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Spawning Abundance of Chinook Salmon in the Chickamin River in 2001

by

Glenn M. Freeman

and

Scott A. McPherson,

July 2003

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

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

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by

Glenn M. Freeman
Division of Sport Fish, Ketchikan

and

Scott A. McPherson
Division of Sport Fish, Douglas

Alaska Department of Fish and Game
Division of Sport Fish
333 Raspberry Road
Anchorage, AK 99518-1599

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Glenn M. Freeman [a]
Alaska Department of Fish and Game, Division of Sport Fish, Region I
P. O. Box 240020, Douglas, AK 99824-0020, USA

Scott A. McPherson
Alaska Department of Fish and Game, Division of Sport Fish, Region I
P. O. Box 240020, Douglas, AK 99824-0020, USA

[a] *Author to whom all correspondence should be addressed: e-mail: glenn_freeman@adfg.state.ak.us*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

A study of chinook salmon *Oncorhynchus tshawytscha* was undertaken on the Chickamin River in 2001 by the Division of Sport Fish. This study was used to estimate the number of large (≥660 mm MEF) spawning salmon, an expansion factor for the peak aerial survey count, and age, sex, and length composition of the population. Escapement was estimated using a two-event mark-recapture experiment. In the first event, fish were captured with set gillnets, marked with uniquely numbered spaghetti tags, and batch marked with two secondary marks. In the second event, spawning and pre-spawning fish were captured with rod and reel gear, examined for marks and sampled for age (scales), sex, and length. The estimated escapement of large chinook salmon was 5,177 (SE = 972) fish. The expansion factor for the peak aerial survey count in 2001 was 5.1 (SE = 0.96). These compare to estimates of abundance of 2,309 (SE = 723) fish in 1995 and 1,587 (SE = 199) fish in 1996, and to expansion factors of 6.5 (SE = 2.03) calculated in 1995 and 3.8 (SE = 0.47) in 1996. The mean expansion factor for all three years was 5.1 (SE =1.36). The estimated escapement of medium-sized (401–659 mm MEF) chinook salmon in 2001 was 1,247 (SE = 326) fish. The combined medium and large escapement was 6,424 (SE = 1,025) chinook salmon, with an estimated 2,841 female spawners. Age-1.3 fish from the 1996 year class composed an estimated 59% of the combined escapement estimate, followed by age-1.4 fish (19%), and age-1.2 fish (17%). Brood years from 1994 through 1998 were represented, with all five age classes originating from freshwater age-1 smolt.

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

INTRODUCTION

The Chickamin River flows into Behm Canal in the Misty Fjords National Monument Wilderness approximately 65 km northeast of Ketchikan, Alaska (Figure 1). The Chickamin River produces the second largest run of chinook salmon *Oncorhynchus tshawytscha* in southern Southeast Alaska (SEAK), and is one of four Behm Canal index streams for the chinook salmon escapement estimation program in SEAK (Pahlke 1998). Peak counts of "large" chinook salmon ≥660 mm mideye-to-fork length (MEF) have been collected using a standardized method (time and area) by helicopter annually since 1975. Eight spawning tributaries and stream reaches are included in the index survey. These index counts are used by the Alaska Department of Fish and Game (ADF&G) and the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC) to evaluate stock status, and to implement abundance-based management. Large chinook salmon are generally fish saltwater-age-3 or older in SEAK.

Peak counts of chinook salmon in the Chickamin River have experienced marked trends, ranging from lows during the base period (1975–1980) to peak counts and broad interannual fluctuations during the 1980s, and a return to lower counts through the 1990s. Peak counts increased again in 1999 and 2000.

From 1981 to 1994, it was assumed that the sum of index counts on eight tributaries represented 62.5% of the total annual escapement to the Chickamin River (Pahlke 1997). To validate the ongoing escapement index, studies were conducted to estimate the escapement of large chinook salmon. In 1995 and 1996, the estimated escapement was 2,309 (SE = 723; Pahlke 1996) and 1,587 (SE = 199; Pahlke 1997) large chinook salmon, respectively. In addition, in 1996, radiotelemetry studies estimated approximately 83% of all spawning occurred in the 8 index streams and no salmon were tracked into British Columbia. Based on these studies the expansion factor was revised to 4.0; i.e., 4 × survey count = total escapement of large fish (Pahlke 1998).

ADF&G Division of Sport Fish obtained funding, as part of the State of Alaska's commitment to a coastwide rebuilding program, to conduct expanded research on the Chickamin River beginning in 2001 to estimate abundance and age, sex, and length composition of spawners. Funding for this program was approved by the Chinook Technical Committee (CTC), using monies appropriated by U.S. Congress, to implement abundance-based management of chinook

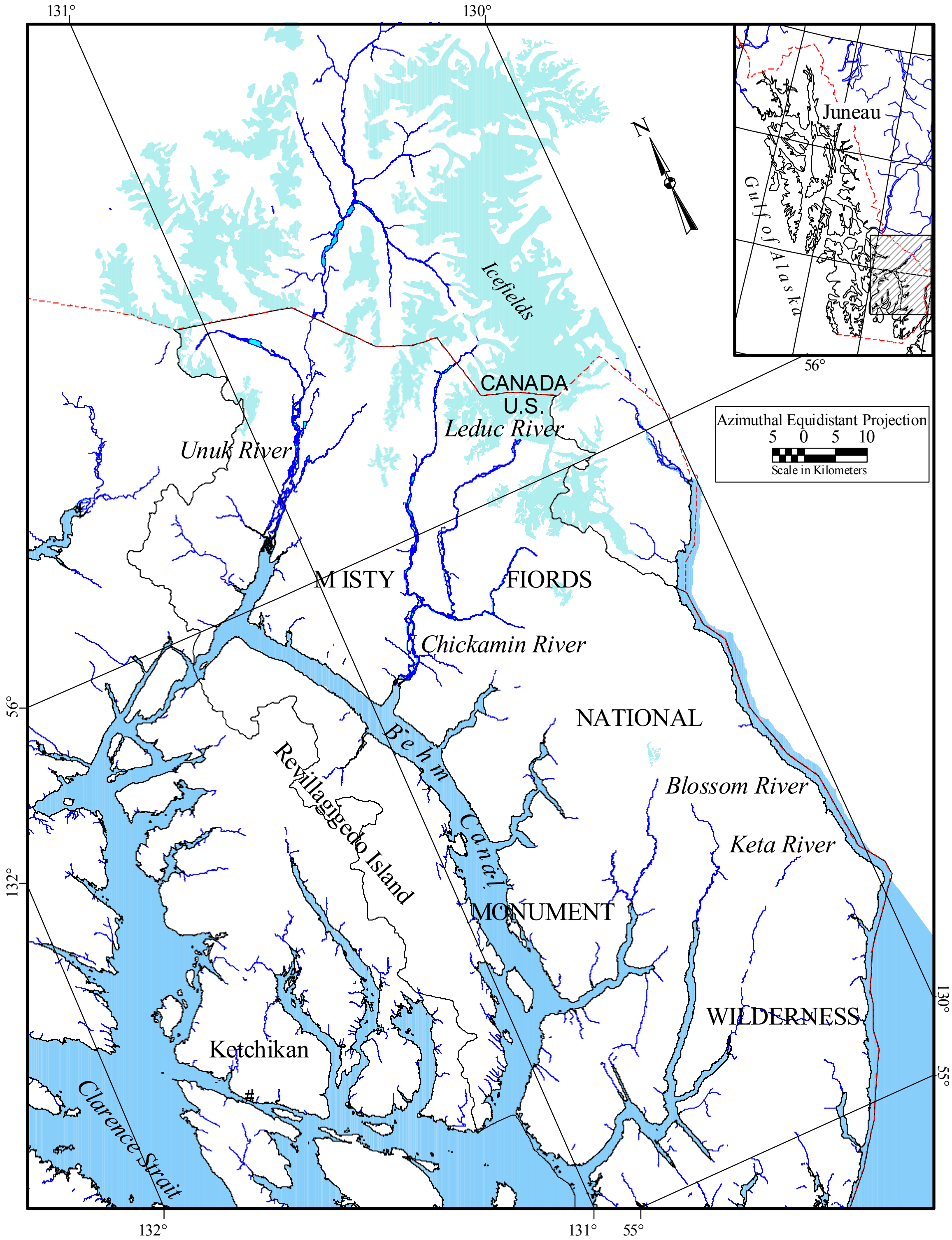


Figure 1.–Behm Canal and Misty Fjords National Monument in Southeast Alaska and location of major chinook salmon producing river systems.

salmon from Oregon to Alaska, as detailed in *"The 1996 U.S. Letter of Agreement,"* signed by U.S. parties in the Pacific Salmon Treaty area.

The U.S. section of the CTC (1997) developed data standards for stock specific assessments of escapement, terminal runs, and forecasts of abundance. The standard for escapement is as follows:

"Escapement. Annual age and sex-specific estimates of total escapement should be available. Point estimates should be accompanied by variance estimates, and both should be based on annual sampling data. Factors used to expand the escapement from index areas (or counts of components of the escapement) should be initially verified a minimum of three times. Those expansion factors that have moderate to large amounts of interannual variability (a coefficient of variation of more than 20%) should be monitored annually."

They concluded that the stock assessment program for the Chickamin River needed improvements: 1) to estimate total escapement in additional years; 2) to estimate an expansion factor converting historical survey counts into estimates of total escapement; and 3) to estimate the escapement by sex and age annually.

An estimate of escapement in 2001 allows calculation of an expansion factor for a third—though nonconsecutive—year, provides data to determine if U.S. CTC escapement data standards (USCTC 1997) are met, and provides an additional data point to estimate total escapements from expanded aerial survey counts back to 1975. 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 (USCTC 1997). Given harvest rate information, total escapement is necessary for estimating population parameters including total production and stock specific spawner-recruit relationships.

ADF&G returned to the Chickamin River in the summer of 2001. Research objectives in 2001 were:

1. Estimate the total escapement of large (≥660 mm MEF) chinook salmon in the Chickamin River in 2001 such that the estimate is within ±25% of the true value 95% of the time;
2. Estimate an expansion factor for converting peak aerial survey counts in the Chickamin River in 2001 to escapement such that future estimates of escapement are within ±25% of the true value 80% of the time; and
3. Estimate age and sex composition of large chinook salmon spawning in the Chickamin River in 2001 such that all estimated fractions are within ±6% of the true values 95% of the time.

Medium (length 401–659 mm MEF) chinook salmon were also sampled because they contribute to the spawning population. A secondary task of the research was to estimate abundance and mean length at age of medium fish.

Research on the Chickamin River in 2001 (and in future years) will determine if the current expansion factor (4.0) for survey counts is indicative of the true spawning magnitude in the Chickamin River. Presently the biological escapement goal range for the Chickamin River stock is a survey index count of 450 to 900 large spawners (McPherson and Carlile 1997). Additional years of spawning escapement estimates will facilitate the ability of ADF&G to convert this to a range of total escapement of large spawners.

In addition, funding from the Southeast Sustainable Salmon Fund was used to re-implement a coded-wire tagging program on juvenile chinook salmon on the Chickamin River in fall, 2001. Recoveries of those tags will be used to revise estimates of harvest and production of chinook salmon in the Chickamin River.

STUDY AREA

The Chickamin River originates in a heavily glaciated area of northern British Columbia and flows into Behm Canal in the Misty Fjords National Monument Wilderness approximately 65 km northeast of Ketchikan, Alaska. Although the Chickamin River is a transboundary river, no chinook salmon spawning areas exist in Canada. Many of its anadromous tributaries flow clear, however, upper system glacial influence results in mostly turbid mainstem flows during summer. The lower river flows through a broad valley bordered by steep-sided mountains. The lower river channel has a relatively flat bottom, with fine riverbed sediments, exposed bars, low gradient with braided channels, and large, bedrock controlled pools. Upriver, the stream is more narrowly contained, with progressively larger cobble, more bedrock controls, steeper gradient, and a higher frequency of logjams than in the lower river.

METHODS

A two-event mark-recapture experiment for a closed population (Seber 1982) was conducted on the Chickamin River in 2001. Set gillnets were used in the lower river as the method of capture for the first event of the experiment. Rod and reel snagging, dipnetting and carcass recovery were employed for the second event. ADF&G studies in 1995 and 1996 showed this to be an effective means for estimating population parameters in the Chickamin River (Pahlke 1996, 1997). The river was accessed from camp by boat downstream to the mouth and upstream to logjams or other impedance barriers located on the lower Leduc Fork, on the mainstem near Indian Creek, and on the South Fork near Barrier Creek.

CAPTURE OF CHINOOK SALMON

The lower river was fished during event 1 with set gillnets at two sites throughout the chinook salmon immigration: Humpy Slough at the mainstem confluence (km 5) and off a point bar just upstream from camp (km 5.5) (Figure 2). The Humpy Slough site was also a setnet site in 1995 and 1996 studies. The campsite was established after efforts to locate a site off Choca Creek proved futile because of snags and debris loading. Setnets were fished throughout the day and tide stages in an effort to maximize chinook catches while using roughly constant daily effort. Two crews of two persons each typically fished six net "shifts" per week, with a target of 6 hours of setnet fishing time per shift. Thus, two shifts were fished on most days except on two nonconsecutive days each week, when single shifts were fished. Generally, one net was fished at the camp site, and two nets were fished at the Humpy Slough site. The nets were watched continuously and a fish was removed from the net as soon as it was observed. If fishing time was lost because of entanglements, snags, cleaning the net, or tidal impacts, the lost time (processing time) was added on to the end of the shift to bring fishing time to 6 hours per set. For each chinook salmon captured 2 minutes of processing time was added to the shift.

MARKING AND SAMPLING

All fish captured in event 1 were sampled for scales, length to the nearest 5 mm MEF, sex, 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 for age analysis. 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 event, a uniquely numbered, spaghetti tag [an improved version of that described in Johnson et al. (1992)] was applied to each fish in good condition just below and anterior to the insertion of the dorsal fin. Each tag consisted of a 5.7-cm section of blue, laminated Floy® tubing shrunk onto a 38-cm piece of 80-lb-test (36.3 kg) monofilament fishing line. The tag was applied by first punching the tip portion of a hollow needle through the fish approximately 1.5 cm below and anterior to the insertion 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. Secondary marks applied (to control for primary loss) included a 0.6-cm punch in the left upper operculum (LUOP) and a left axillary appendage clip (LAA).

SAMPLING ON THE SPAWNING GROUNDS

Rod and reel snagging, dipnetting and carcass recovery were employed to capture fish on or near the spawning grounds during event 2. Fish were captured and sampled in event 2 within tributaries and mainstem areas previously identified as key spawning areas, including the eight spawning areas that comprise the aerial survey indices. 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

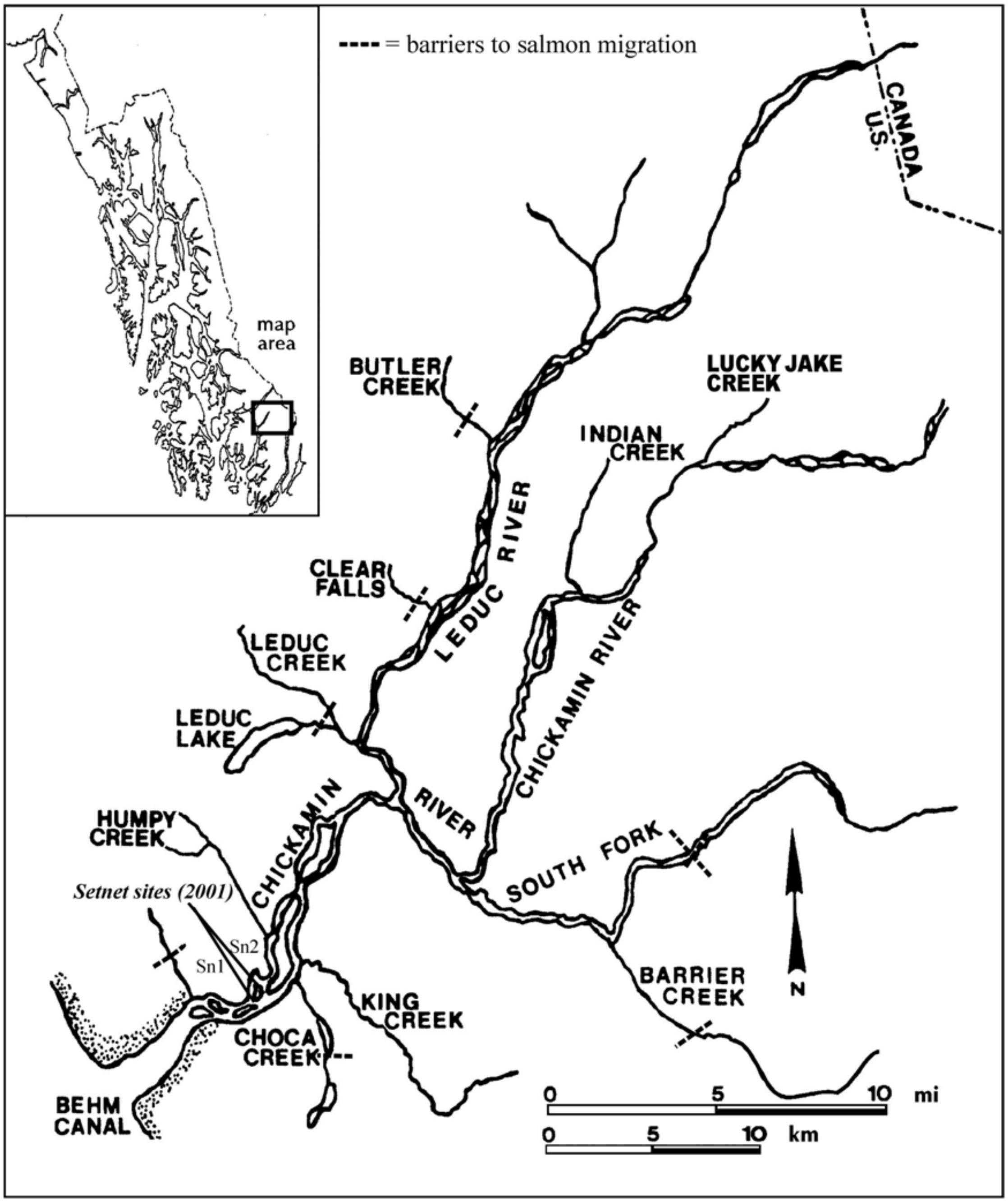


Figure 2.–Chickamin River drainage, with major tributaries, ADF&G research sites, and barriers to salmon migration depicted.

absence of their adipose fin, and sampled for length, sex, and scales using the same techniques employed during event 1. The tag number of each fish marked in event 1 and recaptured in event 2 was noted.

ABUNDANCE ESTIMATE

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

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

(b) both recruitment and mortality do not occur between events;

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

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

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

(f) double sampling does not occur.

Results of two contingency tests were used as evidence of whether assumption (a) was met. The null hypotheses ($\alpha = 0.1$) tested were that the fractions of marked fish were constant across event 2 spatial strata and that the probability of recovering a fish was independent of its initial (temporal) strata in event 1. Failure to confirm one of these hypotheses was taken as evidence that a spatially or temporally stratified estimator of abundance was appropriate (Arnason et al. 1996); otherwise a Petersen model could be used.

Assumption (a) may also be violated if length or sex selective sampling occurs. Two Kolmogorov-Smirnov (K-S) 2-sample tests were used to test the hypothesis that large fish of different lengths were captured with equal probability ($\alpha = 0.1$) (Appendix A1). Size selective sampling across all fish (medium and large fish combined) caught (>400 mm MEF) was investigated using two contingency tests. In the first test, selectivity by size (medium and large) during the second sampling event was investigated by comparing the number of fish marked in event 1 and recaptured in event 2 to the number marked in event 1 and not recaptured in event 2. In the second test, the numbers of fish of each size marked in events 1 and 2 were compared to investigate selectivity in the first sampling event (as reasoned in Appendix A1).

Sex selection of large fish was tested using contingency tests similar to those just described. In the first test, selectivity by sex during the second sampling event was investigated by comparing the number of fish marked in event 1 and recaptured in event 2 to the number marked in event 1 and not recaptured in event 2. In the second test, the numbers of fish of each sex captured in events 1 and 2 were compared to investigate sex selectivity in the first sampling event. Use of these tests assumes sex was accurately determined in each event. To test this assumption, the sex of each recaptured fish (where sex is usually accurately determined) is compared to the sex assigned in event 1. If sex was 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 was assumed to have little effect on behavior of released fish or the catchability of fish on the spawning grounds since only fish in good condition were tagged and released. The use of multiple marks, careful inspection of all fish captured on the spawning grounds, and additional marking of all fish inspected helped to ensure 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). Estimated abundance of large fish $\hat{N}_L$ in the escapement was calculated:

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

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

Mark-recapture methods could not be used to make a reliable estimate of the abundance of medium chinook salmon, because only two marked fish were recaptured (Seber 1982). We estimated the abundance of medium fish $\hat{N}_M$ from the estimated size composition of the spawning population of medium and large fish. Expansion was by the estimated fraction of large fish in the population of large and medium chinook sampled in the gillnet sample in the lower river: $\hat{\gamma} = n_L / n$ where n_L is the number of large fish sampled in the gillnets. Then the escapement of medium size fish was calculated:

$$\hat{N}_M = \hat{N}_L \left(\frac{1}{\hat{\gamma}} - 1 \right) \quad (2)$$

Variance and confidence intervals for $\hat{N}_M$ were estimated through simulation by treating the number of large chinook salmon in the Chickamin River drainage as a binomial variable $n_L^* \sim binom(\hat{\gamma}, n)$, where n is the number of sampled fish (i.e., medium and large). A thousand such simulated samples were drawn for each $\hat{\gamma}^* = n_L^* / n$, creating the empirical distribution $\hat{F}(\hat{\gamma}^*)$ as an estimate of $F(\hat{\gamma})$. Empirical distributions of $\hat{F}(\hat{N}_L{}^*)$ and $\hat{F}(\hat{\gamma}^*)$were matched through equation (2) to produce the distribution $\hat{F}(N_M^*)$, from which the estimate $\mathrm{var}(N_M^*)$ and confidence intervals for $\hat{N}_M$ were produced with the methods described above.

The spawning escapement of large and medium chinook salmon was estimated by $\hat{N} = \hat{N}_L / \hat{\gamma}$. Confidence intervals for $\hat{N}$ and $\mathrm{var}(\hat{N})$ were estimated per the procedures described above.

EXPANSION FACTOR

Since 1975, low altitude aerial surveys of the index streams in the Chickamin River were conducted from a helicopter. These surveys have been standardized for time and area, by tributary (Pahlke 1998). An expansion factor ($\hat{\pi}_t$) for large Chickamin River chinook salmon in a calendar year is:

$$\hat{\pi}_i = \hat{N}_i / C_i \quad (3)$$

$$var(\hat{\pi}_t) = var(\hat{N}_i) / C_i^2 \quad (4)$$

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 mean expansion factor ($\overline{\pi}$) is:

$$\overline{\pi} = \sum_{i=1}^{k} \hat{\pi}_i / k \quad (5)$$

$$var(\overline{\pi}) = \sum_{i=1}^{k} \left(\hat{\pi}_i - \overline{\pi} \right)^2 / (k-1) \quad (6)$$

where k is the number of years with mark-recapture experiments (three for the Chickamin River: 1995, 1996, and 2001). Simulation suggests that measurement error in the mark-recapture experiment does not need to be considered in this variance because of the small sample size (k = 3).

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

$$\hat{N}_t = \overline{\pi} \; C_t \quad (7)$$

$$var(\hat{N}_t) = C_t^2 \; var(\overline{\pi}) \quad (8)$$

AGE AND SEX COMPOSITION

The proportion of the spawning population composed of a given age within the medium or large fish size classes was estimated as a binomial variable:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \quad (9)$$

$$\mathrm{var}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{n_i - 1} \quad (10)$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age j in sized group i, n_{ij} is the number of chinook salmon of age j of size group i, and n_i is the number of chinook salmon in the sample n of size group i. Information gathered during event 1 was not used to estimate age or sex composition as tests (described above) showed sampling in event 1 was biased towards catching large fish. Samples gathered at each spawning tributary were pooled together, because no differences in age composition were apparent between tributaries sampled. Numbers of spawning fish by age were estimated as the sum of the products of estimated age composition and estimated abundance within a size category

$$\hat{N}_j = \sum_i (\hat{p}_{ij}\hat{N}_i) \quad (11)$$

and

$$\operatorname{var}(\hat{N}_j) = \sum_i \begin{pmatrix} \operatorname{var}(\hat{p}_{ij})\hat{N}_i^2 + \operatorname{var}(\hat{N}_i)\hat{p}_{ij}^2 \\ -\operatorname{var}(\hat{p}_{ij})\operatorname{var}(\hat{N}_i) \end{pmatrix} \quad (12)$$

with variance calculated according to procedures in Goodman (1960).

The proportion of the spawning population >400 mm MEF composed of a given age was estimated as the summed totals across size categories

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}} \quad (13)$$

and

$$\operatorname{var}(\hat{p}_j) = \frac{\sum_i (\operatorname{var}(\hat{p}_{ij})\hat{N}_i^2 + \operatorname{var}(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2)}{\hat{N}^2} \quad (14)$$

where variance is approximated according to procedures in Seber (1982):

Sex composition and age-sex composition for the entire spawning population and its associated variances were also estimated using the above equations by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes gender (male or female), such that $\sum_k \hat{p}_k = 1$, and by age-sex $\hat{p}_{jk}$, such that $\sum_{jk} \hat{p}_{jk} = 1$.

RESULTS

TAGGING, RECOVERY, AND ABUNDANCE

Between 11 June and 15 August 2001, 201 chinook salmon were captured, sampled and released with numbered tags and secondary marks in the Chickamin River. Also, 2 medium and 3 large fish were captured but not tagged because they were not in "good" condition. Of the 201 fish marked in event 1, 38 were medium-sized (401–659 mm MEF) and 163 were large (Table 1). The catch at each of the two setnet sites was similar: 20 medium and 82 large fish at the Humpy Slough site, and 20 medium and 84 large fish at the site above camp (Table 2). Appendix A2 contains a summary of effort and catch at both sites.

From 8 August through 30 August 2001, 70 medium and 883 large fish were captured and inspected for marks (Table 3); 2 medium and 27 large marked fish were observed (Table 1), and

Table 1.–Number of medium (401–659 mm MEF) and large (≥ 660 mm MEF) chinook salmon marked in the lower Chickamin River and inspected for marks on the spawning grounds, 2001.

	401–659 mm	≥ 660 mm	Total
A. Released in event 1 with marks (*M*)	38	163	**201**
B. Event 2:			
Captured (C) (*C*)	70	883	**953**
Recaptured (*R*)	2	27	**29**
R/C (%)	2.9%	3.1%	**3.0%**

Table 2.–Catch of medium (401–659 mm MEF) and large (≥ 660 mm MEF) chinook salmon marked with tags, by setnet site and sex, Chickamin River, 2001.

	Males	Females	Total
Humpy Slough site #1			
Catch	64	38	102
Tagged	63	37	100
Mortalities	0	1	1
Above camp site #2			
Catch	62	42	104
Tagged	60	41	101
Mortalities	1	0	1
Total, both sites			
Catch	126	80	206
Tagged	123	78	201
Mortalities	1	1	2

Table 3.–Numbers of chinook salmon sampled by size, location, and mark status during spawning ground surveys, Chickamin River, 2001.

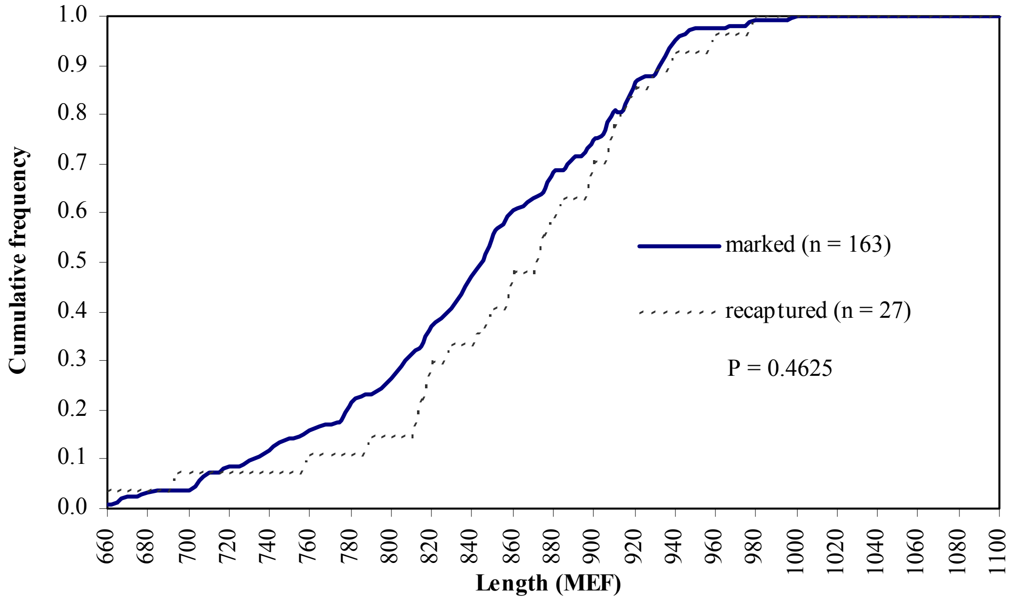
	Captures		Recaptures		Marked rate	
Location	**Medium**	**Large**	**Medium**	**Large**	**Medium**	**Large**
Lower tributaries:						
Choca Creek		3				
Humpy Creek	14	56		2		2
King Creek	32	242		10		10
Subtotal Lower combined	46	301		12	0.0	0.040
Leduc fork tributaries:						
Leduc Creek	1	29	1		1	
Clear Falls Creek		6				
Butler Creek	4	151		4		4
Subtotal Leduc combined	5	186	1	4	0.20	0.022
Middle-upper tributaries:						
Indian Creek	1	43		2		2
Lucky Jake Creek	1	13		1		1
Barrier Creek		22				
South Fork Chickamin R.	17	318	1	8	1	8
Middle-upper combined	19	396	1	11	0.053	0.028
Total	70	883	2	27	0.029	0.031

1 medium and 3 large fish (14% total) recaptured had lost their primary tags. Table 4 summarizes the capture histories of medium and large fish.

Across all medium and large fish combined, sampling on the spawning grounds proved to be selective towards larger chinook salmon. The cumulative density function for marked fish >400 mm MEF was significantly different than the corresponding function for fish recaptured on the spawning grounds (K-S test, P = 0.0986). The cumulative density function for marked fish >400 mm MEF was significantly different than the corresponding function for fish inspected on the spawning grounds (K-S test, P = 0.0001). Because medium-sized fish also return to spawn, we wanted an estimate of both large and medium-sized fish. Thus, we stratified the samples in order to produce a direct estimate of large spawners from mark-recapture statistics and testing (Appendix A1), and used other sampling information to produce an estimate of the number

Table 4.–Summary of capture histories of medium (401–659 mm MEF) and large (≥660 mm MEF) chinook salmon returning to spawn in the Chickamin River, 2001.

Capture history	*LARGE* ≥660 mm	**Source of statistics**
Marked and not recaptured	136	$M_i - R_i$
Marked and recaptured	27	R_i
Not marked, but captured	856	$C_i - R_i$
Not marked and not captured	4,158	$\hat{N}_i - M_i - C_i + R_i$
Effective population for simulations	5,177	$\hat{N}_i$



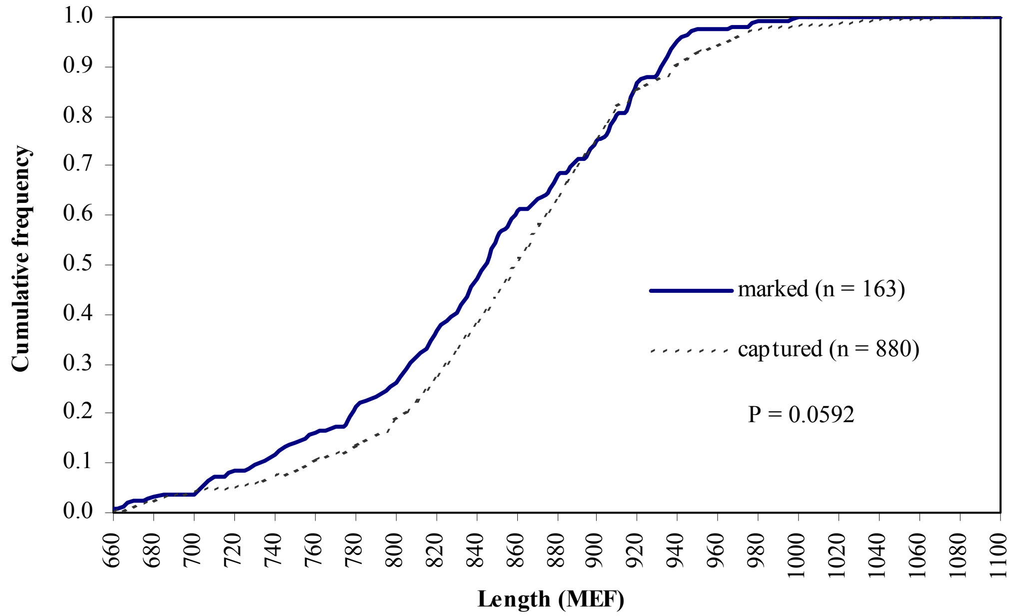


Figure 3.–Cumulative fractions of large (≥660 mm MEF) chinook salmon marked vs. recaptured (top) and marked vs. captured in event 2 (bottom) in the Chickamin River, 2001.

of medium-sized spawners. Although stratification based on size is needed to estimate abundance of all fish >400 mm MEF, we also stratify as a matter of course to obtain comparable estimates for large fish, in determining the expansion factor for survey counts, which include only large fish.

Length frequencies of large fish did not differ significantly (using $\alpha = 0.1$) between fish marked in event 1 and those recaptured on the spawning grounds in event 2 (K-S test, P = 0.46; Figure 3). In contrast, length frequency distributions for fish marked in event 1 and fish inspected for marks in event 2 were significantly different (K-S test, P = 0.06) (Figure 3—note both plots are nearly identical—and the large difference in p-values results from the large difference in sample sizes). Based on the statistical results, further stratification of the experiment was not needed to estimate abundance of large fish (Appendix A1).

On the basis of frequencies of sexes recovered and not recovered in event 2 ($\chi^2 = 0.36$, P = 0.55, df = 1), we determined that sex-selectivity for large fish did not occur during the second sampling event. However, the sex of fish marked in event 1 and examined in event 2 was significantly different ($\chi^2 = 3.50$, P = 0.06, df = 1). Thus, only samples from large fish for event 2 were used for estimating abundance by age, sex, and length for large fish.

A test of the hypothesis that the fraction of large fish carrying marks was constant across spatial recovery strata was accepted ($\chi^2 = 2.62$, df = 3, P = 0.45) (Table 5). In contrast, the hypothesis that recapture probabilities for large marked fish were independent of temporal marking strata was rejected ($\chi^2 = 4.38$, df = 1, P = 0.04) (Table 5). Because one of these two tests was accepted, the Petersen estimator was used to estimate abundance.

The abundance of large fish was thus estimated as $\hat{N}_L = 5{,}177$ (SE = 972) fish (Table 6). This estimate is based on $M_L = 163$, and 883 fish inspected for marks (= C_L) at Choca, Humpy, King, Leduc, Clear Falls, Butler, Indian, Lucky Jake and Barrier creeks and the South Fork Chickamin River (Table 3). Of the 883 fish inspected, 27 (= R_L) were recaptured fish. Four (15%) of the 27 recovered large fish had lost their primary tag, 1 each from Butler, Indian, South Fork and Lucky Jake tributaries. The estimated abundance of large fish has a 95% confidence interval of 3,780 to 7,573, and an estimated relative bias of 2.7%.

We estimated the abundance of medium-sized fish from equation 2—i.e., based on the abundance of large fish and the proportion of large fish in either event 1 (tagging) or event 2. Medium and large-sized fish marked in event 1 were recaptured at different rates ($\chi^2 = 3.19$, P = 0.07, df = 1, medium fish being sampled at a lower rate), and samples in event 2 contained relatively fewer medium fish than in event 1 ($\chi^2 = 26.2$, P <0.0001, df = 1). Thus, event 2 was selective for large fish (or against medium fish) in the pool of medium and large fish. Though selectivity in event 1 for fish >400 mm MEF is unknown, we judge event 1 to be the best estimate of the proportion of large fish amongst fish >400 mm MEF, because our 7¼" gillnets caught relatively *more* medium fish than did samplers in event 2.

The abundance of medium fish was estimated (equation 2) as $\hat{N}_M = 1{,}247$ (SE = 326) fish (Table 7). Age and sex composition was estimated from the spawning grounds sampling of medium fish (401–659 mm MEF). The spawning grounds sample was used because the sampling within medium fish on the spawning grounds

Table 5.–Number of marked large chinook salmon released in the lower Chickamin River and recaptured by marking period and recovery location, and the number examined for marks by recovery area, 2001.

Marking dates	Number marked	Fraction recovered	Recovery area: Lower tribs	Leduc tribs	Indian tribs	South Fork	Total
6/19 to 7/17	52	0.06	0	2	0	1	3
7/18 to 8/15	111	0.19	12	1	2	6	21
Total/average	163	0.17	12	4[a]	3[a]	8[a]	27
Number inspected			301	186	56	340	883
Fraction marked			0.04	0.02	0.05	0.02	0.03

[a]In addition, one fish with a missing spaghetti tag was recovered at each area shown.

Table 6.–Peak survey counts, mark-recapture estimates of abundance and estimated expansion factors for large (≥ 660 mm MEF) chinook salmon in the Chickamin River, 1995, 1996, and 2001.

	Year			
Parameter	1995	1996	2001	Average
Survey count	356	422	1,010	596
Mark-recapture estimate (M-R)	2,309	1,587	5,177	3,024
M-R standard error	723	199	972	
M-R 95% relative precision	61.4%	24.6%	36.8%	40.9%
M-R lower 95% CI	1,388	1,279	3,780	
M-R upper 95% CI	4,650	2,089	7,573	
Survey count/(M-R)	15.4%	26.6%	19.5%	20.5%
Expansion factor	6.5	3.8	5.1	5.1
SE[expansion factor]	2.03	0.47	0.96	1.36[a]
CV of expansion factor	31.3%	12.5%	18.8%	26.6%

[a]Average expansion factor SE calculated as SD of yearly expansion factors in 1995, 1996, and 2001.

was more representative of the age/sex distribution for this size class, whereas the gillnet sample was biased toward larger fish within the medium size class (see Figure 4). The estimated abundance of medium fish has a 95% confidence interval of 788 to 2,038, and an estimated relative bias of 3.1%.

ESTIMATES OF AGE, SEX, AND LENGTH COMPOSITION

Age-1.3 chinook salmon from the 1996 year class dominated the age and sex compositions of chinook salmon >400 mm MEF on the spawning grounds of the Chickamin River in 2001. Age-1.3 fish constituted 59% (SE = 3.8%) of the estimated escapement (Table 7), age-1.4 fish constituted 19% (SE = 1.7%), age-1.2 fish constituted 17% (SE = 3.6%) and age-1.1 fish constituted 5% (SE = 1.8%). Males composed 56% (SE = 3.1%) of the escapement and there were an estimated 2,841 (SE = 541) females (all large fish) in the spawning population. An estimated 48% of males were age-1.3 fish, 30% were age-1.2 fish, 12% were age-1.4 fish and 10% were age-1.1 fish. An estimated 72% of females were age-1.3 fish, 27% were age-1.4 fish and 1% were age-1.5 fish. Note that the abundance of age-1.1 fish was incomplete as a portion of the members of this age class are small fish (<401 mm MEF) and we did not have a representative sampling program to estimate their abundance. All scale samples that were successfully aged were age-1. fish, which are yearling smolt.

Within size groups, medium fish were 100% males, and large fish were mostly (55%, SE = 1.8%) females (Table 7). Age composition of medium fish was 28% (SE = 5.9%) age-1.1 fish, 71% (SE = 6.0%) age-1.2 fish, and 2% (SE = 1.7%) age-1.3 fish. For combined sexes of large fish, 3.8% (SE = 0.7%) were age-1.2, 72.6% (SE = 1.6%) were age-1.3, 23.0% (SE = 1.5%) were age-1.4, and 0.6% (SE = 0.3%) were age-1.5 fish.

Average length increased with age for male and female chinook salmon (combined) sampled (Table 8). Within age-1.3 fish, females were slightly (an estimated 14 mm) longer than males, while age-1.4 males averaged an estimated 20 mm longer than their female counterparts. The length frequency distribution of fish by age class (age-1.1 to age-1.5) is shown in Figure 5; note that the relative abundance amongst age classes is different than shown in Table 7 because samples in Figure 5 are unweighted samples from the spawning grounds.

Ages of small, medium, and large (unweighted) fish sampled in set gillnets and from the spawning grounds are shown in Appendix A3.

Table 7.–Estimated abundance of the escapement, by age and sex, of medium (401–659 mm MEF) and large (≥660 mm MEF) chinook salmon in the Chickamin River, 2001. Estimates are from chinook sampled on the spawning grounds (event 2).

PANEL A: MEDIUM CHINOOK SALMON (401–659 mm MEF)

		Brood year and age class					
		1998	1997	1996	1995	1994	
		1.1	1.2	1.3	1.4	1.5	Total
Males	Sample size	16	41	1			58
	Percent	27.6	70.7	1.7			100.0
	SE of percent	5.9	6.0	1.7			0.0
	Escapement	344	882	22			1,247
	SE of esc.	115	242	22			326
Total	Sample size	16	41	1			58
	Percent	27.6	70.7	1.7			100.0
	SE of percent	5.9	6.0	1.7			0.0
	Escapement	344	882	22			1,247
	SE of esc.	115	242	22			326

PANEL B: LARGE CHINOOK SALMON (≥660 mm MEF)

		Brood year and age class					
		1998	1997	1996	1995	1994	
		1.1	1.2	1.3	1.4	1.5	Total
Males	Sample size		31	266	66	2	365
	Percent		3.8	32.9	8.2	0.2	45.1
	SE of percent		0.7	1.7	1.0	0.2	1.8
	Escapement		198	1,702	422	13	2,336
	SE of esc.		51	330	93	9	447
Females	Sample size			321	120	3	444
	Percent			39.7	14.8	0.4	54.9
	SE of percent			1.7	1.3	0.2	1.8
	Escapement			2,054	768	19	2,841
	SE of esc.			395	158	11	541
Total	Sample size		31	587	186	5	809
	Percent		3.8	72.6	23.0	0.6	100.0
	SE of percent		0.7	1.6	1.5	0.3	0.0
	Escapement		198	3,756	1,190	32	5,177
	SE of esc.		51	710	236	15	972

PANEL C: MEDIUM AND LARGE CHINOOK SALMON

		Brood year and age class					
		1998	1997	1996	1995	1994	
		1.1	1.2	1.3	1.4	1.5	Total
Males	Sample size	16	72	267	66	2	423
	Percent	5.4	16.8	26.8	6.6	0.2	55.8
	SE of percent	1.8	3.6	2.1	0.9	0.1	3.1
	Escapement	344	1,080	1,724	422	13	3,583
	SE of esc.	115	247	331	93	9	554
Females	Sample size	0	0	321	120	3	444
	Percent	0.0	0.0	32.0	12.0	0.3	44.2
	SE of percent	0.0	0.0	2.4	1.3	0.2	3.1
	Escapement	0	0	2,054	768	19	2,841
	SE of esc.	0	0	395	158	11	541
Total	Sample size	16	72	588	186	5	867
	Percent	5.4	16.8	58.8	18.5	0.5	100.0
	SE of percent	1.8	3.6	3.8	1.7	0.2	0.0
	Escapement	344	1,080	3,778	1,190	32	6,424
	SE of esc.	115	247	710	236	15	1,025

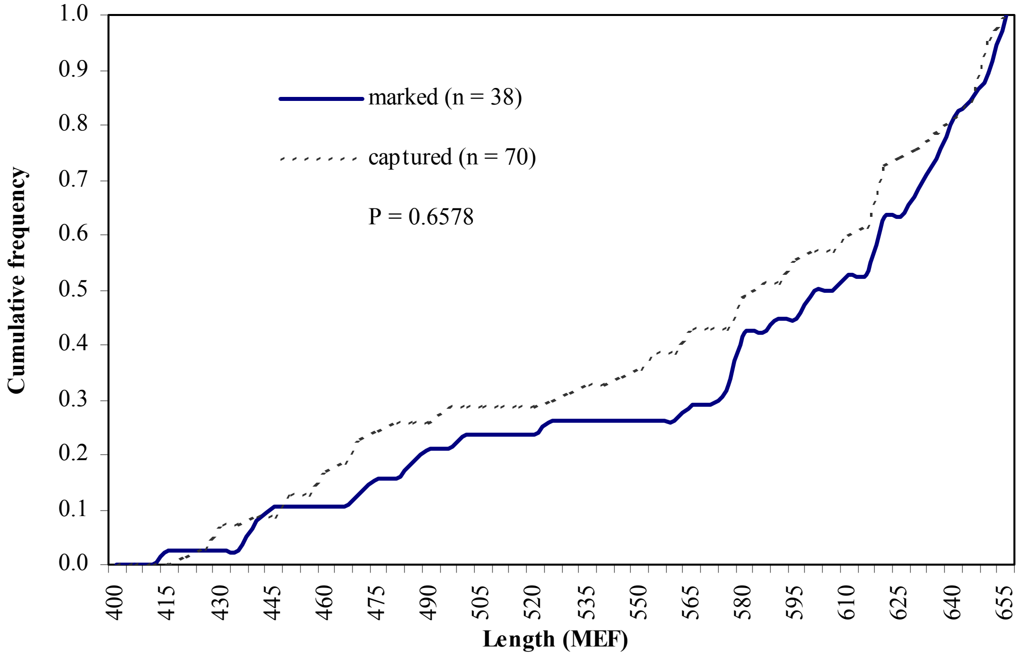


Figure 4.–Cumulative fractions of medium (401–659 mm MEF) chinook salmon marked in event 1 vs. captured in event 2 in the Chickamin River, 2001.

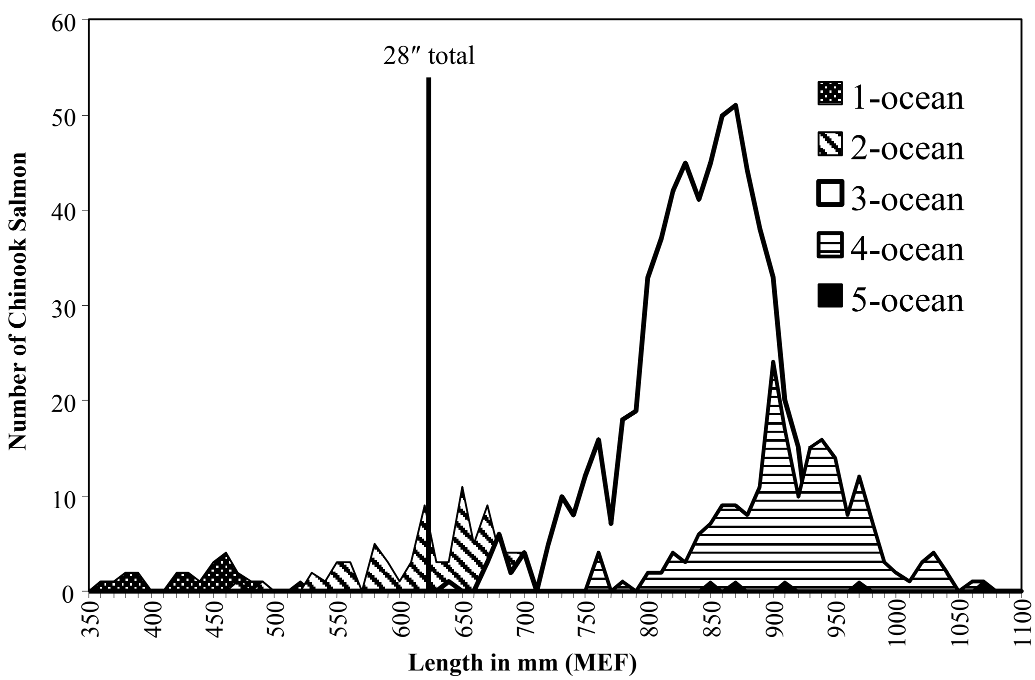


Figure 5.–Numbers of chinook salmon by ocean age from samples taken in event 2, Chickamin River, 2001. Based on regulations for Southeast Alaska, 28″ is the minimum total length of chinook salmon permitted for harvest in the sport fishery.

Table 8.–Average length by sex and age of chinook salmon sampled in the Chickamin River, 2001. Estimates include all chinook sampled and successfully aged from the spawning grounds.

		Brood year and age class					
		1998	1997	1996	1995	1994	
		1.1	1.2	1.3	1.4	1.5	Total
Males	Sample size	22	72	267	66	2	429
	Average length	437	643	836	929	893	
	SD	42	54	67	68	25	
	SE	9	6	4	8	18	
Females	Sample size			321	120	3	444
	Average length			850	909	965	
	SD			41	50	110	
	SE			2	5	64	
Sexes combined	Sample size	22	72	588	186	5	873
	Average length	437	643	844	916	936	
	SD	42	54	54	58	88	
	SE	9	6	2	4	40	

EXPANSION FACTOR

A peak survey count of 1,010 large chinook salmon was obtained at the Chickamin River in 2001. The expansion factor for 2001 was estimated at 5.1 (SE = 0.96), compared with 6.5 in 1995 and 3.8 in 1996 (Table 6). The mean expansion factor was the average of these three estimates, also 5.1 (SE = 1.36) (Table 6). With a coefficient of variation (CV) of 26.6%, this estimate is above (less precise than) the 20% precision guideline in USCTC (1997).

Computer files of worksheets used for estimates in this report are displayed in Appendix A4.

DISCUSSION

The estimated return of 5,177 large chinook salmon in 2001 was the highest to the Chickamin River since 1986, if we accept using the average expansion from the three years of mark-recapture estimates. This year also marked the fourth consecutive year of increasing peak index survey counts, and the third straight year the established escapement goal has been met (index count 450–900 fish; McPherson and Carlile 1997).

Physical and biological characteristics of the lower Chickamin River present challenges for setnetting. Relative to the Unuk River and other chinook salmon systems studied in Southeast Alaska, the lower Chickamin River lacks obvious holding areas or easily detected migration routes. High bycatch of pink and chum salmon adds further challenges. Setnet site selection and fishing are also hampered by a tidally influenced mainstem channel that is largely straight, wide, and uniform in shape and flow. Based on studies conducted in 1995 (Pahlke 1996) and 1996 (Pahlke 1997), high bycatch of (especially) chum and pink salmon may limit chinook salmon catches in setnets during the latter half of July. Though not estimated, a markedly lower chum salmon return was evident in 2001 than in 1996. Pink salmon bycatch was high, yet they are easier to release than chum salmon and do not appear to impact chinook salmon catches as much. However, low chinook salmon catches from 24 to 31 July occurred during the highest pink salmon catches of the season (Appendix A1).

Our use of 7¼" gillnets has proven size selective for larger fish amongst all sizes and ages, but this method works well given our objectives. Indeed, this year the ratio of medium to large fish caught using gillnets was superior to that collected using snagging and carcass surveys on the spawning grounds. Direct evidence of handling or stress-related mortality was low (2 of 206 caught in gillnets). Crews maintained a constant watch on the nets, and responded quickly to free entangled fish. Pahlke (1997) reported low mortality from using these methods, and he observed that 90% of gillnet-caught and radiotagged fish were tracked upstream to spawning areas in 1996. Use of this gear did, and has in almost all previous similar studies, produce an unbiased estimate within large fish, and stratification of the large and medium data into two size groups is not cumbersome nor unexpected. Sampling on the spawning grounds appears to produce unbiased estimates of age and sex composition when samples are separated into these two size groups.

In 2001, the 163 large chinook salmon marked in event 1 fell about 100 fish below expectations. We attributed low setnet catches to limited setnet site locations, bycatch, and to a lesser extent, tidal influence on the nets. Effort was consequently increased above planned levels during the first two weeks of event 2 to capture and sample more fish. The added effort helped greatly, as event 2 catches were about twice as high as we originally expected. Efforts were again successfully focused on the established index spawning areas, which appear to be representative of the escapement. Foot surveys of Humpy Creek proved more reliable than aerial counts at counting chinook salmon, and should be continued.

CONCLUSIONS AND RECOMMENDATIONS

The estimated expansion factors for 1995, 1996, and 2001 ranged from 3.8 to 6.5 (CV = 12.5% to 31.3%). Continuation of this project for two additional years will provide a more precise estimate of the expansion factor, and provide a more reliable base from which to estimate future escapements through aerial index surveys.

An increase in the number of fish marked during event 1 in future years would improve the precision of the chinook salmon escapement estimate. This may best be accomplished through the establishment of alternate setnet site(s). Early season test fishing of several potential sites upriver from existing ones, yet downstream of the Leduc Fork may yield higher catches.

Our ability to estimate the escapement of medium-sized fish within even ±40% of the true value 95% of the time remains a challenge because of low marking and recovery rates. The use of smaller mesh nets (5", e.g.) hung looser than and fished in conjunction with the standard nets may increase catches of smaller fish which have to date more effectively avoided capture. Size selective sampling on the spawning grounds may continue to be a significant problem using existing fishing methods. Thus, increased effort and smaller mesh gillnets should prove important in meeting future sampling goals. However, this could also increase the bycatch of pink and chum salmon. Additional staffing during event 2 might also lead, via modified procedures, to reduced sampling selectivity on the spawning grounds, and additional captures of medium-sized fish.

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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 A2.–Setnet catch and effort records on the Chickamin River, 2001.

Date	Setnet site	Start time	Stop time	Net hrs fished	Large chinook	Cum. total	Percent	Medium chinook	Cum. total	Percent	Chum	Pink	Sockeye	Coho	Comments
11-Jun	Humpy Slough	9:46	15:46	6.0	0	0	0%	0	0	0%					Fished downstream & x-stream nets
12-Jun	Humpy Slough	14:26	19:00	4.6	0	0	0%	0	0	0%					1 net pulled-large snag
13-Jun	Humpy Slough	16:31	20:28	6.0	0	0	0%	0	0	0%					
14-Jun	Humpy Slough	6:23	12:26	6.0	0	0	0%	0	0	0%					
15-Jun	Humpy Slough	6:27	12:27	6.0	0	0	0%	0	0	0%					
16-Jun	Humpy Slough	7:26	13:27	6.0	0	0	0%	0	0	0%					
18-Jun	Humpy Slough	9:10	15:13	6.0	0	0	0%	0	0	0%					
19-Jun	Humpy Slough	9:30	15:45	6.2	1	1	1%	0	0	0%					
20-Jun	Humpy Slough	14:06	19:55	5.8	0	1	1%	0	0	0%					Rain, rising water, strong current
21-Jun	Humpy Slough	11:36	17:36	6.0	0	1	1%	0	0	0%					
22-Jun	Humpy Slough	8:54	12:30	3.6	0	1	1%	0	0	0%					Net pulled-strong reverse tide
22-Jun	Humpy Slough	16:33	20:25	3.8	1	2	1%	0	0	0%	1				
23-Jun	Humpy Slough	7:59	13:35	5.6	0	2	1%	0	0	0%					Net pulled early to avoid rev tide
23-Jun	Humpy Slough	16:36	21:16	4.5	0	2	1%	0	0	0%					
24-Jun	Humpy Slough	9:52	15:54	6.0	1	3	2%	0	0	0%					Current strong @ outgoing tide
25-Jun	Humpy Slough	7:04	13:08	6.0	2	5	3%	0	0	0%	1				
25-Jun	Humpy Slough	13:09	19:13	6.0	2	7	4%	0	0	0%	2	1			Slack net during high slack tide
26-Jun	Humpy Slough	10:58	17:10	6.1	2	9	6%	1	1	3%	5	1			
27-Jun	Humpy Slough	7:06	13:14	6.0	2	11	7%	0	1	3%	1				
27-Jun	Above camp site	15:38	18:06	2.4	1	12	7%	1	2	5%					Fished downstream net only
28-Jun	Humpy Slough	8:15	14:15	6.0	0	12	7%	0	2	5%					
28-Jun	Above camp site	9:36	15:42	5.9	0	12	7%	0	2	5%					
29-Jun	Humpy Slough	8:35	14:42	6.0	2	14	9%	0	2	5%	2	3			1 DV
29-Jun	Above camp site	9:42	15:50	6.0	3	17	10%	0	2	5%	2				Fished 2 nets effectively
30-Jun	Humpy Slough	6:11	12:13	6.0	1	18	11%	0	2	5%	4	1			
30-Jun	Above camp site	11:17	17:20	6.0	0	18	11%	1	3	8%			1		1 DV
1-Jul	Humpy Slough	7:10	13:28	6.2	3	21	13%	0	3	8%	9	1			2 DV
2-Jul	Humpy Slough	6:20	12:24	6.0	1	22	13%	0	3	8%	6	3			
2-Jul	Above camp site	11:59	18:03	6.0	2	24	15%	0	3	8%	6	3			Both chinook caught in ds net
3-Jul	Humpy Slough	5:15	11:23	6.0	2	26	16%	0	3	8%	8	3	1		
3-Jul	Above camp site	13:04	19:04	6.0	0	26	16%	0	3	8%	2	2			

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Appendix A2.–Page 2 of 3.

Date	Setnet site	Start time	Stop time	Net hrs fished	Large chinook	Cum. total	Percent	Medium chinook	Cum. total	Percent	Chum	Pink	Sockeye	Coho	Comments
4-Jul	Above camp site	8:30	14:32	6.0	0	26	16%	1	4	10%	8				
5-Jul	Above camp site	6:20	12:20	6.0	0	26	16%	0	4	10%	7	1			
5-Jul	Above camp site	12:20	18:24	6.0	1	27	17%	0	4	10%	6				
6-Jul	Humpy Slough	12:19	18:25	6.0	2	29	18%	0	4	10%		1	1		Cross net flailed out in current
6-Jul	Above camp site	6:36	12:38	6.0	0	29	18%	0	4	10%	2				
7-Jul	Above camp site	12:17	18:17	6.0	1	30	18%	0	4	10%		1			
8-Jul	Humpy Slough	12:15	18:18	6.0	1	31	19%	0	4	10%	5	1			
9-Jul	Above camp site	6:40	12:42	6.0	1	32	20%	0	4	10%	3				
9-Jul	Above camp site	12:42	18:48	6.1	0	32	20%	1	5	13%	8	1			1 DV
10-Jul	Humpy Slough	4:56	10:58	6.0	1	33	20%	0	5	13%	13	5	1		
10-Jul	Humpy Slough	10:58	17:11	6.2	1	34	21%	0	5	13%	19	19			
11-Jul	Humpy Slough	5:38	12:08	6.4	2	36	22%	0	5	13%	33	17			1 DV; large snag at pull time
12-Jul	Above camp site	6:05	12:07	6.0	1	37	23%	0	5	13%	10	10			1 DV
12-Jul	Above camp site	12:07	18:09	6.0	0	37	23%	1	6	15%	5	13	1		1 DV
13-Jul	Humpy Slough	4:40	11:07	6.0	2	39	24%	1	7	18%	40	48			1 DV
13-Jul	Above camp site	4:48	10:48	6.4	0	39	24%	0	7	18%	18	17	1		
14-Jul	Humpy Slough	7:40	10:57	6.3	0	39	24%	0	7	18%	37	16			
14-Jul	Above camp site	4:40	11:00	6.2	3	42	26%	0	7	18%	52	10	1		
15-Jul	Humpy Slough	6:32	12:46	6.2	0	42	26%	0	7	18%	31	27	1		
16-Jul	Above camp site	6:15	12:21	6.0	2	44	27%	0	7	18%	19	21			
16-Jul	Above camp site	12:21	18:27	6.0	2	46	28%	1	8	20%	9	26			All chin caught in ds net
17-Jul	Above camp site	6:32	12:38	6.0	3	49	30%	0	8	20%	66	13	1		All chin caught in x-net
17-Jul	Above camp site	12:38	19:05	6.3	3	52	32%	1	9	23%	19	5			
18-Jul	Above camp site	8:18	14:24	6.0	1	53	33%	2	11	28%	46	49	1		
18-Jul	Above camp site	14:24	20:52	6.3	4	57	35%	0	11	28%	46	28	1		All chinook caught in ds net
19-Jul	Humpy Slough	7:07	13:15	5.9	6	63	39%	1	12	30%	32	159	1		Rev tide problems-20+ pink mort
19-Jul	Above camp site	12:05	20:30	8.1	7	70	43%	0	12	30%	32	159	1		Bycatch net mort problems
20-Jul	Humpy Slough	6:11	11:20	4.9	3	73	45%	3	15	38%	6	111			
20-Jul	Above camp site	14:55	21:10	6.1	3	76	47%	2	17	43%	55	25			
21-Jul	Above camp site	6:24	12:40	6.1	8	84	52%	0	17	43%	21	18			Trouble setting cross net
21-Jul	Above camp site	12:40	19:25	6.6	6	90	55%	0	17	43%	49	38	1		
22-Jul	Above camp site	7:28	11:39	4.2	1	91	56%	0	17	43%	10	26			
22-Jul	Above camp site	11:39	19:43	7.7	9	100	61%	0	17	43%	22	86	1		1 chin caught in x-net, 8 in ds net
23-Jul	Above camp site	6:05	12:13	6.0	3	103	63%	1	18	45%	20	54			

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Appendix A2.–Page 3 of 3.

Date	Setnet site	Start time	Stop time	Net hrs fished	Large chinook	Cum. total	Percent	Medium chinook	Cum. total	Percent	Chum	Pink	Sockeye	Coho	Comments
23-Jul	Above camp site	6:05	12:13	6.0	3	103	63%	1	18	45%	20	54			
23-Jul	Above camp site	12:13	18:18	6.0	3	106	65%	0	18	45%	15	61			All chin caught in ds net
24-Jul	Above camp site	6:56	12:58	6.0	1	107	66%	0	18	45%	10	243			Chin caught in cross net
24-Jul	Above camp site	12:58	18:48	5.8	0	107	66%	0	18	45%	12	145			
25-Jul	Above camp site	13:08	19:04	5.9	1	108	66%	0	18	45%	3	335			1 DV; ds net pulled @15:30-bycatch
26-Jul	Above camp site	6:32	11:01	4.5	0	108	66%	0	18	45%	4	318			Fished 1 net-mort problem-pulled
27-Jul	Above camp site	10:25	16:35	6.1	1	109	67%	1	19	48%	1	359			Fished downstream net only
28-Jul	Humpy Slough	9:19	15:23	6.3	1	110	67%	0	19	48%	6	299			Many pinks stressed-limited x-net
28-Jul	Above camp site	8:10	14:25	6.0	0	110	67%	0	19	48%	2	181			Fished downstream net only
29-Jul	Above camp site	9:40	15:50	6.1	0	110	67%	1	20	50%	2	167			Fished downstream net only
30-Jul	Humpy Slough	7:32	13:34	5.9	1	111	68%	2	22	55%	3	233	1		Fished downstream net only
30-Jul	Above camp site	10:58	17:17	6.3	0	111	68%	1	23	58%	1	249			Fished downstream net only
31-Jul	Humpy Slough	9:40	13:41	4.0	1	112	69%	0	23	58%	2	122	1		Fished downstream net only
31-Jul	Above camp site	10:31	14:44	4.2	0	112	69%	0	23	58%	2	120			Fished downstream net only
1-Aug	Humpy Slough	9:44	15:48	6.0	2	114	70%	0	23	58%	4	156			
1-Aug	Above camp site	9:50	15:56	6.0	2	116	71%	1	24	60%	1	98			
2-Aug	Humpy Slough	10:42	17:14	6.4	3	119	73%	2	26	65%	4	229			
2-Aug	Above camp site	10:33	17:00	6.3	4	123	75%	1	27	68%	9	188			
3-Aug	Humpy Slough	12:25	18:55	6.2	6	129	79%	0	27	68%	5	185			
3-Aug	Above camp site	11:14	17:32	6.3	1	130	80%	3	30	75%	5	185			
4-Aug	Humpy Slough	11:44	17:55	6.0	5	135	83%	0	30	75%	3	173	1		
5-Aug	Humpy Slough	7:36	13:44	6.0	2	137	84%	2	32	80%	6	126			
5-Aug	Humpy Slough	13:44	19:57	6.2	2	139	85%	0	32	80%	2	74			
6-Aug	Humpy Slough	10:15	16:21	6.1	2	141	87%	1	33	83%	5	98			
6-Aug	Above camp site	10:16	16:30	6.0	2	143	88%	1	34	85%	4	46			
7-Aug	Humpy Slough	11:34	17:48	6.1	4	147	90%	0	34	85%	4	111			
7-Aug	Above camp site	11:18	17:19	6.0	2	149	91%	0	34	85%	2	66			
9-Aug	Humpy Slough	12:35	18:56	6.2	4	153	94%	0	34	85%	4	94	1	1	
10-Aug	Humpy Slough	11:16	17:40	6.2	2	155	95%	3	37	93%	9	112		5	
11-Aug	Humpy Slough	12:25	18:27	6.0	1	156	96%	0	37	93%	3	66		3	
13-Aug	Humpy Slough	13:15	19:28	6.1	3	159	98%	0	37	93%	2	46		4	
14-Aug	Humpy Slough	13:02	19:52	6.6	4	163	100%	2	39	98%	4	169		3	
15-Aug	Humpy Slough	11:37	17:55	6.2	0	163	100%	1	40	100%	5	299	1	11	
				Totals	163			40			942	6,376	20	27	

Appendix A3.–Age by sex of unweighted large (≥660 mm MEF), medium (401–659 mm MEF), and small (≤400 mm MEF) chinook salmon sampled in set gillnets and from spawning grounds, Chickamin River, 2001.

Panel A. Chinook salmon sampled in event 1 (set gillnets)

			Brood year and age class					
			1998	1997	1996	1995	1994	
			1.1	1.2	1.3	1.4	1.5	**Total**
Large fish	Males	Sample size		7	55	15		**77**
		Percent		9.1%	71.4%	19.5%		**52.7%**
	Females	Sample size		1	53	15		**69**
		Percent		1.4%	76.8%	21.7%		**47.3%**
	Total	Sample size		8	108	30		**146**
		Percent		5.5%	74.0%	20.5%		
Medium fish	Males	Sample size	8	26	1			**35**
		Percent	22.9%	74.3%	2.9%			**97.2%**
	Females	Sample size		1				**1**
		Percent		100.0%				**2.8%**
	Total	Sample size	8	27	1			**36**
		Percent	22.2%	75.0%	2.8%			
Small fish	Males	Sample size	1					**1**
		Percent	100.0%					**100.0%**
	Total	Sample size	1					**1**
		Percent	100.0%					
Set gillnets	Males	Sample size	9	33	56	15		**113**
All chinook		Percent	8.0%	29.2%	49.6%	13.3%		**61.7%**
	Females	Sample size		2	53	15		**70**
		Percent		2.9%	75.7%	21.4%		**38.3%**
	Total	Sample size	9	35	109	30		**183**
		Percent	4.9%	19.1%	59.6%	16.4%		

Panel B. Chinook salmon sampled in event 2 (spawning grounds)

			1998	1997	1996	1995	1994	
			1.1	1.2	1.3	1.4	1.5	**Total**
Large fish	Males	Sample size		31	266	66	2	**365**
		Percent		8.5%	72.9%	18.1%	0.5%	**45.1%**
	Females	Sample size			321	120	3	**444**
		Percent			72.3%	27.0%	0.7%	**54.9%**
	Total	Sample size		31	587	186	5	**809**
		Percent		3.8%	72.6%	23.0%	0.6%	
Medium fish	Males	Sample size	16	41	1			**58**
		Percent	27.6%	70.7%	1.7%			**100.0%**
	Females	Sample size						**0**
		Percent						**0.0%**
	Total	Sample size	16	41	1			**58**
		Percent	27.6%	70.7%	1.7%			
Small fish	Males	Sample size	6					**6**
		Percent	100.0%					**100.0%**
	Total	Sample size	6					**6**
		Percent	100.0%					
Spawning	Males	Sample size	22	72	267	66	2	**429**
grounds		Percent	5.1%	16.8%	62.2%	15.4%	0.5%	**49.1%**
All chinook	Females	Sample size			321	120	3	**444**
		Percent			72.3%	27.0%	0.7%	**50.9%**
	Total	Sample size	22	72	588	186	5	**873**
		Percent	2.5%	8.2%	67.4%	21.3%	0.6%	

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Appendix A3.–Page 2 of 2.

Panel C. Chinook salmon sampled in event 1 (set gillnets) and event 2 (spawning grounds) combined

			Brood year and age class					
			1998	1997	1996	1995	1994	
			1.1	1.2	1.3	1.4	1.5	**Total**
Large fish	Males	Sample size		38	321	81	2	**442**
		Percent		8.6%	72.6%	18.3%	0.5%	**46.3%**
	Females	Sample size		1	374	135	3	**513**
		Percent		0.2%	72.9%	26.3%	0.6%	**53.7%**
	Total	Sample size		39	695	216	5	**955**
		Percent		4.1%	72.8%	22.6%	0.5%	
Medium fish	Males	Sample size	24	67	2			**93**
		Percent	25.8%	72.0%	2.2%			**98.9%**
	Females	Sample size		1				**1**
		Percent		100.0%				**1.1%**
	Total	Sample size	24	68	2			**94**
		Percent	25.5%	72.3%	2.1%			
Small fish	Males	Sample size	7					**7**
		Percent	100.0%					**100.0%**
	Total	Sample size	7					**7**
		Percent	100.0%					
Set gillnets &	Males	Sample size	31	105	323	81	2	**542**
spawning		Percent	5.7%	19.4%	59.6%	14.9%	0.4%	**51.3%**
grounds	Females	Sample size		2	374	135	3	**514**
All chinook		Percent		0.4%	72.8%	26.3%	0.6%	**48.7%**
	Total	Sample size	31	107	697	216	5	**1,056**
		Percent	2.9%	10.1%	66.0%	20.5%	0.5%	

Appendix A4.–Computer files used to estimate the spawning abundance and age, sex, and length data for chinook salmon in the Chickamin River in 2001.

File name	Description
Chickamin King 2001-FDS.xls	Spreadsheets containing mark-recapture data, summary tables, chi-square test results, Kolmogorov-Smirnov (K-S) 2-sample test results, abundance estimation, age, and sex composition data.
Chick01T&F.xls	Spreadsheets used to develop report tables and figures.