Fishery Data Series No. 96-37

Abundance of the Chinook Salmon Escapement on the Chickamin River, 1995

by

Keith A. Pahlke

November 1996

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Spell out acre and ton.

Time and temperature

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

Spell out year, month, and week.

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

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

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ABSTRACT

The abundance of large chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Chickamin River in 1995 was estimated using a mark-recapture experiment. Age, sex, and length compositions were estimated for the immigration. Set gillnets were used to capture 112 immigrant chinook salmon ≥660 mm in (mid-eye to fork) length during June, July, and August 1995; 109 fish were marked with spaghetti tags and opercle punches. During August, 167 chinook salmon ≥660 mm long were captured at spawning sites and inspected for tags; 7 of these fish had been previously marked. A modified Petersen model (n1 = 109, n2 = 167, m2 = 7) estimated that 2,309 (SE = 723) chinook salmon ≥ 660 mm in length immigrated to the Chickamin River in 1995. Peak survey counts in August totaled 356 large chinook, about 15% of the estimated inriver run.

From immigrant age and length composition data collected in gillnet and spawning ground samples, it was estimated that 1.8% of the gillnet catch was age -1.1, 20.2% was age -1.2, 37.6% age -1.3, 35.8% age -1.4, and 1.8% age -1.5 (72 males and 63 females) and that 7.3% of the spawning ground samples were age -1.2, 24.4% age -1.3, 66.7% age -1.4, and 1.6% age -1.5 (76 males and 92 females).

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, Chickamin River, mark-recapture, escapement, abundance, Behm Canal.

INTRODUCTION

In the mid- to late 1970s, it became apparent that chinook salmon *Oncorhynchus tshawytscha* stocks in the Southeast Alaska region were depressed, relative to historical levels of production (Kissner 1982). The Alaska Department of Fish and Game (ADF&G) developed a structured rebuilding program in 1981 to rebuild Southeast chinook salmon stocks over a 15-year period (roughly three life cycles; ADF&G 1981). The rebuilding program has been evaluated, in part, by monitoring trends in indices of escapement for important stocks. Stocks in eleven river systems in Southeast Alaska are surveyed annually: the Situk, Alsek, Chilkat, Taku, King Salmon, Stikine, Unuk, Chickamin, Blossom, and Keta rivers, and Andrew Creek. Of the eleven index systems, total escapement has been estimated at the Situk, Chilkat, Taku, Unuk and King Salmon rivers and at Andrew Creek.

The Unuk, Chickamin, Blossom, and Keta rivers flow through the Misty Fiords National Monument/Wilderness into Behm Canal, a narrow saltwater passage east of Ketchikan (Figure 1). These rivers constitute the four index systems for the chinook salmon program in southern Southeast Alaska (Pahlke 1994) and are collectively referred to as the Behm Canal chinook systems. Since 1975 these four systems have been monitored with annual peak surveys to provide index escapement counts. Between 1986 and 1989, survey counts reached peak levels in the Behm Canal systems, then began a steady decline. By 1993, concern for the status and health of these stocks became a priority issue. The Unuk River (the largest system) was selected for a study to validate the ongoing index program in 1994 (Pahlke et al. 1996) and a similar project was implemented on the Chickamin River in 1995.

The objectives of the study were:

(1) to estimate the abundance of large spawning chinook in the Chickamin River; and

(2) to estimate age, sex, and length compositions of chinook salmon in the Chickamin River.

Results from the study would permit a benchmark index survey-to-abundance expansion factor to be estimated; i.e., to estimate what fraction of total escapement is seen in the peak survey count.

STUDY AREA

The Chickamin River originates in a heavily glaciated area of northern British Columbia and flows into Behm Canal approximately 65 km northeast of Ketchikan, Alaska (Figure 2).

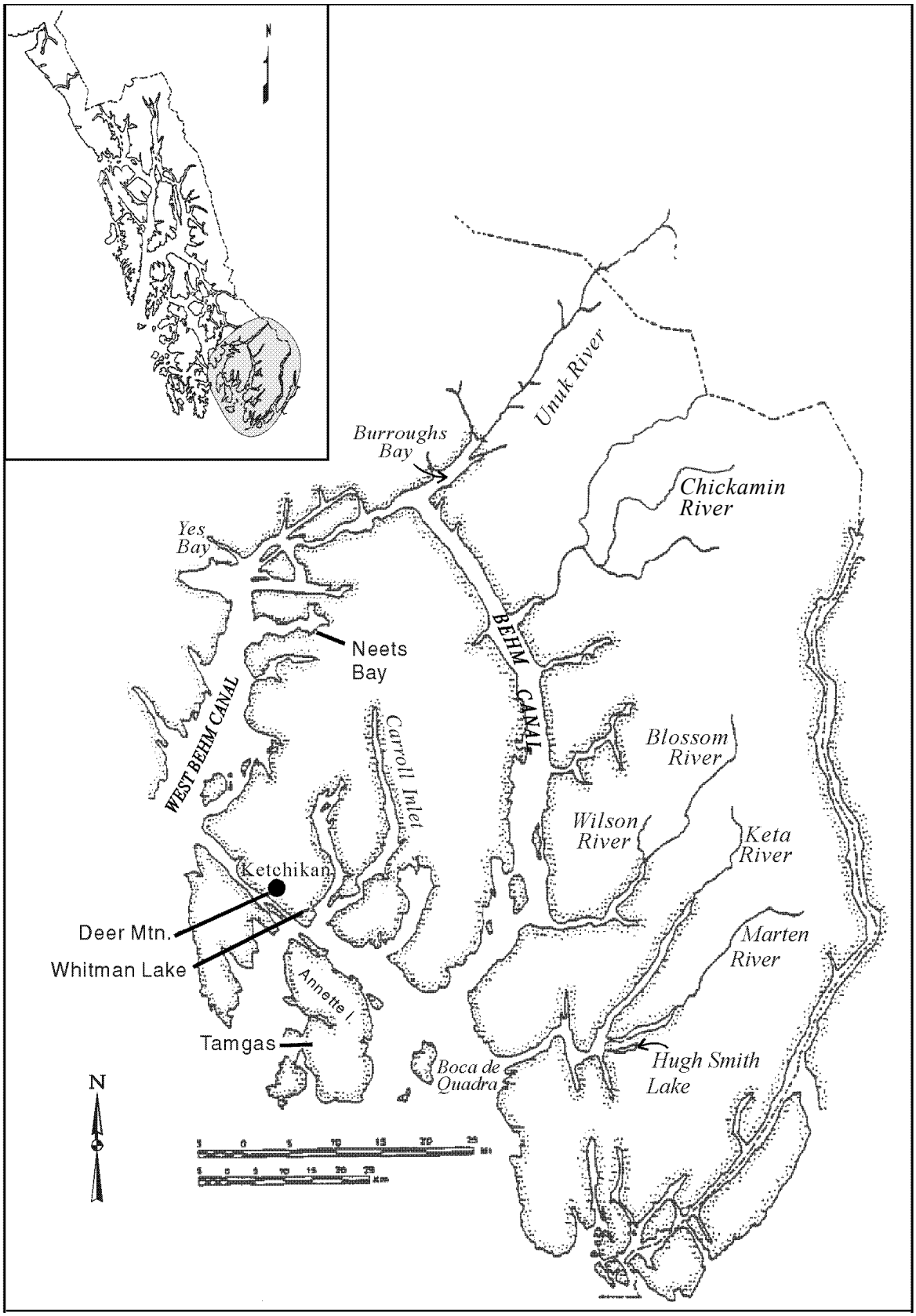

Figure 1. Behm Canal area, showing major chinook systems and hatcheries.

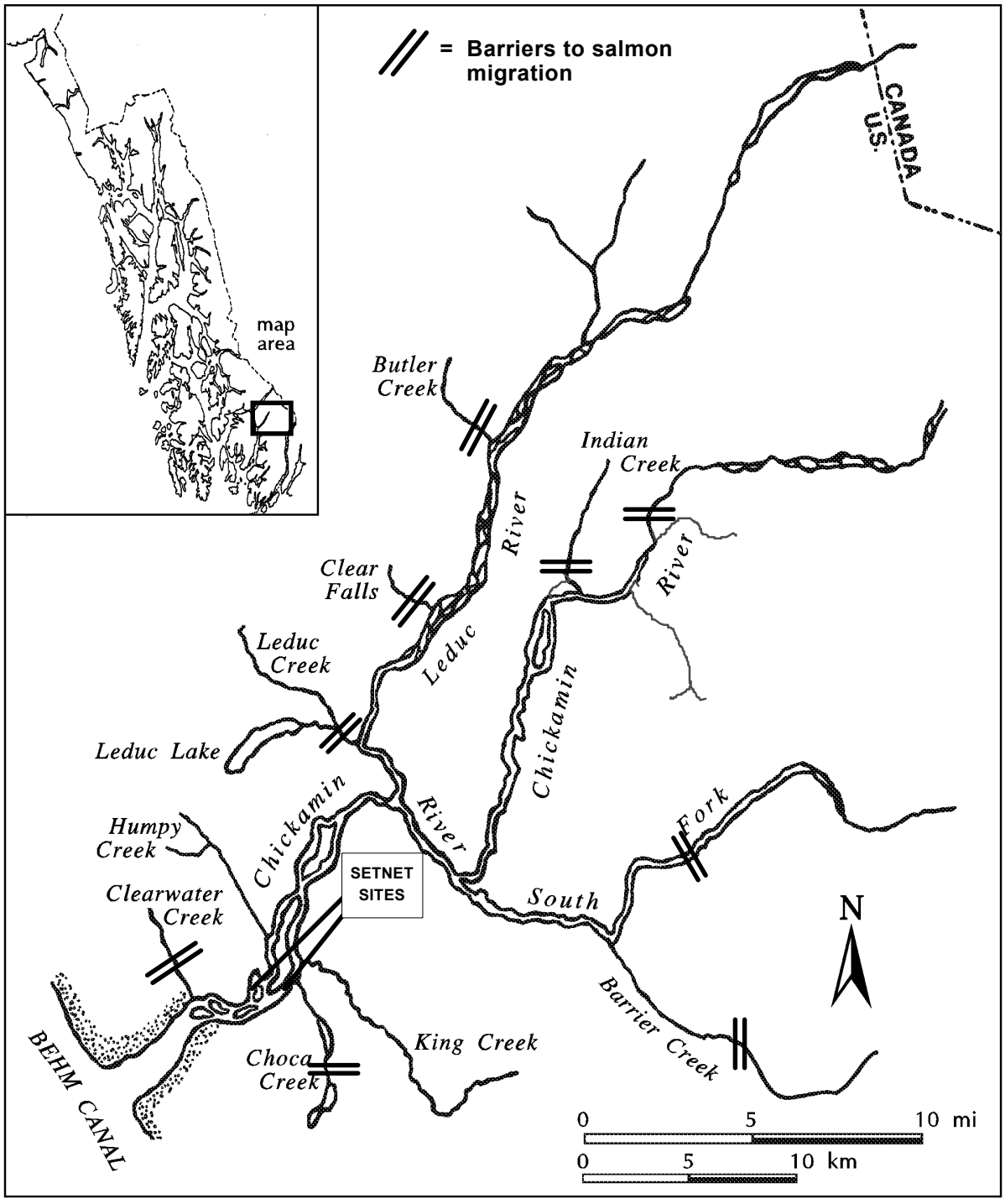

Figure 2. Chickamin River drainage, showing major tributaries, barriers to fish migration and location of ADF&G research sites.

Although it is technically a transboundary river, there are no known chinook salmon spawning areas on the Chickamin River in Canada. Eight spawning areas in Alaska are included in the index survey. Aerial survey counts and distribution of spawning chinook salmon to the eight areas in 1981–1995 are shown in Table 1. Average spawning distributions include: Humpy Creek (5%), King Creek (31%), Leduc Creek (3%), Clear Falls Creek (7%), Butler Creek (13%), Indian Creek (8%), South Fork (21%), and Barrier Creek (13%). Since 1981, it has been assumed that the sum of these index counts represents 62.5% of the total annual escapement to the Chickamin River (Pahlke 1994).

The present index escapement goal for Chickamin River chinook salmon is 525 fish ≥660 mm MEF length. This goal was adopted in July 1994 on the basis of spawner recruit analysis in McPherson and Carlile (*In prep.*).

METHODS

The abundance estimate of immigrating chinook salmon relied on marking fish with uniquely numbered tags as they traversed the lower Chickamin River to upstream spawning sites. Sampling effort was held reasonably constant across the temporal span of the migration. As immigration waned, sampling for marks and age composition began at spawning sites.

Set gillnets 100 feet long and 18 feet deep, made of 7.5-inch stretch mesh, were fished at two locations on the lower Chickamin River between June 12 and August 25 to capture adult chinook salmon. One site was located near the mouth of Humpy Slough and another site was located near the mouth of Choca Creek (Figure 2). These two sites were below all known spawning areas, with the exception of Humpy Creek.

One net was fished approximately 7 hours per day at the Choca Creek site, and two nets were fished approximately 7 hours per day (each) at the Humpy Slough site. Nets were set between 8 a.m. and 10 a.m. At the Choca Creek site, the net crossed about one third of the river, while at the Humpy Creek site the combined nets were fished in a 'V' shape that covered less than one fourth of the river. Both sites were fished daily unless high water or manpower shortages occurred. The nets were watched continuously and a fish was removed from the net as soon as it was observed. If fishing time was lost due to entanglements, snags, cleaning the net, or the like, the lost time (processing time) was added on to the end of the day to bring fishing time to 7 hours per net.

Captured chinook salmon were placed in a box filled with water, quickly untangled or cut from the net, tagged, scale sampled, and their length and sex recorded during a visual examination (Johnson et al. 1993). Fish were classified as "large" if their mid-eye to fork length (MEF) was > 660 mm, or "small" if their MEF was < 660mm (Pahlke 1994). Fish were judged to be "bright" or "dark" on the basis of external appearance, and the presence or absence of sea lice (*Lepeophtheirus* sp.) was noted. General health and appearance of the fish was recorded, including injuries due to handling or predators.

Each fish was marked with a uniquely numbered stainless steel tag, applied to the left operculum, a ¼-inch diameter hole in the dorsal portion of the operculum applied with a paper punch, and the amputation of the left axillary appendage (McPherson et al. 1996).

ABUNDANCE

The number of large chinook salmon in the Chickamin River escapement was estimated from a two-event mark-recapture experiment (Seber 1982). Fish captured by gillnet in the lower river and marked were included in event 1, and fish were inspected for marks on the spawning grounds for event 2. During event 2, fish were captured with dip nets and spears at seven spawning ground sites. The population was assumed to be closed during the study from August 7 through September 7.

Double-sampling on the spawning grounds was prevented by punching a hole in the lower (ventral) portion of the operculum of live fish

Table 1. Distribution of spawning chinook salmon among index areas of the Chickamin River for years when all index areas were surveyed.

Year	South Fork Creek	%	Barrier Creek	%	Butler Creek	%	Leduc Creek	%	Indian Creek	%	Humpy Creek	%	King Creek	%	Clear Falls Creek	%	Total
1981	51	13	105	27	51	13	25	7	12	3	4	1	105	27	31	8	384
1982	84	15	149	26	37	6	36	6	30	5	37	6	165	29	33	6	571
1984	185	17	171	16	124	11	15	1	103	9	88	8	388	35	28	3	1,102
1985	136	14	156	16	93	10	8	0	125	13	50	5	377	39	12	1	957
1987	261	27	76	8	120	12	19	2	115	12	26	3	310	32	48	5	975
1988	280	36	82	10	159	20	25	3	32	4	19	2	164	21	25	3	786
1989	226	24	90	10	137	15	57	6	84	9	22	2	224	24	94	10	934
1990	135	24	107	19	27	5	20	4	24	4	35	6	163	29	53	9	564
1991	125	26	18	4	49	10	14	3	38	8	13	3	185	38	45	9	487
1992	87	25	4	1	68	20	4	1	20	6	8	2	131	38	24	7	346
1993	67	17	46	12	68	17	11	3	29	7	13	3	80	21	75	19	389
1994	31	8	29	7	64	16	18	5	16	4	44	11	129	33	57	15	388
Avg.	161	22	96	13	92	13	22	3	57	8	30	4	228	31	43	6	728
1995	87	24	12	3	59	17	60	17	36	10	13	4	62	17	27	8	356

and slashing sampled carcasses. The length and sex of each fish was recorded if possible, along with the presence or absence of tags, opercle punches, and axillary fin clips. Five scales were collected from each fish for age analysis.

The validity of the (assumed closed-population) experiment rests on several assumptions, including that: (a) every fish has an equal probability of being marked in event one, *or* that every fish has an equal probability of being captured in event 2, *or* that marked fish mix completely with unmarked fish; (b) recruitment and "death" (emigration) do not both occur between sampling events; (c) marking does not affect catchability (or mortality) of the fish; (d) fish do not lose their marks between sample events; (e) all recovered marks are reported; and (f) double sampling does not occur (Seber 1982; Bernard and Hansen 1992).

Because of the duration of event 1 in this mark-recapture study, the first two assumptions must be carefully considered. Assumption (a) implies that tagging must occur in proportion to abundance during immigration, or if it does not, that there is no difference in age composition and immigration timing between stocks bound for different spawning locations, since mixing does not occur in time and between recovery areas. Assumption (a) also implies that sampling is not size-selective. Assumption (b) suggests tagging across the immigration, since deaths occur between sampling events.

A 2x2 contingency table (chi-square statistic) was used to test the hypothesis ($\alpha = 0.05$) that fish captured at the Choca Creek and Humpy Slough tagging sites were bound at equal rates for upper (Butler, Clear Falls, Leduc, Indian, Barrier, South Fork creeks) and lower (Humpy and King creeks) Chickamin River spawning sites. A similar test was used to determine if fish tagged at the two sites were recovered at equal rates. If they were, data for both sites were combined to estimate abundance.

To provide evidence that assumption (a) was met, contingency table analysis was used to test the hypothesis ($\alpha = 0.05$) that fish sampled in upper and lower spawning sites were marked at similar rates. If this hypothesis was accepted, a simple Petersen model was used to estimate abundance; otherwise a stratified Petersen model (Darroch 1961; Seber 1982, chapter 11) was employed. Variance, bias and confidence intervals for the Petersen estimator were estimated with modifications of the bootstrap

procedures in Buckland and Garthwaite (1991). Also, contingency table analysis was used to determine if fish marked early (prior to July 13) and late (July 13–August 22) in the immigration traveled at similar rates to spawning sites in the upper and lower Chickamin River. If this hypothesis was rejected, migratory timing of the stocks differed, and rationale for stratifying the marking event by time was demonstrable.

Confidence intervals for the estimate were calculated using the bootstrap percentile method (Efron and Tibshirani 1993). The difference between the average of bootstrap estimates and the Petersen estimator is an estimate of the statistical bias in the latter statistic (Efron and Tibshirani 1993).

The possibility of selective sampling was also investigated, since assumption (a) could be violated if sampling rate varied according to the size (or sex) of the fish. The hypothesis that fish of different sizes were captured with equal probability was tested with a Kolmogorov-Smirnov (K-S) 2-sample test (Bernard and Hansen 1992). Sex selection was tested using a 2 x 2 contingency table. If apparent, the abundance estimation procedures could be stratified by ages (age .3 versus age .4 and .5) and/or by sex.

Recruitment of untagged fish into the population was unlikely (assumption b), because gillnetting operations spanned the immigration and continued without large interruption. We assume tagged and untagged fish experience the same mortality (assumption c) from natural causes. Thus, estimates are germane to the time of tagging rather than recapture. To minimize effects of tag loss, all marked fish received a dorsal opercle punch, and the left axillary appendage was clipped, providing secondary marks which cannot be lost. Similarly, we inspected all fish captured on the spawning grounds for marks (assumption e), and double sampling was prevented by placement of a ventral opercle punch (assumption f).

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

All fish captured in the gillnet and spawning ground surveys were sampled for scales to enable age determination (Olsen 1995). Proportions by age or by sex in gillnet and spawning grounds samples were estimated by

$$\hat{p}_i = \frac{n_i}{n} \qquad (1)$$

$$V[\hat{p}_i] = \frac{\hat{p}_i(1-\hat{p}_i)}{n-1} \qquad (2)$$

where

p_i = proportion in the age, sex, or length group i;

n_i = the number in the sample of group i; and

n = sample size.

The age composition of chinook captured in the two lower river gillnets was compared using a chi-square test, prior to combining these samples. The test was also conducted for the different spawning areas. The age composition of the combined gillnet samples was compared with the age composition from the pooled spawning grounds using another chi-square test.

Estimates of mean length at age and its variance was calculated by standard normal procedures.

RESULTS

One hundred twelve (112) large (age 1.3 and older) and 23 small chinook salmon were captured in the lower Chickamin River between June 12 and August 25, 1995 (Table 2; Appendices A1, A2). Setnet effort was maintained at 7 hours per day, with two nets at the Humpy Slough site and one net at the Choca Creek site, although several days were not sampled (Figure 3c; Appendices B1, B2).

Catch rates ranged from 0 to 0.85 fish/net/hour, peaking on June 29, when 8 large chinook were captured (Figure 3a). The date of 50% cumulative

Table 2. Catch of large chinook salmon, number marked with tags and mortalities, by tagging site and sex, Chickamin River, 1995.

	Choca Creek site			Humpy Slough site			
	Male	Female	Subtotal	Male	Female	Subtotal	Total
Catch	20	27	47	30	35	65	112
Tagged	20	26	46	29	34	63	109
Mortalities		1	1	1	1	2	3

catch was July 10 at the Choca Creek site and July 12 at the Humpy Slough site (Figure 4). Two large fish died in the nets, and one adipose clipped fish was sacrificed to recover the coded-wire tag. The remaining 109 fish were marked with stainless steel tags, upper opercle punches and axillary appendage clips. The sex ratio of large chinook salmon caught in the gillnets was approximately equal (62 females, 50 males). Small chinook were released without any tags. In addition, 2,976 chum *O. keta*, 6 sockeye *O. nerka* and 5,791 pink salmon *O. gorbuscha* were captured and released (Appendix B).

ABUNDANCE

One hundred sixty-seven (167) large chinook salmon were examined for marks on the spawning grounds, and 7 marked fish were recovered (Table 3). Only 3 of the recovered fish still carried the numbered tag; the remaining 4 fish could not be identified as to tagging site or date. The distribution of fish tagged at the Humpy Slough site was not significantly different from that of fish tagged at the Choca Creek site ($\chi 2 = 0.76$, df = 1, P = 0.383), so tags from each site were also pooled. There was no significant difference between the distribution of fish tagged prior to July 13 and from July 13 to August 22 ($\chi 2 = 0.75$, df = 1, P = 0.386), which indicated a similar migratory timing for the stocks.

Finally, the probability of recovering a marked fish in the lower (Humpy and King, 0.087) and upper tributaries (Leduc, Clear Falls, Butler, Indian, South Fork, Barrier, 0.035) was not significantly different ($\chi 2 = 1.06$ df = 1, P = 0.303). The power of these tests to detect violations of the mark-recapture experiment assumptions was very low because of small sample sizes. With this caveat, Chapman's modified Petersen model (n1 = 109, n2 = 167, m2 = 7) could be used to estimate the number of large chinook salmon in the escapement to the Chickamin River.

Large females were captured more frequently than large males (97 females versus 70 males) in the escapement samples. This result is likely related to the observation (Paul Kissner, 1985) that female chinook salmon tend to die on their redds, while males tend to drift downstream after spawning. This sexual trait can cause size selective sampling if females tend to be older or larger than males.

Length distributions of fish marked in event 1 and recovered in event 2 were not significantly different (KS tests, P = 0.17; Figure 5a). However, the length distributions of fish captured in event 1 and event 2 were different (KS test, P < 0.001; Figure 5b). These tests indicate size selectivity during event 1, and that only fish sampled during event 2 should be used to estimate the age, sex and length compositions (Bernard and Hansen 1992). However, since there were only 7 recaptures, the power of the first hypothesis test is very low. Some size selectivity probably occurred in event 2, due to the selection for somewhat larger female carcasses. Thus, the experiment could be stratified by sex (or size) if sample sizes were large. However, since only 7 marked fish were recovered this was not possible.

Although 4 of 7 fish sampled in spawning ground surveys had lost their primary (numbered) tag, tag loss is not a factor in the experiment, because fish did not lose their secondary or tertiary marks. The estimated abundance was 2,309 fish (SE = 723). The 95% bootstrap confidence limits were 1,388 and 4,650, and the estimated relative bias was 12.4%.

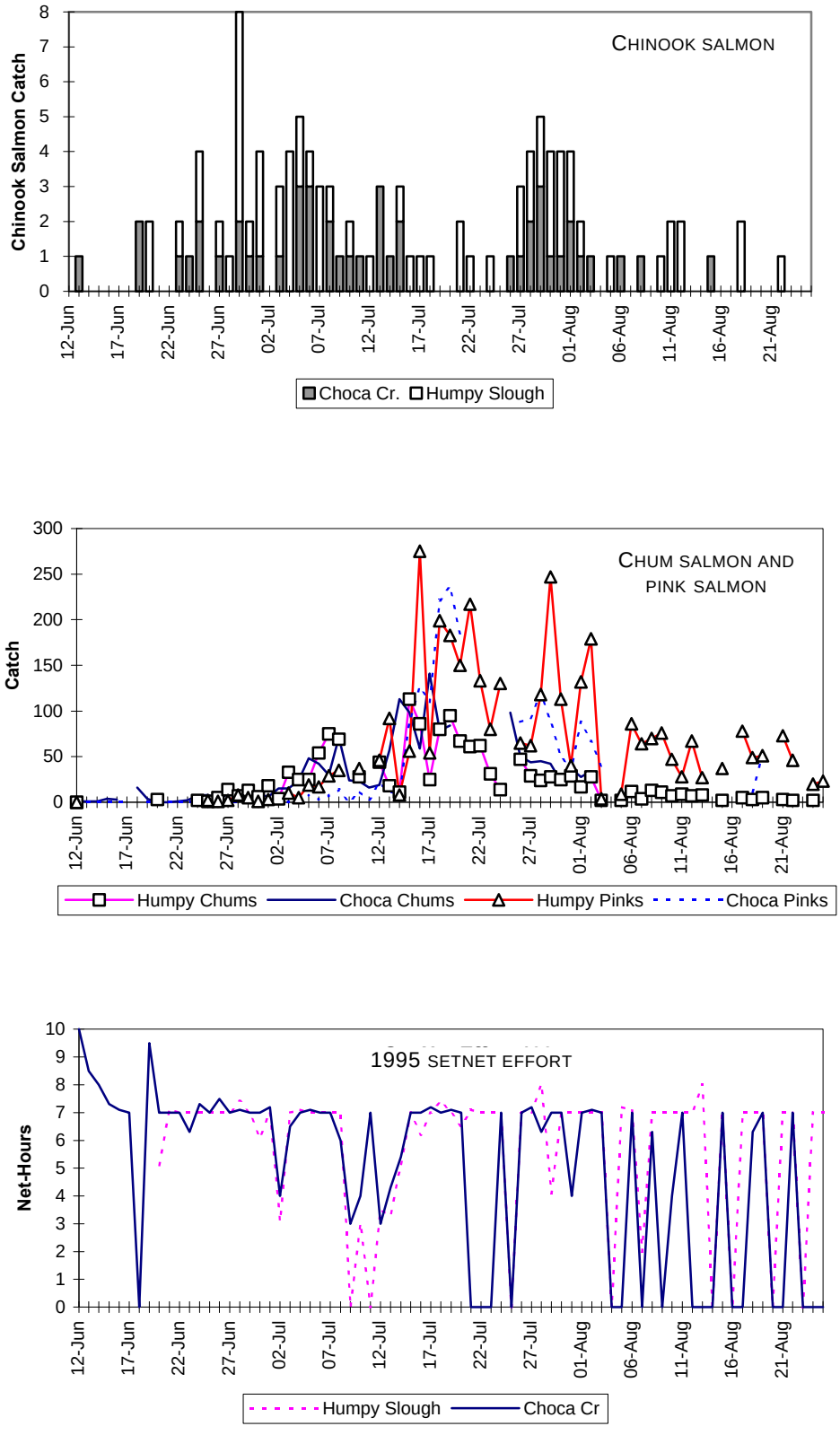

Figure 3. Daily catch of large chinook salmon, daily catch of chum and pink salmon, and setnet effort (net-hours), by date and location, Chickamin River, 1995.

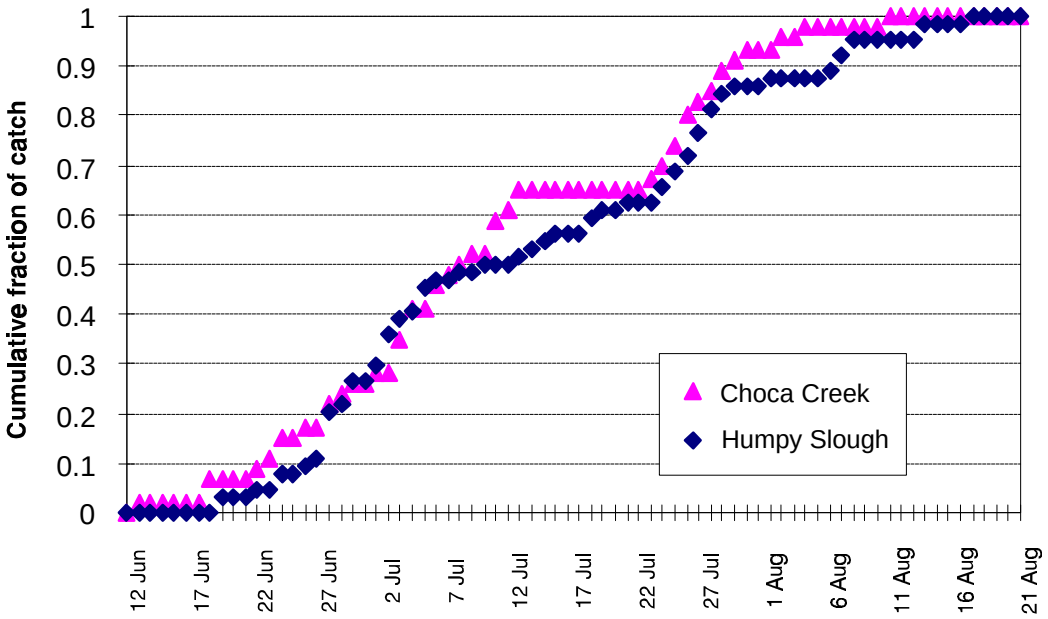

Figure 4. Cumulative catch of large chinook salmon by date and capture site, Chickamin River, 1995.

Table 3. Numbers of marked and unmarked chinook salmon sampled during spawning ground surveys by size and location, Chickamin River, 1995.

	Captures				Recaptures		
	Large		Small		Large		
Location	Males	Females	Males	Females	Males	Females	Comments
Humpy Creek	4	3	0	0	0	0	
King Creek	6	12	3	0	1	1	includes 1 lost tag
Leduc Creek	4	14	0	0	0	0	1 unknown sex in male column
Clear Falls Creek	6	6	3	0	0	0	
Butler Creek	19	18	2	0	1	0	includes 1 lost tag
Indian Creek	6	7	2	0	1	0	includes 1 lost tag
South Fork	25	37	2	0	1	2	includes 1 lost tag
Barrier Creek	0	0	0	0	0	0	
Total	70	97	12	0	4	3	

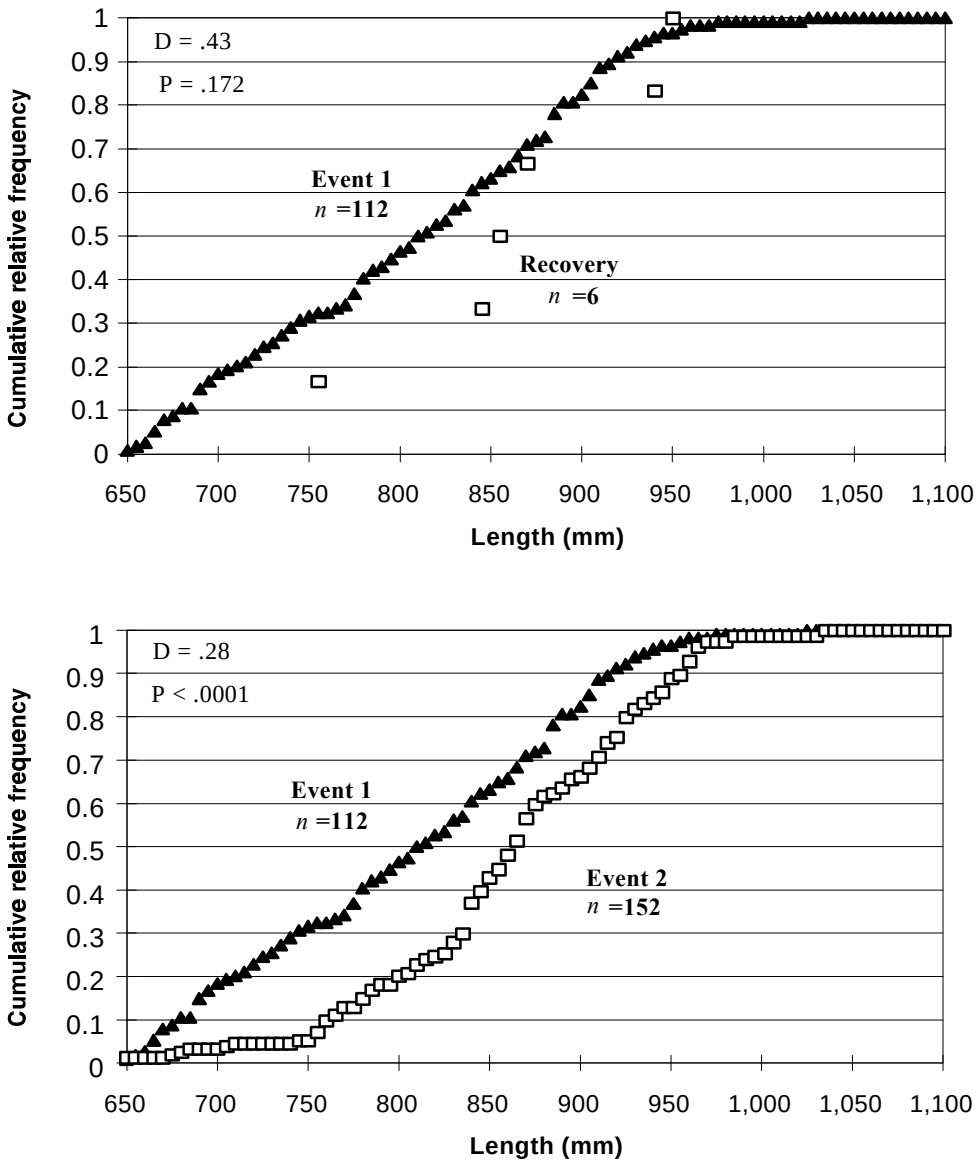

Figure 5. Cumulative relative frequency of large chinook salmon captured in event 1 (lower river setnet) and marked chinook salmon recovered in event 2 (spawning ground sampling) and cumulative relative frequency of chinook salmon captured in event 1 and all chinook salmon sampled in event 2.

AGE, SEX, AND LENGTH COMPOSITIONS

Sex, length and scale samples were collected from 135 chinook salmon during gillnetting in the lower river. Complete (both fresh and salt water) ages could be determined for 109 fish; saltwater age and sex was estimated for 135 fish. The dominant age classes were 1.3 and 1.4 (Table 4). With the exception of four fish age 2., all sampled fish spent 1 year in fresh water. The gillnet sample was 53% male and 47% female. As expected, small fish were scarce in the large-mesh gillnet catches; however, they were even scarcer in spawning ground samples. Length and sex was recorded for every fish but is reported only for fish of known age (Table 5). Lengths from all fish were used in analysis of length distribu-tions. Lengths ranged from 360 to 1,025 mm.

Table 4. Age composition of chinook salmon in the Chickamin River set gillnet catch and spawning ground samples, by sex and age class, 1995.

	Brood year and age class								
	1992	1991	1990		1989		1988	1987	
	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Total
GILLNET SAMPLE									
Female	0	0	15	0	30	0	2	1	48
Male	2	22	26	1	9	1	0	0	61
Percent	1.8	20.2	23.9	0.9	8.3	0.9			56.0
SE	1.3	3.9	4.1	0.9	2.6	0.9			4.8
All fish	2	22	41	1	39	1	2	1	109
Percent	1.8	20.2	37.6	0.9	35.8	0.9	1.8	0.9	1.0
SE	1.3	3.9	4.7	0.9	4.6	0.9	1.3	0.9	
SPAWNING GROUND SAMPLE									
Female	0	0	10		52		2		64
Percent			8.1		42.3		1.6		52.0
SE			2.5		4.5		1.1		4.5
Male	0	9	20		30		0		59
Percent		7.3	16.3		24.4				48.0
SE		2.4	3.3		3.9				4.5
All fish	0	9	30		82		2		123
Percent		7.3	24.4		66.7		1.6		100.0
SE		2.4	3.9		4.3		1.1		
COMBINED SAMPLE									
Female	0	0	25		82		4	1	112
Percent			10.8		35.3		1.7	0.4	48.3
SE			2.0		3.1		0.9	0.4	3.3
Male	2	31	46	1	39	1	0		120
Percent	0.9	13.4	19.8	0.4	16.8	0.4			51.7
SE	0.6	2.2	2.6	0.4	2.5	0.4			3.3
All fish	2	31	71	1	121	1	4	1	232
Percent	0.9	13.4	30.6	0.4	52.2	0.4	1.7	0.4	100.0
SE	0.6	2.2	3.0	0.4	3.3	0.4	0.9	0.4	

One hundred seventy-nine (179) fish were examined during spawning ground sampling, and scale samples were obtained from 169 individuals. Complete ages could be determined for 123 fish, saltwater ages for 167; sex was estimated for 178 fish, and length was recorded for 164 fish.

All sampled fish spent 1 year in fresh water, and the dominant ages were 1.3 and 1.4 for males and 1.4 for females (Table 4). The sample was 54% female and 46% male. Length ranged from 430 to 1,035 mm (Table 5). Pooled gillnet and spawning ground samples were used to estimate age and sex composition of the escapement (Table 4).

One adipose fin clipped chinook salmon was recovered from the Chickamin River spawning grounds in 1995. The CWT indicated the fish was from a group of Unuk River broodstock fish released from Little Port Walter Hatchery in 1991.

DISCUSSION

Concerns about a possible conservation problem for Behm Canal chinook stocks stem almost entirely from the decline in observed escapements. Similar concerns over low observed peak escapements in the Chilkat River had resulted in fishery restrictions and an adult mark-recapture and radio tagging study in 1991 and 1992 (Johnson et al. 1992). The radio tags showed the spawning distribution to be greatly different from the surveyed index areas, and the mark-recapture estimate was an order of magnitude higher than the observed counts. In that case, the index areas proved not to be representative of the actual escapement, and the surveys were discontinued. The Chilkat study cast some doubt on other chinook index surveys that haven't been validated by weir counts or mark-recapture studies.

This study does not address the conservation issue directly, but shows that escapement to the Chickamin River in 1995 was greater than previously assumed expansion factors would have indicated (see Table 1 and Pahlke 1995); Chickamin River index counts are normally expanded by 1.6 to estimate escapement.

About 15.4% (or 356) of the estimated 2,309 large chinook salmon immigrating to the Chickamin River in 1995 were counted in the peak aerial survey, the same as the proportion of the estimated escapement observed on the Unuk River in 1994 (Pahlke et al. 1996). Much lower percentages were observed in the Chilkat River, a glacial Southeast Alaska chinook salmon system where few clearwater tributary areas are available to count spawning fish (Johnson et al. 1992, 1993). In contrast, Skaugstad (1993) found that aerial surveys for chinook salmon accounted for between 19 and 71% of the mark-recapture estimate on the Salcha River, a large clearwater tributary of the Yukon, depending on the size of the escapement and survey conditions.

A concern in planning this study was that the mouths of Humpy Creek and King Creek, known chinook spawning areas, are very low in the Chickamin River and subject to tidal influence. Both sampling sites were also located in intertidal areas which presented two potential problems. First, the effectiveness of the gillnets in capturing fish will be affected by the changing tides, and behavior of migrating fish may also be linked to tides. Second, fish that have just entered fresh water may be more susceptible to stress-related mortality than fish that are acclimated to fresh water (Vincent-Lang et al. 1993).

There did not appear to be any relationship between chinook salmon catches and tide stage. Chinook were captured in small numbers at all stages of tide and river depth (Appendix B). Both sites were effective at catching fish of the targeted size range, as indicated by the catches of chinook and also by the large catches of similar sized chum salmon throughout the duration of the study. Chum catches were so high on some days (peak daily catch 141 fish) that the effectiveness of the nets may have been affected by gear saturation (Rothschild 1978). The highest chum catches during mid July corresponded with a drop in chinook catches, which then increased again in late July as the chum catches dropped (Figure 3b). We saw "bright" fish with sea lice (indicating recent entry into fresh water; McLean et al. 1990) in our gillnets as late as August 3, and "dark" fish without lice were caught as early as June 28. Whether there actually is a bimodal pattern in chinook immigration timing or the decrease in chinook catches in July was a result of high chum catches cannot be determined from this study, due to the small number of tag recoveries.

Increased mortality due to handling is a concern in this study. The number of tags recovered was small, and no fish were radio-tagged to provide an estimate of mortality. Vincent-Lang et al. (1993) documented much higher mortality rates in sport caught coho salmon captured in estuary waters than in fish captured above the estuary. However, chinook salmon captured with sport gear in estuary waters of the Kenai River experienced handling mortalities of less than 10% (Bendock and Alexandersdottir 1992). In a mark-recapture study on the Unuk River in 1994, chinook salmon were captured and handled similar to the fish in this study, except that capture sites were upriver from major tidal influence and a different external tag was used. A portion of those fish were also marked with radio

Table 5. Estimated length composition of chinook salmon in Chickamin River set gillnet catch and spawning ground samples, by sex and age class, 1995.

	Brood year and age class								
	1992	1991	1990		1989		1988	1987	
	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	Total
GILLNET SAMPLE									
Female									
Sample size			15		30		2	1	48
Avg. length			767		866		888	810	
SE			63.41		69.56		3.54		
Male									
Sample size	2	22	26	1	9	1			61
Avg. length	398	634	740	635	869	845			
SE	53.03	64.49	78.91		78.16				
All fish									
Sample size	2	22	41	1	39	1	2	1	109
Avg. length	398	634	750	635	866	845	888	810	
SE	53.0	64.5	73.9		70.6		3.5		
SPAWNING GROUND SAMPLE									
Female									
Sample size			10		47		2		59
Avg. length			805		884		918		
SE			35.70		50.48		17.68		
Male									
Sample size		9	20		26				55
Avg. length		607	765		905				
SE		75.13	59.10		69.47				
All fish									
Sample size		9	30		73		2		114
Avg. length		607	778		892		918		
SE		75.13	55.20		58.29		17.68		

transmitters, and 86% of the radio-tagged fish were successfully tracked to spawning grounds, indicating low mortality due to capture by set gillnets and tagging procedures (Pahlke et al. 1996). Loss of the steel jaw tags used in 1995 was significant (4 of 7); however, the secondary marks were effective at identifying marked fish.

Although sample sizes are small (Table 3), recovery rates of marked fish in lower (King and Humpy Creeks, 0.087) and upper spawning areas (all others, 0.035) were not significantly different ($\chi 2 = 1.06$, $P = 0.303$). Also, there was no statistical difference between recovery rates of fish marked at each site. Of the seven spawning areas sampled, marked fish were recovered in four of the larger samples. Thus, some concern regarding capture locations in the lower Chickamin River was relieved following the sampling.

Several assumptions required to estimate the abundance of spawning chinook salmon in this study deserve additional discussion. Our primary strategy for satisfying assumptions of the abundance study was to maintain constant fishing effort across the migration. Fishing effort was not held constant over the entire immigration (Figure 3). However, because tests to detect different tagging fractions and/or migratory timing of up- and downriver stocks

were inconclusive due to small sample size, we cannot conclude a problem resulted from the variations in tagging effort over time.

Two other difficulties in the study are hard to resolve. First, statistical tests to detect departures from assumptions of experiments (Table 3) have low power because of small sample sizes. We had neither the ability to boost sample sizes greatly (to remove this problem), nor have we undertaken simulation studies to discern the extent to which biases might exist in worst-case situations. However, we take some comfort from a belief the experimental design is generally sound and that significant departures from the assumptions have not been identified in similar, previous studies (Johnson et al. 1992, 1993; Pahlke et al. 1996). One relatively simple method of addressing this problem in future studies is to increase sample sizes in spawning ground surveys.

Second, length and sex composition data in this study indicate that size selective sampling may have occurred in both the spawning surveys and during gillnet fishing. Gillnets are well documented to be size selective, but for the fish of interest in this experiment (length ≥660 mm MEF), gillnets do not show strong selectivity. In addition, the age composition of the large fish captured in the gillnets was not similar to that of the spawning ground escapement sample (Table 4).

Spearing dead and dying fish was our primary method of collecting fish on the spawning grounds. There are two possible problems with this method of sampling. First, behavior differences between sexes (commitments to redds after spawning) may result in selective sampling, as noted earlier. Also, females tend to develop white tails which are quite visible as they remain near their redds, while males do not. This causes further selective sampling of females, because they are more easily seen.

Other methods might be used to obtain large, unbiased samples on the spawning grounds under these conditions. One would be to build upstream migrant weirs. Also, dip nets, seines, and angling could be used to sample pre-spawning fish in a more random manner.

Spawning ground sampling was hampered by a logjam in the Leduc River, which prevented access by boat to Leduc, Clear Falls and Butler creeks. Also, the observed escapement to King Creek in 1995 was only 62 fish, down from the 1981–1994 average of 228. King Creek has the latest spawning timing in the Chickamin and usually accounts for almost a third of the chinook counted (Table 1). In 1995, only 17% of the observed escapement was in King Creek, the lowest proportion ever observed.

CONCLUSIONS AND RECOMMENDATIONS

This was the first attempt at estimating the total escapement of chinook salmon to the Chickamin River. Although sample sizes were small, it appears feasible to conduct a mark-recapture experiment with acceptable results using methods developed in 1995. Operation of set gillnets appears to be an effective method of capturing large chinook salmon migrating up the Chickamin River. Index area counts underestimate the magnitude of the escapement. The project should be repeated to provide replicates of the 1995 study, with radio tags applied in event 1 to provide estimates of handling mortality, and modifications in event 2 required to increase the sample size.

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APPENDIX

Appendix A1. Fish number, date captured, length, age, tag number and comments on fish captured on the Chickamin River, Humpy Slough site, 1995.

No.	Date	Sex	Length (MEF)	Age			Tag no.		Comments
				FW	SW	AEC	Jaw	Ad clip	
1	20-Jun	M	885	1	4		26		Brown, no lice, good condition
2	20-Jun	F	930	1	4		27		Bright, no lice, seal bite, good condition
3	20-Jun	M	650	1	2				Bright, no lice, bad bite, probably died, UOP
4	23-Jun	M	840	1	4		28		Reddish/semi-bright, healed slash, healthy, UOP
5	25-Jun	F	925			3	30		Bright, lice, good condition, UOP
6	25-Jun	F	865		4	3	31		Bright, lice, good condition, UOP
7	27-Jun	F	765		4	3	34		Bright, lice, red meat, good cond, small female
8	27-Jun	M	655	1	3				Bright, lice, UOP
9	28-Jun	F	785		3		36		Dark, poor condition
10	29-Jun	M	885	1	4		37		Bright, good condition, red meat
11	29-Jun	M	690			3	38		Bright, good condition, red meat
12	29-Jun	M	665	1	2		39		Bright, good condition, red meat
13	29-Jun	F	905	1	4		40		Bright, good condition, red meat
14	29-Jun	F	870		4	3	41		Bright, good condition, red meat
15	29-Jun	M	670	1	2		42		Bright, good condition, red meat
16	30-Jun	M	775	1	3		43		Bright/pink, good condition, red meat
17	1-Jul	F	910		4	3	44		Bright, good condition, red meat
18	1-Jul	F	905	1	4		46		Bright, good condition, red meat
19	1-Jul	M	845	2	3		47		Semi-bright, good condition, red meat
20	3-Jul	M	695	1	2		48		Bright, good condition, red meat
21	3-Jul	F	900	1	4		49		Bright, good condition, red meat
22	4-Jul	F	910	1	4		50		Bright, good condition, red meat
23	4-Jul	M	580	1	2				Bright, good condition, red meat
24	4-Jul	M	955	1	4		51		Dark, good condition, red meat
25	4-Jul	F	820	1	4			18901	Bright, killed Ad Clip, white meat
26	4-Jul	M	780	1	3		52		Dark, fair condition, red meat
27	5-Jul	M	710		3	3	53		Semi-bright, good condition, red meat
28	5-Jul	F	930	1	4		54		Bright with gray, good condition, red meat
29	6-Jul	F	730	1	4		55		Bright, good condition, red meat
30	7-Jul	M	360	1	1				Bright, good condition, red meat
31	7-Jul	F	920	1	4		56		Bright, good condition, red meat
32	7-Jul	F	720	1	3		57		Brown, good condition, red meat
33	7-Jul	F	775	1	3		58		Red/dark, good condition, red meat
34	8-Jul	F	810	1	3		59		Brown, good condition, red meat
35	10-Jul	F	910	1	4		60		Bright, good condition, red meat
36	12-Jul	M	680	1	2		61		Bright, good condition, red meat
37	15-Jul	M	775		3	3	62		Bright, good condition, red meat
38	16-Jul	M	785	1	3		63		Reddish, very tired, red meat
39	17-Jul	F	940	1	4		64		Semi-bright, good condition, red meat
40	18-Jul	F	810	2	4		65		Dark, good condition, white meat
41	18-Jul	F	635	1	3				Bright, smallest female ever seen
42	19-Jul	M	635	1	2				Bright, good condition, red meat
43	21-Jul	M	690	1	3		66		Bright, good condition, red meat
44	21-Jul	M	640	1	2				Semi-bright, good condition, red meat
45	21-Jul	M	690	1	2		67		Bright, good condition, red meat
46	21-Jul	M	615	1	2				Bright, sluggish, red meat
47	22-Jul	M	835	1	4		68		Semi-bright, brown, good shape, red meat
48	24-Jul	F	740	1	3		69		Bright, good condition, red meat
49	26-Jul	M	630	1	3				Gray, good condition
50	26-Jul	M	475		2	3			Bright, good condition

-continued-

Appendix A1. Page 2 of 2.

No.	Date	Sex	Length (MEF)	Age			Tag no.		Comments
				FW	SW	AEC	Jaw	Ad clip	
51	27-Jul	F	700	1	3		70		Bright, good shape, red meat, scar
52	27-Jul	F	880		5	3	71		Bright, good shape, white meat
53	27-Jul	M	640	1	3				Bright, good shape, red meat
54	28-Jul	M	795	1	3		72		Dark/red, good condition, red meat
55	28-Jul	F	885	1	4		73		Semi-bright, good condition, red meat
56	29-Jul	M	705	1	2		74		Bright, good condition, red meat
57	29-Jul	M	670	1	3		75		Bright, good condition, red meat
58	29-Jul	M	560	1	2				Bright, good condition, red meat
59	30-Jul	F	860	1	4		101		Bright/gray, good condition, red meat
60	30-Jul	F	830	1	4		102		Bright, good condition, red meat
61	30-Jul	M	640	1	2				Bright, good condition, red meat
62	30-Jul	M	735	1	3		103		Bright, good condition, red meat
63	31-Jul	F	875	1	3		104		Semi-bright, good condition, red meat
64	31-Jul	F	825	1	4		105		Semi-bright, 20 min revival time after picking from net
65	31-Jul	F	680	1	4		106		Super-bright, good condition, red meat
66	1-Aug	F	740			3	110		Bright, good condition, no scales
67	1-Aug	M	795	1	4		111		Green/black/red, good condition, red meat
68	1-Aug	M	790	1	4		112		Bright/brown, good condition, white meat
69	2-Aug	M	800		4				Mortality, light red, red meat
70	5-Aug	M	675	1	3		114		Bright, good condition, red meat
71	8-Aug	M	440	1	2				Bright, good condition
72	8-Aug	M	625	1	2				Semi-bright, good condition
73	10-Aug	M	665	1	2		116		Semi-bright/reddish, good condition, red meat
74	11-Aug	M	695	1	2		118		Bright, good condition, red meat
75	11-Aug	F	855		4	3	119		Green, good condition, red meat
76	11-Aug	M	645	1	3				Bright, good condition, red meat
77	12-Aug	M	735	1	3		121		Green/black, good condition, red meat
78	12-Aug	M	935	1	3		123		Bright gray, good condition, white meat
79	18-Aug	F	890	1	5		125		Bright gray, sluggish, red meat
80	18-Aug	F	905		4	3	151		Gold gray, good condition, red meat
81	22-Aug	F	840	1	4		153		Bright, good condition, red meat

Appendix A2. Fish number, date captured, length, age, tag number and comments on fish captured on the Chickamin River, Choca Creek site, 1995.

No.	Date	Sex	Length (MEF)	Age FW	Age SW	Age AEC	Tag no. Jaw	Tag no. Ad clip	Comments
1	13-Jun	F	885	1	5				Dead in net, white flesh
2	19-Jun	F	780	1	3		1		Semi-bright, good condition
3	19-Jun	M	820	1	3		2		Semi-bright, good condition
4	23-Jun	M	1025	1	4		3		Bright gray, good condition, red meat
5	24-Jun	F	840	1	4		4		Bright, good condition, red meat
6	25-Jun	F	840	1	4		5		Bright, good condition, red meat
7	25-Jun	F	890		4	R	6		Bright gray, minor gill bleed, white meat
8	27-Jun	F	885	1	4		10		Bright, good condition, red meat
9	29-Jun	M	700	1	3		7		Bright/reddish, good condition, red meat
10	29-Jun	M	635	1	2				Bright, good condition
11	29-Jun	F	750	1	4		8		Bright gray, good condition, red meat
12	30-Jun	M	725	1	3		25		Semi-bright/red, fair condition, red meat
13	1-Jul	F	910		4	R	9		Bright, good condition, red meat
14	3-Jul	M	780			R	11		Brown, good condition, no scales, red meat
15	3-Jul	F	830	1	4		12		Bright, good condition, red meat
16	5-Jul	F	865		4	R	13		Bright, good condition, red meat
17	5-Jul	F	720	1	3		14		Bright, good condition, red meat
18	5-Jul	M	850	1	3		16		Bright, good condition, red meat
19	5-Jul	M	640		3	R			Bright, good condition, red meat
20	6-Jul	F	900	1	4		17		Bright, good condition, red meat
21	6-Jul	M	625		2	R			Bright, good condition, red meat
22	6-Jul	M	635	2	2				Bright, good condition, red meat
23	6-Jul	M	870		3	R	18		Bright gray, good condition, red meat
24	6-Jul	F	830	1	3		19		Brown, good condition, red meat
25	8-Jul	F	845	1	4		20		Bright, good condition, red meat
26	8-Jul	M	815	1	4		21		Red, good condition, red meat
27	9-Jul	M	715	1	3		22		Bright, good condition, red meat
28	10-Jul	F	870	1	4		76		Bright gray, good condition, white meat
29	11-Jul	M	690	1	3		23		Semi-bright, bleeding from gill, red meat
30	13-Jul	F	755	1	3		77		Brown, good cond, split snout, hook wound, red meat
31	13-Jul	F	770	1	3		78		Bright, good condition, red meat
32	13-Jul	F	855	1	3		79		Bright, good condition, red meat
33	14-Jul	M	800	1	3		80		Semi-bright gray, good condition, white meat
34	15-Jul	F	960	1	4		82		Dark, good condition, red meat
35	15-Jul	F	725	1	3		83		Bright, good condition, red meat
36	18-Jul	M	635	1	2				Gray, tired, red meat
37	26-Jul	M	745	1	3		85		Dark, good condition, red meat
38	27-Jul	M	660	1	2		86		Gray, good condition, red meat
39	28-Jul	F	810	1	3		87		Gray, good condition, red meat
40	28-Jul	M	805	1	3		88		Pink, tired, red meat
41	29-Jul	M	885	1	3		89		Semi-bright, good condition, red meat
42	29-Jul	F	920		4	R	90		Bright, good condition, red meat
43	29-Jul	F	975	1	4		91		Semi-bright, good condition, red meat
44	30-Jul	F	890	1	4		92		Bright, good condition, red meat
45	31-Jul	M	945		4	R	93		Gray/black, lower caudal lobe chewed off
46	1-Aug	M	670	1	3		94		Bright, good condition, red meat
47	1-Aug	M	665	1	2		95		Bright, good condition, red meat
48	1-Aug	M	500	1	2				Bright, red meat, two minutes reviving
49	2-Aug	F	915	1	4		96		Bright, good shape, red meat
50	10-Aug	F	780		4	R	115		Bright, good shape, red meat
51	6-Aug	M	690	1	3		99		Semi-bright, good shape, red meat
52	8-Aug	M	865		3	R	126		Gray, good shape
53	8-Aug	M	435	1	1				
54	15-Aug	F	745	1	4		128		Bright pink, good condition, red meat

Appendix B1. Setnet catch and effort records Chickamin River, 1995, Humpy Slough site.

Date	Start time	Stop time	Total time	Process		Net/ hours	Large chin	Small chin	Chum	Pink	Sock	Tide		Crew	Comments
				Time	Effort							Time	Height		
20-Jun	10:37	16:00	05:23	00:10	05:13	5.10	2	1	3			07:23	12.3	DM/JF	
21-Jun	08:25	15:32	07:07	00:00	07:07	7.10	0					08:34	11.3	DM/BU	
22-Jun	08:20	15:25	07:05	00:05	07:00	7.00	0					09:48	11.1	JF/BU	
23-Jun	08:20	15:30	07:10	00:10	07:00	7.00	1					10:53	11.4	JF/JF	
24-Jun	08:18	15:25	07:07	00:05	07:02	7.00	0		2			11:48	11.9	DM/BU	
25-Jun	08:12	15:28	07:16	00:15	07:01	7.00	2		1	2		12:30	12.5	DM/JF	ALL FISH IN AM, 1 DOLLY
26-Jun	08:15	15:40	07:25	00:25	07:00	7.00	0		5	1		13:09	13	JF/JF	
27-Jun	09:00	16:30	07:30	00:30	07:00	7.00	1	1	14	2		13:44	13.4	DM/KP	HOT, 2 RECAP CHUM, 3 DOLLY
28-Jun	08:20	16:35	08:15	00:40	07:35	7.40	1		7	8	1	14:18	13.8	KP/JF	HOT, 2 NETS, 1 RECAP CHUM
29-Jun	08:30	16:30	08:00	01:00	07:00	7.00	6		13	5		14:52	14	DM	HOT, 2 NETS, 1 RECAP CHUM, 3 KINGS LARGE JACKS?
30-Jun	08:30	14:50	06:20	00:10	06:10	6.10	1		6	1		16:10	14.1	DM/KP	
01-Jul	08:15	15:45	07:30	00:30	07:00	7.00	3		18	3		15:25	14.1	JF/JF	4 RECAP CHUM,
02-Jul	12:25	15:35	03:10	00:00	03:10	3.10	0		4						
03-Jul	08:20	16:00	07:40	00:40	07:00	7.00	2		33	10		17:13	14.1	JF/BU	1 RECAP KING,5 CHUM, 1 DOLLY
04-Jul	08:12	15:50	07:38	00:30	07:08	7.10	4	1	25	5		17:57	14.1	DM/BU	1 AD CLIPPED-SACRIFICED, 3 TAGGED
05-Jul	08:25	15:55	07:30	00:30	07:00	7.00	2		25	19		18:48	14.2	JF/JF	1 KING, 2 CHUM RECAPS
06-Jul	08:25	16:10	07:45	00:45	07:00	7.00	1		54	17		07:20	11.3	DM/JF	1 CHUM RECAP
07-Jul	08:30	16:05	07:35	00:35	07:00	7.00	3	1	75	29	1	08:43	11.2	DM/BU	3 DOLLY
08-Jul	08:20	16:05	07:45	00:45	07:00	7.00	1		69	35		10:02	11.7	JF/BU	1 DOLLY
09-Jul			00:00		00:00	0.00									
10-Jul	08:20	11:30	03:10	00:15	02:55	3.00	1		28	37		12:07	13.9	JF/BU	1 RECAP CHUM
11-Jul					00:00	0.00									
12-Jul	08:20	12:30	04:10	00:25	03:45	3.50	1		44	46		13:46	15.8	JF/BU	3 RECAP CHUM
13-Jul	08:30	12:25	03:55	00:25	03:30	3.30	0		18	92		14:31	16.4	JF/DM	1 RECAP KING, CHUM, FLOW REVERSAL AT HIGH TIDE
14-Jul	08:06	13:30	05:24	00:10	05:14	5.10	0		11	8		15:15	16.6	DM/JF	PULLED WHEN TIDE GOT TOO FAST
15-Jul	10:40	18:10	07:30	00:30	07:00	7.00	1		113	56		15:59	16.4	JF/LW	PULLED WHEN TIDE GOT TOO FAST
16-Jul	08:30	15:00	06:30	00:10	06:20	6.20	1		86	275		16:44	15.9	DM/LW	1 DOLLY
17-Jul	08:30	15:50	07:20	00:20	07:00	7.00	1		25	54		17:30	15.3	JF/BU	
18-Jul	08:30	16:15	07:45	00:05	07:40	7.40	1		80	199		18:19	14.5	DM/LW	PULLED CROSS NET AT 11:00
19-Jul	08:15	15:45	07:30	00:30	07:00	7.00	0	1	95	183		06:41	11.7	JF/BU	
20-Jul	08:28	15:45	07:17	00:30	06:47	6.50	0		67	150		07:52	10.7	dm/bu	NETS TIED END TO END
21-Jul	08:15	15:55	07:40	00:30	07:10	7.10	2	2	61	217		09:12	10.3	DH/BU	1 RECAP CHUM
22-Jul	08:30	16:00	07:30	00:30	07:00	7.00	1		62	133		10:26	10.6	DH/JF	
23-Jul	08:25	15:55	07:30	00:30	07:00	7.00	0		31	80		11:24	11.2	DM/BU	
24-Jul	08:25	16:00	07:35	00:30	07:05	7.00	1		14	130		11:49	14.6	DH/JF	
25-Jul			00:00		00:00	0.00									

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Date	Start time	Stop time	Total time	Process		Net/ hours	Large chin	Small chin	Chum	Pink	Sock	Tide		Crew	Comments
				Time	Effort							Time	Height		
26-Jul	08:20	15:50	07:30	00:30	07:00	7.00	0	2	47	65		13:21	13.5	DM/DH	1 JACK RECAP 3 TIMES
27-Jul	08:20	15:50	07:30	00:30	07:00	7.00	2	1	29	62		13:53	14.1	JF/BU	
28-Jul	08:10	16:40	08:30	00:30	08:00	8.00	2		24	118		14:24	14.6	JF/BU	1 RECAP KING
29-Jul	08:15	12:55	04:40	00:30	04:10	4.10	2	1	28	247		14:55	14.9	BU/DM	NET BALLED UP AS SOON AS TIDE HIT
30-Jul	08:25	15:55	07:30	00:30	07:00	7.00	3	1	25	113		15:27	15.1	DM/MC	
31-Jul	08:25	15:55	07:30	00:30	07:00	7.00	3		29	40		16:01	15.2	DH/BU	
01-Aug	08:20	15:55	07:35	00:30	07:05	7.00	2		17	132		16:38	15.1	DM/MC	RECAP AND RETAG 1 KING
02-Aug	08:25	15:55	07:30	00:30	07:00	7.00	1		28	179		17:20	14.9	DH/BU	1 MORT KING
03-Aug	08:20	15:25	07:05	00:05	07:00	7.00	0		2	4		05:48	12.1	DM/MC	
04-Aug			00:00		00:00	0.00									
05-Aug	08:25	15:55	07:30	00:15	07:15	7.20	1		2	9		08:24	11	JF/BU	
06-Aug	08:15	15:55	07:40	00:30	07:10	7.10	0		12	86		09:49	11.5	DM/BU	1 RECAP KING # 103
07-Aug	14:00	16:30	02:30	00:30	02:00	2.00	0		4	64		10:58	10.6	BU/JF	1 COHO
08-Aug	08:30	16:00	07:30	00:30	07:00	7.00	0	2	13	70		11:54	14	DH/JF	1 RECAP KING # 91, 1 COHO
09-Aug	08:30	16:00	07:30	00:30	07:00	7.00	0		11	76		12:54	15.2	BU/DH	1 COHO
10-Aug	08:30	15:55	07:25	00:25	07:00	7.00	1		7	47		13:26	16.1	JF/BU	1 RECAP KING RETAGGED AS # 115
11-Aug	08:28	15:55	07:27	00:27	07:00	7.00	2	1	9	28		14:07	16.8	DM/DH	1 COHO
12-Aug	08:20	15:52	07:32	00:30	07:02	7.00	2		7	67		14:48	17	DM/DH	7 COHO, 1 KING HOOK IN MOUTH
13-Aug	08:20	16:35	08:15	00:15	08:00	8.00	0		8	27		15:27	16.8	JF/BU	2 COHO, 50% PINKS SPAWNED OUT
14-Aug						0.00									
15-Aug	08:25	15:45	07:20	00:20	07:00	7.00	0		2	37		16:47	15.3	DM/BU	3 COHO, 1 RECAP KING # 128
16-Aug			00:00		00:00	0.00									
17-Aug	08:20	15:40	07:20	00:20	07:00	7.00	0		5	78		06:01	11.7	JF/BU	2 COHO, 2 DOLLY
18-Aug	08:10	15:40	07:30	00:30	07:00	7.00	2		3	49		07:08	10.5	DH/BU	2 COHO
19-Aug	08:25	15:40	07:15	00:15	07:00	7.00	0		5	51		08:30	10	DH/JF	3 COHO, 2 DOLLY
20-Aug			00:00		00:00	0.00									
21-Aug	08:25	15:45	07:20	00:20	07:00	7.00	0		3	73		10:54	11	DH/BU	2 COHO, 2 DOLLY
22-Aug	08:30	15:50	07:20	00:20	07:00	7.00	1		2	46		11:39	12	BU/DH	12 COHO
23-Aug			00:00		00:00	0.00									
24-Aug	08:45	15:50	07:05	00:05	07:00	7.00	0		2	20		12:16	13	DM/BU	5 COHO
25-Aug	08:45	15:55	07:10	00:10	07:00	7.00	0			23		13:19	14.8	BU/JF	5 COHO

Appendix B2. Setnet catch and effort records, Chickamin River, 1995, Choca Creek site.

Date	Start time	Stop time	Total time	Process		Net/ hours	Large chin	Small chin				Water		Tide		Crew	Comments
				Time	Effort				Chum	Pink	Sock	Temp	Depth	Time	Height		
12-Jun	09:10					10.0											
13-Jun		08:50	23:20		23:20	8.5	1	0	1	0	0						OVERNIGHT SET 1 KING, 1 CHUM, 1 STEELHEAD-ALL DEAD
14-Jun	08:40	16:40	08:00	00:00	08:00	8.0	0	0	1	0	0	5		14:48	16.1	DD/JF	
15-Jun	08:30	16:00	07:30	00:00	07:30	7.3	0	0	1	0	0	6		15:36	16.1	DM/BU	
16-Jun	08:40	16:13	07:33	00:20	07:13	7.1	0	0	4	0	0	6	1.3	16:25	15.8	DM/BU	ALL ON INCOMING TIDE
17-Jun	08:30	15:45	07:15	00:15	07:00	7.0	0	0	3	0	0	6	1.5	17:16	15.4	DM/JF	
18-Jun			00:00		00:00	0.0											
19-Jun	08:15	19:00	10:45	01:00	09:45	9.5	2	0	16	0	0	6	1.8	06:12	13.3	JF/JF	KINGS ON INCOMING TIDE
20-Jun	08:10	15:30	07:20	00:20	07:00	7.0	0	0	4	0	0	6	2.4	07:23	12.3	JF/BU	
21-Jun	08:15	15:25	07:10	00:10	07:00	7.0	0	0	0	0	0	6	2	08:34	11.3	JF/JF	
22-Jun	08:20	15:23	07:03	00:00	07:03	7.0	0	0	0	0	0	7	3.1	09:48	11.1	DM/JF	WATER RISING
23-Jun	08:27	15:05	06:38	00:08	06:30	6.3	1	0	1	0	0	6	3.4	10:53	11.4	DM/BU	
24-Jun	08:50	16:30	07:40	00:10	07:30	7.3	1	0	2	0	0	5	2.1	11:48	11.9	JEF/JCF	
25-Jun	08:15	15:30	07:15	00:15	07:00	7.0	2	0	7	1	0	7	1.7	12:30	12.5	JEF/BU	
26-Jun	08:20	16:35	08:15	00:25	07:50	7.5	0	0	8	0	0	7	1.3	13:09	13	DM	
27-Jun	08:15	15:30	07:15	00:15	07:00	7.0	1	0	4	0	0	7	1.6	13:44	13.4	JEF/JCF	1 KING RECEDING TIDE
28-Jun	08:11	15:50	07:39	00:30	07:09	7.1	0	0	9	0	0		1.11	14:18	13.8	DM/JIMF	1 DOLLY VARDEN
29-Jun	08:30	17:40	09:10	02:10	07:00	7.0	2	1	9	1	0		2.1	14:52	14	KP/JEF	1 JACK, NET PULLED FROM 14:00 TO 15:40, 2 RECAP CHUMS
30-Jun	08:20	15:50	07:30	00:30	07:00	7.0	1	0	10	2	0		3.4	16:10	14.1	JEF/JCF	1 RECAP CHUM
01-Jul	08:20	16:00	07:40	00:20	07:20	7.2	1	0	9	2	0	8	3.6	15:25	14.1	DM/BU	
02-Jul	08:10	12:05	03:55	00:00	03:55	4.0	0	0	6	1	0	7	3.2			DM/BU	
03-Jul	08:18	15:45	07:27	00:35	06:52	6.5	1	0	15	0	0	7	2.1	17:13	14.1	DM/JF	1 RECAP/ MISSING TAG, OPERCULUM TORE. RETAGGED K. WITH #11.
04-Jul	08:20	15:40	07:20	00:20	07:00	7.0	0	1	15	3	0		3.1	17:57	14.1	JEF/JCF	1 RECAP KING-JACK, 1 RECAP CHUM
05-Jul	08:25	16:05	07:40	00:30	07:10	7.1	3	1	24	8	0	7.5	2.4	18:48	14.2	DM/BU	1 JACK
06-Jul	08:15	15:50	07:35	00:35	07:00	7.0	3	2	48	3	0		2.5	07:20	11.3	JIM/BU	2 OCEAN JACKS, RECAP TAG #19
07-Jul	08:05	15:45	07:40	00:40	07:00	7.0	0	0	42	7	0		2.8	08:43	11.2	JEF/JCF	
08-Jul	08:20	14:55	06:35	00:30	06:05	6.0	2	0	30	14	0	7	2.9	10:02	11.7	DM/JCF	ONE DROPOUT OF NET
09-Jul	13:50	17:20	03:30	00:30	03:00	3.0	1	0	71	0	0		1.11			JIM/BILL	5 DOLLY VARDENS, 2 CHUM RECAPS
10-Jul	12:20	16:40	04:20	00:20	04:00	4.0	1	0	24	12	0		2	12:07	13.9	JF/BU	1 RECAP CHUM

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Date	Start time	Stop time	Total time	Process		Net/ hours	Large chin	Small chin				Water		Tide		Crew	Comments
				Time	Effort				Chum	Pink	Sock	Temp	Depth	Time	Height		
11-Jul	08:40	16:00	07:20	00:20	07:00	7.0	1	0	23	3	0	8	3.5			DM/JF/BU	
12-Jul	13:10	16:10	03:00		03:00	3.0	0	0	16	21	0			13:46	15.8	JF/BU	2 RECAP CHUMS
13-Jul	13:18	18:07	04:49	00:20	04:29	4.3	3	0	19	12	0	8	2.3	14:31	16.4	DM/BU	4 RECAP CHUMS
14-Jul	13:47	20:00	06:13	00:30	05:43	5.4	1	0	57	9	0		3	15:15	16.6	JF/BU	4 RECAP CHUMS
15-Jul	08:28	16:17	07:49	00:50	06:59	7.0	2	0	113	88	0	8	2.5	15:59	16.4	DM/BU	3 RECAP CHUMS
16-Jul	08:20	15:40	07:20	00:20	07:00	7.0	0	0	98	126	0		1.6	16:44	15.9	JF/BU	
17-Jul	08:35	16:20	07:45	00:30	07:15	7.2	0	0	59	110	0	8	3.6	17:30	15.3	DM/LW	
18-Jul	08:25	15:50	07:25	00:25	07:00	7.0	0	1	141	221	0	7	2.11	18:19	14.5	JF/BU	1 JACK
19-Jul	08:30	16:20	07:50	00:40	07:10	7.1	0	0	79	236	0	7	2.9	06:41	11.7	DM/DH	
20-Jul	08:25	15:55	07:30	00:30	07:00	7.0	0	0	84	185	0	8	2.9	07:52	10.7	JF/D	
21-Jul			00:00		00:00	0.0								09:12	10.3		
22-Jul			00:00		00:00	0.0								10:26	10.6		
23-Jul			00:00		00:00	0.0								11:24	11.2		
24-Jul	08:30	16:00	07:30	00:30	07:00	7.0	0	0	35	146	0	6.5	2.1	11:49	14.6	DM/BU	
25-Jul			00:00		00:00	0.0											
26-Jul	08:20	15:55	07:35	00:35	07:00	7.0	1	0	98	88	0		3	13:21	13.5	BU/JF	TAG 84 IS VOID
27-Jul	08:30	16:15	07:45	00:30	07:15	7.2	1	0	50	92	0	7	2	13:53	14.1	DM/DH	
28-Jul	08:30	15:30	07:00	00:30	06:30	6.3	2	0	44	120	0	7	1.1	14:24	14.6	DM/DH	
29-Jul	08:20	15:50	07:30	00:30	07:00	7.0	3	0	45	89	0		1	14:55	14.9	DH/JF	#91 (3RD FISH) TWICE
30-Jul	08:25	16:00	07:35	00:30	07:05	7.0	1	0	42	50	0		0.9	15:27	15.1	BU/DH	SEVERAL CHUMS WERE SPAWNED OUT
31-Jul	08:30	12:40	04:10	00:10	04:00	4.0	1	0	23	34	0	7.5	3.2	16:01	15.2	DM/MC	
01-Aug	08:30	16:00	07:30	00:30	07:00	7.0	2	1	37	88	0		1.1	16:38	15.1	BU/DH	1 JACK
02-Aug	08:22	16:00	07:38	00:30	07:08	7.1	1	0	28	67	0	7	1.4	17:20	14.9	DM/MC	
03-Aug	08:20	15:50	07:30	00:30	07:00	7.0	1	0	34	40	0		3	05:48	12.1	BU/DH	
04-Aug			00:00		00:00	0.0											
05-Aug			00:00		00:00	0.0								08:24	11		
06-Aug	08:25	15:55	07:30	00:30	07:00	7.0	1	0	35	114	0		2.1	09:49	11.5	JF/DH	2 SEALS IN NET
07-Aug			00:00		00:00	0.0								10:58	10.6		
08-Aug	08:30	15:30	07:00	00:30	06:30	6.3	1	1	17	71	1	7	1.9	11:54	14	DM/BU	retagged, formerly 97 now # 115
09-Aug			00:00		00:00	0.0								12:54	15.2		

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Date	Start time	Stop time	Total time	Process		Net/ hours	Large chin	Small chin				Water		Tide		Crew	Comments
				Time	Effort				Chum	Pink	Sock	Temp	Depth	Time	Height		
10-Aug	09:20	13:25	04:05	00:05	04:00	4.0	0	0	5	8	0		1.7	13:26	16.1	DM/DH	
11-Aug	08:45	16:15	07:30	00:30	07:00	7.0	0							14:07	16.8		1 COHO
12-Aug			00:00		00:00	0.0								14:48	17		
13-Aug			00:00		00:00	0.0								15:27	16.8		
14-Aug			00:00		00:00	0.0											
15-Aug	08:40	16:05	07:25	00:25	07:00	7.0	1	0	8	40	0		2.6	16:47	15.3	JF/DH	9 COHO. NETSET D.R. OF CHOCA. 15% SPAWNOUT PS AND Chums
16-Aug			00:00		00:00	0.0											
17-Aug			00:00		00:00	0.0								06:01	11.7		
18-Aug	09:30	16:10	06:40	00:10	06:30	6.3	0	0	2	11	0	6.5	0.6	07:08	10.5	DM/JF	
19-Aug	08:25	15:40	07:15	00:15	07:00	7.0	0	0	5	51	0	7		08:30	10	JF/DH	2 DOLLY VARDENS, 3 COHO. 30% SPAWNED P.S.
20-Aug			00:00		00:00	0.0											
21-Aug			00:00		00:00	0.0								10:54	11		
22-Aug	09:05	16:10	07:05	00:05	07:00	7.0	0	0	2	9	3	7	0.8	11:39	12	DM/JF	
23-Aug			00:00		00:00	0.0											
24-Aug			00:00		00:00	0.0								12:16	13		
25-Aug			00:00		00:00	0.0								13:19	14.8		

Appendix B3. Computer files used to estimate the spawning abundance of chinook salmon in the Chickamin River in 1995.

File Name	Description
SETNETC.xls	EXCEL spreadsheet with setnet tagging data--daily effort, catch by species, and water depth by site; setnet charts.
CHKESC95.xls	EXCEL spreadsheet with recovery data for chinook salmon in the Chickamin River in 1995. Includes recovery data by tributary (date, length (MEF), sex, age and any marks); length frequencies; length at age; age composition of setnet and tributary samples; KS test data; charts.
41CHKM95.xls	EXCEL spreadsheet with setnet tagging data for each fish tagged--site, date, sex, length (MEF), age, tag numbers and comments.
XXXXXXX.doc	WORD 6.0 (Windows) file of this FDS report.