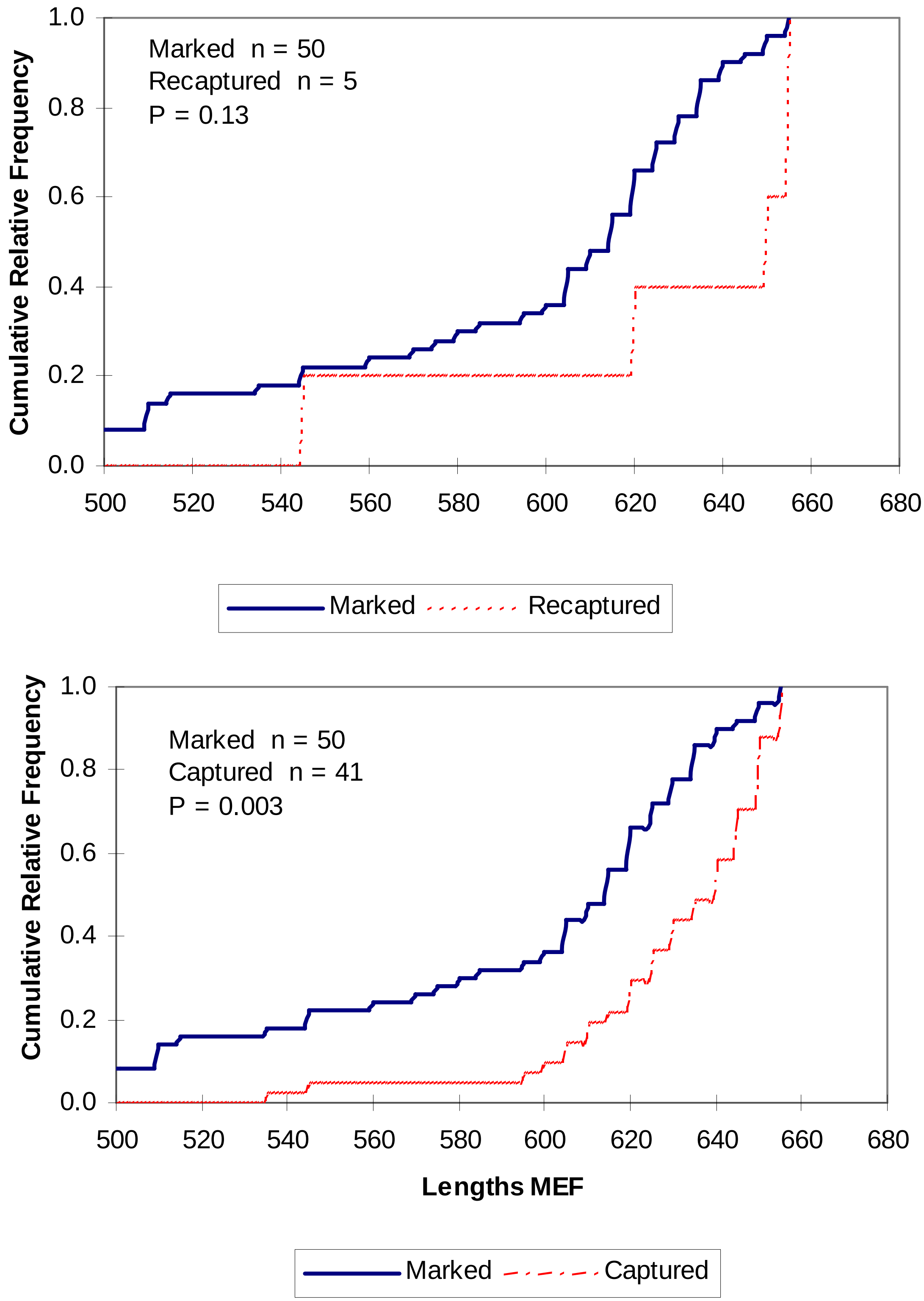


Figure 5.–Cumulative fractions of medium Chinook salmon marked vs. recaptured (top) and marked vs. captured (bottom) in the Blossom River in 2005.

Table 2.–Estimated abundance of the escapement, by age and sex, of medium (500–659 mm MEF) and large (≥660 mm MEF) Chinook salmon in the Blossom River in 2005.

		Brood Year and Age Class									
		2002	2002	2001	2001	2000	2000	1999	1999	1998	
		1.1	0.2	1.2	0.3	1.3	0.4	1.4	0.5	1.5	Total
Panel A. Age composition of medium Chinook salmon											
Males	Sample size	13	1	59	0	0	0	0	0	0	73
	Percent	17.8	1.4	80.8	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	SE of percent	4.5	1.4	4.6	0.0	0.0	0.0	0.0	0.0	0.0	
	Escapement	57	4	259	0	0	0	0	0	0	321
	SE of esc.	23	4	86	0	0	0	0	0	0	105
Total	Sample size	13	1	59	0	0	0	0	0	0	73
	Percent	17.8	1.4	80.8	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	SE of percent	4.4	4.5	1.4	4.6	0.0	0.0	0.0	0.0	0.0	
	Escapement	57	4	259	0	0	0	0	0	0	321
	SE of esc.	23	4	86	0	0	0	0	0	0	105
Panel B. Age composition of large Chinook salmon											
Males	Sample size	0	2	60	6	104	0	20	0	1	193
	Percent	0.0	0.6	18.5	1.8	32.0	0.0	6.2	0.0	0.3	59.4
	SE of percent	0.0	0.4	2.2	0.7	2.6	0.0	1.3	0.0	0.3	2.7
	Escapement	0	6	171	17	296	0	57	0	3	550
	SE of esc.	0	4	27	7	40	0	14	0	3	64
Females	Sample size	0	0	1	4	95	1	29	1	1	132
	Percent	0.0	0.0	0.3	1.2	29.2	0.3	8.9	0.3	0.3	40.6
	SE of percent	0.0	0.0	0.3	0.6	2.5	0.3	1.6	0.3	0.3	2.7
	Escapement	0	0	3	11	271	3	83	3	3	376
	SE of esc.	0	0	3	6	37	3	17	3	3	47
Total	Sample size	0	2	61	10	199	1	49	1	2	325
	Percent	0.0	0.6	18.8	3.1	61.2	0.3	15.1	0.3	0.6	100.0
	SE of percent	0.0	0.4	2.2	1.0	2.7	0.3	2.0	0.3	0.4	
	Escapement	0	6	174	28	567	3	140	3	6	926
	SE of esc.	0	4	27	9	66	3	24	3	4	99
Panel C. Age composition of medium and large Chinook salmon											
Males	Percent	4.6	0.8	34.5	1.4	23.8	0.0	4.6	0.0	0.2	69.8
	SE of percent	0.4	0.3	2.0	0.6	2.0	0.0	1.0	0.0	0.2	2.2
	Escapement	57	10	430	17	296	0	57	0	3	871
	SE of esc.	23	6	90	7	40	0	14	0	3	123
Females	Percent	0.0	0.0	0.2	0.9	21.7	0.2	6.6	0.2	0.2	30.2
	SE of percent	0.0	0.0	0.2	0.5	2.0	0.2	1.2	0.2	0.2	2.2
	Escapement	0	0	3	11	271	3	83	3	3	376
	SE of esc.	0	0	3	6	37	3	17	3	3	47
Total	Percent	4.6	0.8	34.7	2.3	45.5	0.2	11.2	0.2	0.5	100.0
	SE of percent	0.4	0.3	2.1	0.7	2.4	0.2	1.5	0.2	0.3	
	Escapement	57	10	433	28	567	3	140	3	6	1,247
	SE of esc.	23	6	90	9	66	3	24	3	4	144

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, 2005.

Marking dates	Number marked	Fraction recovered	Recovery area km 6–9	Recovery area km 10+	Recovery area Total
7/8 to 7/23	76	0.32	5	19	24
7/24 to 7/30	94	0.28	5	19	24
Total (average)	170	(0.30)	10	39[a]	49[a]
		Number inspected	60	210	270
		Fraction marked	0.17	0.19	0.18

[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, 2004, and 2005.

Parameter	Year 1998	Year 2004	Year 2005	Year Ave.
Survey count	91	333	445	212
Mark Recapture estimate	364	734	926	549
M-R standard error	77	76	99	76
95% relative precision	41.5	20.3	21.3	27.7
M-R lower 95% C.I.	292	609	791	
M-R upper 95% C.I.	597	908	1,148	
Survey count/(M-R)	0.25	0.45	0.48	0.39
Expansion factor	4.0	2.2	2.1	2.8
SE[expansion factor]	0.85	0.21	0.22	0.52

Although 2005 was not as dry as the summer of 2004, conditions for counting and sampling Chinook salmon were exceptionally good. We believe that the counting conditions were extraordinary in the Blossom River in 2004 and 2005 and that the 1998 expansion factor may be more representative of normal water conditions.

DISCUSSION

Success of the mark-recapture experiment on the Blossom River depended on satisfaction of the model assumptions for a closed population. Experience gained on the Blossom and Keta rivers helped us meet project objectives. The location of the camp and high water levels allowed good access and sampling effort throughout July.

Sampling during event 2 was very successful in 2005 despite a high water event that curtailed sampling for four days. Good water levels for navigation and fish movement to the spawning areas, and the use of a helicopter for three sampling trips to the upper river allowed us to sample from the entire spawning population during event 2. Exceptional visibility and timing (large groups of pre-spawn Chinook holding in areas with good visibility) resulted in a peak aerial survey count that represented over 48% of the estimated escapement of large fish in 2005. This compares to 25% in 1998 and over 45% in 2004; the three year average on the Keta River was about 34%. We believe that the escapement in 2005 was similar to, or slightly higher than, escapements since 1989, but that the survey count represented a larger proportion of the escapement because of exceptional counting conditions and a strong return of 3-ocean fish. It appeared that new fish entered the river during the hiatus between event 1 and event 2 in 2005, however consistency tests concluded that condition (a) was satisfied.

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 are proposing to continue this study again in 2006 to see if we have been experiencing typical or abnormal survey conditions. The USCTC also suggests that if expansion factors have moderate to large amounts of variability (a coefficient of

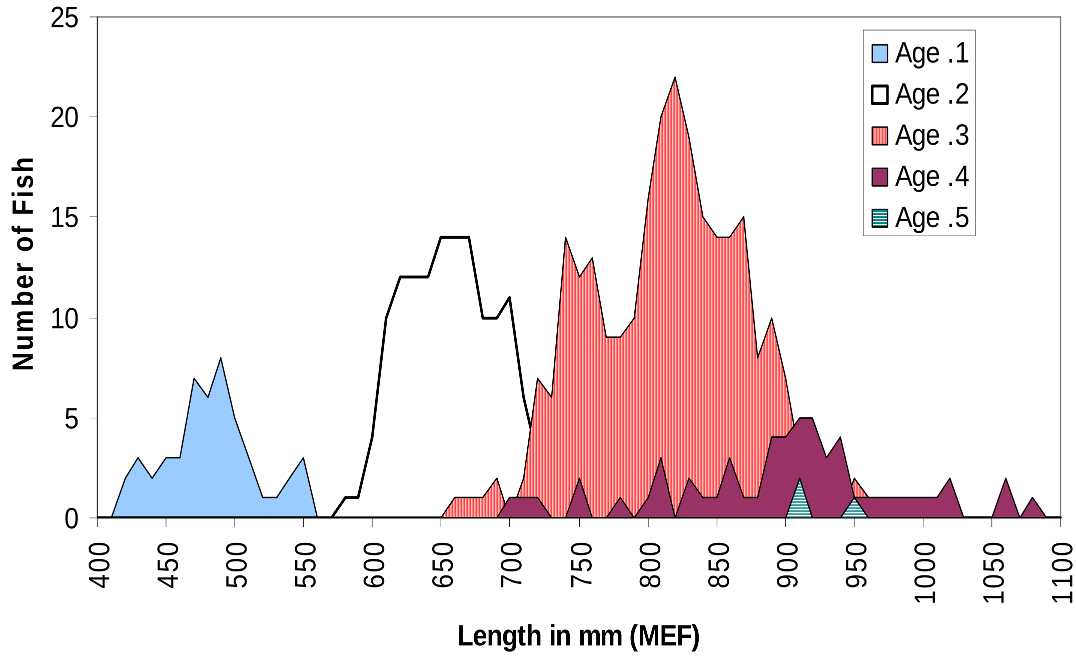


Figure 6.–Numbers of Chinook Salmon by ocean age and length from the Blossom River, 2005.

variation of more than 20%), they should be annually evaluated.

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 and 2005 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. Three Chinook salmon with missing adipose fins were found in the Blossom River in 2005; a 680-mm MEF male, a 770-mm female and a 765-mm female were sacrificed and sampled for coded wire tags. The ADF&G Mark, Tag, and Age Laboratory in Juneau found the 680-mm male to be a wild salmon tagged on the Unuk River in October of 2001. The 770-mm female was a hatchery release from Neets Bay in 2002, and no tag was found in the third fish. In the 1998 study, one fish with a missing adipose fin was encountered. That fish was released from the Kitimat Hatchery in British Columbia.

Mean lengths by age class for Chinook salmon 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 2006). This 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.

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

Table 5.–Average length by sex and age of Chinook salmon sampled in the Blossom River in 2005. Estimates include all Chinook salmon encountered in events 1 and 2.

		Brood year and age class								
		2002	2001	2002	2000	2001	1999	1999	1998	1999
		1.1	1.2	0.2	1.3	0.3	1.4	0.4	1.5	0.5
Males	n	45	119	3	104	6	20	0	1	0
	Avg. length	481	659	655	794	818	902		905	
	SD	34	40	43.3	64	64	124			
	SE	5	4	25	6	26	28			
Females	n	0	1	0	95	4	29	1	1	1
	Avg. length		710		835	816	893	885	955	910
	SD				43	19	44			
	SE				4	9	8			
Sexes combined	n	45	120	3	199	10	49	1	2	1
	Avg. length	481	659	655	814	818	897	885	930	910
	SD	34	40	43.3	59	49	85		35	
	SE	5	4	25	4	15	12		25	

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. Chinook salmon did not normally utilize typical deep holding water on the lower Blossom River below river km 5.5 during the immigration phase of the spawning run. Instead, we found them utilizing shallow open runs for short periods of time before moving up the river. This could be due to the seals' reluctance to hold in shallow areas of the river. 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 moved more rapidly through the lower river to access holding water below spawning areas in the Blossom River.

When pursuing actively spawning fish in event 2, there are usually several males with each female on a redd, so a sex selective bias could occur. Kissner and Hubartt (1986) found that post-spawn females generally hold positions and defend redds while spawned-out males drift downstream. 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. 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. Targeting of an individual fish while sampling pre-spawn fish in event 2 was limited in most cases by the large size of the river.

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 salmon enter the lower river in bright condition and then spend 1–3 months inriver before spawning. A check of all 54 fish recaptured with tags confirmed that all fish were assigned the same sex in the two events. 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 salmon, 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 for short time periods following extended high water events during event 2.

The estimated escapement of fish <500 mm MEF remains unknown. Methodology used during event 2 of this study proved unsuccessful at capturing fish smaller than 500 mm. Incorporation of such methods as hook and line with bait, or extending event 2 by a couple of weeks could be considered, but recovery of small fish on a river the size of the Blossom may not be economically feasible.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1.–Detection of size or sex selective sampling during a 2-sample mark recapture experiment and its effects on estimation of population size and population composition.

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

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

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

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

Case II:

Reject H_o	Fail to reject H_o	Reject H_o

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

Case III:

Fail to reject H_o	Reject H_o	Reject H_o

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

Case IV:

Reject H_o	Reject H_o	Reject H_o

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

Evaluation Required:

Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

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

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

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

-continued-

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

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

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

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

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

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

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

and

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

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

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

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

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

Appendix A2.–Sex, length (MEF in mm), age, capture and recovery data for Chinook salmon caught in the Blossom River in 2005.

Fish Number	Date	Sex	Length (MEF)	Age	Tag Number	Condition	Capture Site (km)	Recovery Site (km)
1	8-Jul	M	770	1.3	3201	bright	7.5	
2	9-Jul	M	700	1.2	3202	bright	7.5	
3	9-Jul	F	890	R.3	3204	bright	8	
4	9-Jul	M	815	1.3	3205	bright	7.5	
5	9-Jul	M	475	1.1	no tag	bright	7.5	
6	9-Jul	F	785	1.3	3206	bright	7.5	
7	9-Jul	M	910	1.4	3207	semi bright	7.5	14
8	10-Jul	M	680	R.3	3208	bright	7.5	
9	10-Jul	F	840	1.3	3209	bright	7.5	
10	10-Jul	M	795	1.3	3210	bright	7.5	
11	10-Jul	F	870	1.3	3211	bright	7.5	15
12	10-Jul	F	885	1.3	3212	bright		
13	11-Jul	F	940	1.4	3213	semi bright	7.5	11
14	11-Jul	M	605	1.2	no tag	bright	7.5	
15	11-Jul	M	780	1.3	3214	bright	7.5	
16	11-Jul	F	855	1.3	no tag	bright	7.5	
17	11-Jul	M	470	1.1	no tag	bright	4	
18	11-Jul	F	915	1.4	3215	semi bright	5.5	
19	11-Jul	M	665	1.2	3216	bright	5.5	16
20	11-Jul	F	760	1.3	3217	bright	5.5	
21	12-Jul	F	900	1.3	3218	bright	6	
22	12-Jul	F	855	1.3	3219	bright	7.5	16
23	12-Jul	F	865	1.3	3220	bright	7.5	
24	12-Jul	M	625	1.2	3221	semi bright	3	
25	12-Jul	M	665	1.2	3222	brown	7.5	
26	13-Jul	M	430	1.1	no tag	bright	7.5	
27	14-Jul	F	830	1.3	3223	brown	8	
28	14-Jul	M	870	1.3	3224	red	6	
29	14-Jul	M	595	1.2	3225	bright	6	
30	14-Jul	M	805	1.3	3226	bright	6	
31	15-Jul	M	635	1.2	no tag	colored	5.5	
32	15-Jul	M	660	1.2	3227	bright	5.5	
33	16-Jul	F	745	1.3	3228	semi bright	6	7
34	16-Jul	M	630	1.2	3229	bright	6	
35	16-Jul	M	805	1.3	3230	bright	7.5	
36	16-Jul	M	740	R.3	3231	semi bright	7.5	
37	16-Jul	F	820	R.3	3232	semi bright	7.5	
38	16-Jul	M	485	1.1	no tag	bright	6.5	
39	16-Jul	M	445	1.1	no tag	bright	6.5	
40	16-Jul	F	840	1.3	3233	bright	6	12
41	16-Jul	M	480	1.1	no tag	bright	6	
42	16-Jul	F	865	1.3	3234	bright	6	
43	16-Jul	M	585	1.2	no tag	bright	8	
44	16-Jul	F	790	R.3	3235	bright	6	
45	16-Jul	F	915	1.4	3236	bright	6	16
46	16-Jul	F	850	R.3	3237	gold	8	
47	16-Jul	F	735	R.3	3238	gold	7	12
48	16-Jul	M	800	1.3	3239	bright	7	

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Fish Number	Date	Sex	Length (MEF)	Age	Tag Number	Condition	Capture Site (km)	Recovery Site (km)
49	16-Jul	F	875	1.3	3240	bright	7	16
50	17-Jul	F	820	1.3	no tag	bright	3.5	
51	17-Jul	M	690	1.2	3241	bright	4	
52	17-Jul	M	610	1.2	3242	bright	4	
53	17-Jul	M	785	1.3	3243	blush	6	14
54	17-Jul	M	675	1.2	3244	blush	7	
55	17-Jul	F	745	1.4	3245	blush	7	
56	17-Jul	M	710	1.2	3246	bright	7.5	16
57	17-Jul	M	800	1.2	3247	blush	7.5	
58	17-Jul	F	815	1.3	3248	bright	7.5	
59	17-Jul	F	755	1.3	3249	bright	6.5	
60	17-Jul	M	850	1.3	3250	blush	6	16
61	18-Jul	M	720	1.3	3251	blush	7.5	
62	18-Jul	M	635	1.2	3252	blush	7.5	
63	18-Jul	M	455	R.1	no tag	bright	7.5	
64	18-Jul	M	795	1.3	3253	bright	7.5	
65	18-Jul	M	655	1.2	3254	blush	6.5	
66	18-Jul	M	510	1.1	3255	bright	8	
67	18-Jul	M	655	1.2	3256	bright	8	11
68	18-Jul	F	890	1.4	3257	brown	8	7.5
69	18-Jul	M	700	R.2	3258	blush	5.5	
70	18-Jul	M	670	1.2	3259	bright	5.5	
71	19-Jul	M	495	1.1	no tag	bright	7.5	
72	19-Jul	M	430	1.1	no tag	bright	7.5	
73	19-Jul	M	500	1.1	3260	bright	7.5	
74	19-Jul	F	815	R.3	3261	blush	8	
75	19-Jul	M	1,020	1.4	3262	blush	8	
76	20-Jul	M	425	1.1	no tag	bright	7.5	
77	20-Jul	M	420	1.1	no tag	bright	7.5	
78	20-Jul	M	740	1.3	3263	blush	8	
79	20-Jul	M	765	1.2	3264	bright	5.5	
80	20-Jul	M	490	1.1	no tag	bright	7.5	
81	20-Jul	F	765	1.3	3265	bright	6	
82	20-Jul	M	600	R.2	3266	bright	6	
83	20-Jul	M	680	0.2	3267	bright	6	
84	21-Jul	M	460	1.1	no tag	bright	6	
85	21-Jul	M	485	1.1	no tag	bright	8	
86	21-Jul	M	765	1.3	3268	blush	8	14
87	21-Jul	F	805	R.3	3269	blush	8	
88	21-Jul	M	670	R.2	3270	blush	6.5	6
89	21-Jul	M	605	1.2	3271	blush	6.5	
90	21-Jul	M	500	1.1	3272	blush	6.5	
91	21-Jul	M	985	R.4	3273	blush	5.5	9
92	21-Jul	M	995	1.4	3274	blush	5.5	
93	21-Jul	F	860	1.3	3275	blush	5.5	11
94	21-Jul	M	680	1.2	3276	bright	4.5	11
95	21-Jul	M	625	1.2	3277	bright	3.5	

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Fish Number	Date	Sex	Length (MEF)	Age	Tag Number	Condition	Capture Site (km)	Recovery Site (km)
96	21-Jul	F	955	1.5	3278	blush	8	
97	21-Jul	F	855	1.4	3279	blush	8	
98	22-Jul	M	545	1.1	no tag	bright	10	
99	22-Jul	F	860	1.3	3280	blush	5.5	7
100	22-Jul	F	845	1.3	3281	blush	5.5	
101	22-Jul	M	445	1.1	no tag	bright	5.5	
102	23-Jul	M	500	1.1	3282	blush	7.5	
103	23-Jul	M	890	1.3	3283	red	7.5	14
104	23-Jul	M	470	N.S	no tag	bright	7.5	
105	23-Jul	M	640	1.2	3284	bright	8	16
106	23-Jul	M	575	1.2	3285	bright	8	
107	23-Jul	M	735	0.3	no tag	blush	8	
108	23-Jul	M	510	1.1	3286	bright	7	
109	23-Jul	M	635	1.2	3287	bright	7	
110	23-Jul	M	690	1.3	3290	blush	7	
111	23-Jul	M	645	1.2	3288	blush	6.5	
112	23-Jul	F	805	R.3	3289	bright	6.5	
113	23-Jul	M	620	R.2	3291	blush	6.5	
114	23-Jul	M	830	R.3	3292	red	5.5	
115	23-Jul	F	815	1.3	3293	blush	3.5	11
116	23-Jul	M	580	1.2	3294	bright	3.5	
117	23-Jul	F	810	0.3	3295	blush	3.5	14
118	23-Jul	M	740	1.3	3296	blush	3.5	
119	23-Jul	M	870	1.3	3297	blush	3.5	
120	23-Jul	F	855	1.4	3298	blush	3.5	
121	23-Jul	M	490	1.1	no tag	bright	3.5	
122	24-Jul	M	715	1.2	3299	blush	6.5	11
123	24-Jul	F	805	1.3	3300	bright	6.5	
124	24-Jul	F	760	1.3	no tag	bright	6.5	
125	24-Jul	M	485	R.1	no tag	bright	6.5	
126	24-Jul	M	965	1.4	3301	blush	6.5	
127	24-Jul	F	910	0.5	3302	blush	6.5	
128	24-Jul	F	820	1.3	3303	blush	6.5	16
129	24-Jul	F	835	1.4	3304	blush	6.5	11
130	24-Jul	F	900	1.4	3305	red	6.5	7
131	24-Jul	F	805	1.3	3306	blush	6.5	
132	24-Jul	F	815	1.3	3307	blush	6.5	11
133	24-Jul	F	830	R.3	3308	bright	7	
134	24-Jul	F	835	1.3	3309	bright	7	7
135	24-Jul	M	680	1.2	3310	blush	7.5	
136	24-Jul	M	665	1.2	no tag	blush	8	
137	24-Jul	F	900	1.3	3311	bright	8	
138	24-Jul	M	800	1.4	3312	dark	6	
139	24-Jul	M	870	1.3	3313	blush	6	
140	25-Jul	F	865	1.3	3314	bright	3	
141	25-Jul	M	800	1.3	3315	blush	3	11
142	25-Jul	F	820	R.3	3316	bright	3	
143	25-Jul	M	680	1.2	no tag	bright	3	
144	25-Jul	M	705	1.2	3317	bright	3	
145	25-Jul	F	780	1.3	3318	brown	3	11

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Fish Number	Date	Sex	Length (MEF)	Age	Tag Number	Condition	Capture Site (km)	Recovery Site (km)
146	25-Jul	M	570	1.2	3319	blush	3.5	12
147	25-Jul	M	880	0.3	3320	dark	3.5	
148	25-Jul	M	825	R.3	3321	bright	4	
149	25-Jul	M	625	R.2	3322	bright	4	
150	25-Jul	M	720	1.3	no tag	dark	4	
151	25-Jul	M	675	1.2	3323	bright	4	
152	25-Jul	M	735	1.3	3324	bright	4	
153	25-Jul	M	435	R.1	no tag	bright	4	
154	25-Jul	M	660	R.2	3325	bright	4	
155	25-Jul	M	650	1.2	3326	bright	4	
156	25-Jul	M	635	1.2	3327	bright	4	7
157	25-Jul	M	820	1.3	3328	bright	4	
158	25-Jul	M	545	1.1	3329	bright	4	
159	25-Jul	F	710	1.2	3330	bright	4	
160	25-Jul	M	420	1.1	no tag	bright	4.5	
161	25-Jul	M	470	1.1	no tag	bright	4.5	
162	25-Jul	M	610	1.2	3331	bright	5.5	
163	25-Jul	M	820	1.3	3332	brown	5.5	
164	25-Jul	M	670	1.2	3333	blush	5.5	11
165	25-Jul	M	685	1.2	3334	bright	8	
166	25-Jul	M	775	1.3	3335	blush	8	
167	25-Jul	M	475	1.1	no tag	bright	8	
168	25-Jul	M	515	1.1	3336	bright	8	
169	25-Jul	M	930	1.3	3337	dark	8	
170	26-Jul	M	910	1.4	3338	dark	3	
171	26-Jul	M	850	1.3	3339	bright	3	
172	26-Jul	F	780	1.3	3340	bright	3	
173	26-Jul	M	750	1.3	3341	bright	3.5	
174	26-Jul	M	660	1.2	3342	blush	4	10
175	26-Jul	M	620	1.2	3343	bright	4	
176	26-Jul	M	465	1.1	no tag	bright	4	
177	26-Jul	M	680	1.2	no tag	blush	4	
178	26-Jul	M	605	R.2	3344	blush	7	
179	26-Jul	M	810	1.4	3345	dark	7	
180	26-Jul	F	860	R.4	3346	bright	7	
181	26-Jul	F	755	1.3	3347	bright	7	
182	26-Jul	M	510	R.1	3348	bright	7.5	
183	26-Jul	F	885	1.4	3349	bright	7.5	11
184	26-Jul	M	1,020	1.4	3350	dark	7.5	16
185	26-Jul	M	490	1.1	no tag	bright	8	
186	26-Jul	F	900	1.3	3351	bright	5.5	7
187	26-Jul	M	445	1.1	no tag	bright	5.5	
188	26-Jul	M	560	1.1	3352	bright	5.5	
189	27-Jul	M	435	1.1	no tag	blush	8	
190	27-Jul	M	820	R.R	3353	blush	8	
191	27-Jul	F	875	1.3	3354	bright	8	
192	27-Jul	M	835	1.3	3355	blush	8	
193	27-Jul	M	845	R.3	3356	red	8	11
194	27-Jul	F	855	1.3	3357	dark	8	11
195	27-Jul	M	925	1.3	3358	red	8	16

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Fish Number	Date	Sex	Length (MEF)	Age	Tag Number	Condition	Capture Site (km)	Recovery Site (km)
196	27-Jul	M	large	N.S	3359	bright	8	
197	27-Jul	M	750	1.3	3360	brown	8	
198	27-Jul	M	485	1.1	no tag	bright	7.5	
199	27-Jul	F	860	1.3	3361	brown	7.5	
200	28-Jul	M	735	1.3	3362	blush	6	
201	28-Jul	F	825	1.3	3363	bright	7.5	
202	28-Jul	F	865	1.4	3364	blush	7.5	11
203	28-Jul	M	630	R.2	3365	dark	7.5	
204	28-Jul	F	815	1.3	3366	blush	6.5	
205	28-Jul	F	845	1.3	3367	dark	6.5	
206	28-Jul	M	605	R.2	no tag	bright	3.5	
207	28-Jul	M	620	1.2	3368	bright	4	
208	28-Jul	M	680	0.2	3369	bright	4	
209	28-Jul	M	795	1.3	3370	bright	4	
210	28-Jul	M	855	R.3	3371	blush	4	
211	28-Jul	F	840	1.3	3372	blush	4	
212	28-Jul	M	470	1.1	no tag	bright	4	
213	28-Jul	M	615	1.2	3373	blush	4	
214	28-Jul	F	810	R.3	3374	blush	4	
215	28-Jul	M	620	1.2	3375	blush	4	
216	28-Jul	M	650	1.2	3376	bright	4	
217	28-Jul	M	670	1.2	3377	bright	4	11
218	28-Jul	M	475	1.1	no tag	bright	4	
219	28-Jul	F	870	1.3	3378	bright	4	
220	28-Jul	M	615	1.2	3379	bright	4	
221	28-Jul	M	750	R.2	3380	bright	5.5	11
222	28-Jul	M	630	1.2	3381	blush	5.5	
223	28-Jul	F	810	R.3	3382	blush	5.5	
224	28-Jul	F	825	1.3	3383	blush	6.5	
225	28-Jul	F	925	1.4	3384	blush	6.5	
226	29-Jul	M	670	1.2	3385	bright	3.5	11
227	29-Jul	M	730	1.2	3386	bright	3.5	
228	29-Jul	M	465	1.1	no tag	bright	3.5	
229	29-Jul	M	490	1.1	no tag	bright	3.5	
230	29-Jul	M	750	1.3	3387	blush	4	
231	29-Jul	M	725	1.3	3388	blush	4	
232	29-Jul	M	700	1.2	3389	bright	4	
233	29-Jul	M	500	1.1	3390	brown	4	
234	29-Jul	M	620	1.2	3391	blush	5.5	
235	29-Jul	F	810	1.3	3392	bright	8	
236	29-Jul	M	640	1.2	3393	blush	8	
237	29-Jul	F	835	1.3	3394	blush	8	9
238	29-Jul	M	715	1.3	3395	blush	8	7
239	29-Jul	M	615	1.2	3396	dark	8	
240	29-Jul	M	905	1.3	3397	dark	8	
241	29-Jul	M	790	1.3	3398	bright	7.5	
242	29-Jul	M	480	1.1	no tag	blush	7.5	
243	29-Jul	M	820	1.3	3399	blush	7.5	
244	30-Jul	M	840	1.3	3400	blush	3	16

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Fish Number	Date	Sex	Length (MEF)	Age	Tag Number	Condition	Capture Site (km)	Recovery Site (km)
245	30-Jul	F	775	R.3	3401	bright	3	
246	30-Jul	M	810	1.3	3402	red	5.5	11
247	30-Jul	F	810	1.3	3403	bright	5.5	
248	30-Jul	F	870	1.3	3404	blush	5.5	
249	30-Jul	F	800	R.3	3405	dark	5.5	
250	30-Jul	M	720	1.2	3406	bright	5.5	11
251	30-Jul	M	660	R.2	3407	bright	6.5	
252	30-Jul	M	765	1.3	3408	dark	6.5	
253	30-Jul	M	480	1.1	no tag	blush	6.5	
254	30-Jul	M	780	1.4	3409	blush	6.5	
255	30-Jul	M	715	1.2	3410	blush	6.5	
256	30-Jul	M	535	1.1	3411	blush	6.5	
257	30-Jul	M	665	1.2	3412	bright	8	
258	30-Jul	F	915	1.3	3413	dark	8	
259	30-Jul	M	810	1.3	3414	dark	8	
260	30-Jul	M	615	1.2	3415	blush	8	
261	30-Jul	F	845	1.3	3416	blush	8	7

Appendix A3.–Age composition by length class and sex for Chinook salmon sampled in the Blossom River in 2005.

EVENT 1 SAMPLE		Brood Year and Age Class									
		2002	2002	2001	2001	2000	2000	1999	1999	1998	
		1.1	0.2	1.2	0.3	1.3	0.4	1.4	0.5	1.5	Total
Small Chinook salmon (<440 mm MEF)											
Males	Number sampled	29									29
	Percent	100.0									100
	SE of percent										
Medium Chinook salmon (440-659 mm MEF)											
Males	Number sampled	11		32							43
	Percent	25.6		74.4							100
	SE of percent	6.7		6.7							
Large Chinook salmon (≥660 mm MEF)											
Males	Number sampled		2	28	2	43	0	9			84
	Percent		1.3	18.8	1.3	28.9		6.0			56.4
	SE of percent		0.9	3.2	0.9	3.7		2.0			4.1
Females	Number sampled			1	1	49		12	1	1	65
	Percent			0.7	0.7	32.9		8.1	0.7	0.7	43.6
	SE of percent			0.7	0.7	3.9		2.2	0.7	0.7	4.1
Total	Number sampled		2	29	3	92		21	1	1	149
	Percent		1.3	19.5	2.0	61.7		14.1	0.7	0.7	100
	SE of percent		0.9	3.3	1.2	4.0		2.9	0.7	0.7	
EVENT 2 SAMPLE		Brood Year and Age Class									
		2002	2002	2001	2001	2000	2000	1999	1999	1998	
		1.1	0.2	1.2	0.3	1.3	0.4	1.4	0.5	1.5	Total
Small Chinook salmon (<440 mm MEF)											
Males	Number sampled	3									3
	Percent	100									100
	SE of percent										
Medium Chinook salmon (440-659 mm MEF)											
Males	Number sampled	2	1	27							30
	Percent	6.7	3.3	90.0							100
	SE of percent	4.6	3.3	5.6							
Large Chinook salmon (≥660 mm MEF)											
Males	Number sampled			32	4	61		11		1	109
	Percent			18.2	2.3	34.7		6.3		0.6	61.9
	SE of percent			2.9	1.1	3.6		1.8		0.6	3.7
Females	Number sampled				3	46	1	17			67
	Percent				1.7	26.1	0.6	9.7			38.1
	SE of percent				1.0	3.3	0.6	2.2			3.7
Total	Number sampled			32	7	107	1	28		1	176
	Percent			18.2	4.0	60.8	0.6	15.9		0.6	100
	SE of percent			2.9	1.5	3.7	0.6	2.8		0.6	

Appendix A4.–Estimated average length by sex and age of Chinook salmon sampled in escapements in 11 rivers in Southeast Alaska in 2004.

SUMMARY. AVERAGE LENGTH OF MALE CHINOOK SALMON SAMPLED IN SOUTHEAST ALASKA IN 2004

	BROOD YEAR AND AGE CLASS													
	2003	2002	2001	2002	2001	2000	2001	2000	1999	2000	1999	1998	1999	1998
	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
1. Keta		442			664			841			958			
2. Blossom				731	661		802	795		969	964			
3. Chickamin		430			658			787			925			
4. Unuk		394			640			770			885			
5. Stikine		578			617			782			889			
6. Andrew Cr					615			741			858			
7. King Salmon								825						
8. Taku		380			609	598		741			837			
9. Chilkat		381			589			772			910			
10. Alsek					573			795	777		944			
11. Situk				576			767	828		875				

SUMMARY. AVERAGE LENGTH OF FEMALE CHINOOK SALMON SAMPLED IN SOUTHEAST ALASKA IN 2004

	BROOD YEAR AND AGE CLASS													
	2003	2002	2001	2002	2001	2000	2001	2000	1999	2000	1999	1998	1999	1998
	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
1. Keta								833			946			
2. Blossom								835			921			
3. Chickamin					722			822			898			
4. Unuk					669			794			873			871
5. Stikine					696			792			839			
6. Andrew Cr								784			840			
7. King Salmon								816						
8. Taku					737			752	741		815			
9. Chilkat								787			859			
10. Alsek					572			771	774		870	850		
11. Situk				582			764			844				

SUMMARY. AVERAGE LENGTH OF CHINOOK SALMON SAMPLED IN SOUTHEAST ALASKA IN 2004 SEXES COMBINED

	BROOD YEAR AND AGE CLASS													
	2003	2002	2001	2002	2001	2000	2001	2000	1999	2000	1999	1998	1999	1998
	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
1. Keta		442			664		865	838			949			
2. Blossom				731	662		811	813		934	937			
3. Chickamin		430			659			799			906			979
4. Unuk		394			640			777			877			871
5. Stikine		578			622			787	817		855			
6. Andrew Cr					615			755			845			
7. King Salmon								821			860			
8. Taku		380			613	598		747	752		822			
9. Chilkat		381			589			780			874			
10. Alsek					573			781	774		904			
11. Situk				578			765	820		856	838		885	
Averages		434		655	626		814	793	781	895	879			925

Note: age classes with fewer than four fish sampled were not reported in summary panels.

Appendix A5.–Computer files used to estimate the spawning abundance and age, sex, length data for Chinook salmon in the Blossom River in 2005.

File name	Description
KSlargeoutput.xls	Spreadsheets containing mark-recapture data, Kolmogorov-Smirnov (K-S) test results, summary tables, and graphs for large Chinook salmon
KSmediumoutput.xls	Spreadsheets containing mark-recapture data, Kolmogorov-Smirnov (K-S) test results, summary tables, and graphs for medium Chinook salmon
Blossom05MRchinook.xls	Spreadsheets containing Chinook salmon length at age data and charts.
Pi_hat05.xls	Spreadsheets containing expansion factor calculations.