Fishery Data Series No. 95-5

Salmon Studies in Interior Alaska, 1994

by
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Alaska Department of Fish and Game

Division of Sport Fish

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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

FISHERY DATA SERIES NO. 95-5

SALMON STUDIES IN INTERIOR ALASKA, 1994

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

In 1994, abundances were estimated for chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Salcha and Chena rivers near Fairbanks, Alaska. Estimates of abundance were also made for chum salmon *O. keta*, however the time period that was sampled (5 July through 12 August) covered only a portion of the chum salmon escapement. A stratified systematic sampling design was used to count chinook and chum salmon during 20 min periods each hour as they passed beneath elevated counting structures on the Salcha and Chena rivers. Estimates of abundance for chinook and chum salmon in the Salcha River were 18,399 (SE = 549) and 39,450 (SE = 740), respectively. Estimates of abundance for chinook and chum salmon in the Chena River were 11,877 (SE = 479) and 9,984 (SE = 347), respectively. Chinook salmon carcasses were collected during early August from both rivers. Males comprised 53% of the sample in the Salcha River and 54% in the Chena River. Ages 1.3 and 1.4 comprised more than 90% of the fish sampled in both rivers. Estimated potential egg productions were the highest on record in both rivers. Estimates were 74.9 million eggs (SE = 5.4 million) in the Salcha River, and 48 million eggs (SE = 3.6 million) in the Chena River. The highest counts of chinook salmon during aerial surveys were 11,823 for the Salcha River and 1,570 for the Chena River populations. These aerial counts were 64% and 13% of the respective abundance estimates.

Coho salmon *O. kisutch* in the mainstem Delta Clearwater River near Delta Junction were counted from a drifting river boat on 5 and 24 October. Counts in spring areas adjacent to the mainstem river and in tributaries not accessible by boat were conducted from a helicopter on 27 October. The total count for the entire river was 80,240 coho salmon, which was approximately three times higher than any count on record. The count of coho salmon in the mainstem river was 62,675 (78%), while the count in tributaries and spring areas was 17,565 (22%). Two-hundred-ninety-nine carcasses were collected on 16 November. The sex composition of the sample was 52% male and 48% female. Ages 1.1 and 2.1 comprised 63% and 37% of the sample, respectively.

Key words: chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *Oncorhynchus keta*, coho salmon, *Oncorhynchus kisutch*, Salcha River, Chena River, Delta Clearwater River, age-sex-length composition, aerial survey, fecundity, egg production, abundance, counting towers, carcass survey, escapement.

CHINOOK AND CHUM SALMON STUDIES IN THE SALCHA AND CHENA RIVERS

INTRODUCTION

The Salcha and Chena rivers have some of the largest chinook salmon escapements in the Yukon River drainage (Schultz et al. 1994). The Salcha River is a 250 km, clear stream flowing into the Tanana River about 60 km east of Fairbanks (Figure 1). The Chena River is a 240 km, clear stream that flows into the Tanana River 8 km west of Fairbanks (Figure 2). At the mouth of the Salcha River there is a popular sport fishery. Annual harvests have approached 1,000 chinook salmon in some years (Mills 1979-1994; Table 1). There is also a sport fishery that takes place in the lower 72 km of the Chena River where annual harvests have exceeded 700 chinook salmon (Mills 1979-1994; Table 1). Before reaching their spawning grounds, the chinook salmon travel about 1,500 km from the ocean and pass through six different commercial fishing districts in the Yukon and Tanana rivers (Figure 3). Subsistence and personal use fishing also occur in each district.

In previous years, the abundance of the chinook salmon escapements into the Salcha and Chena rivers were estimated using mark-recapture experiments and monitored with aerial surveys. This information has been used to evaluate management of the commercial, subsistence, personal, and

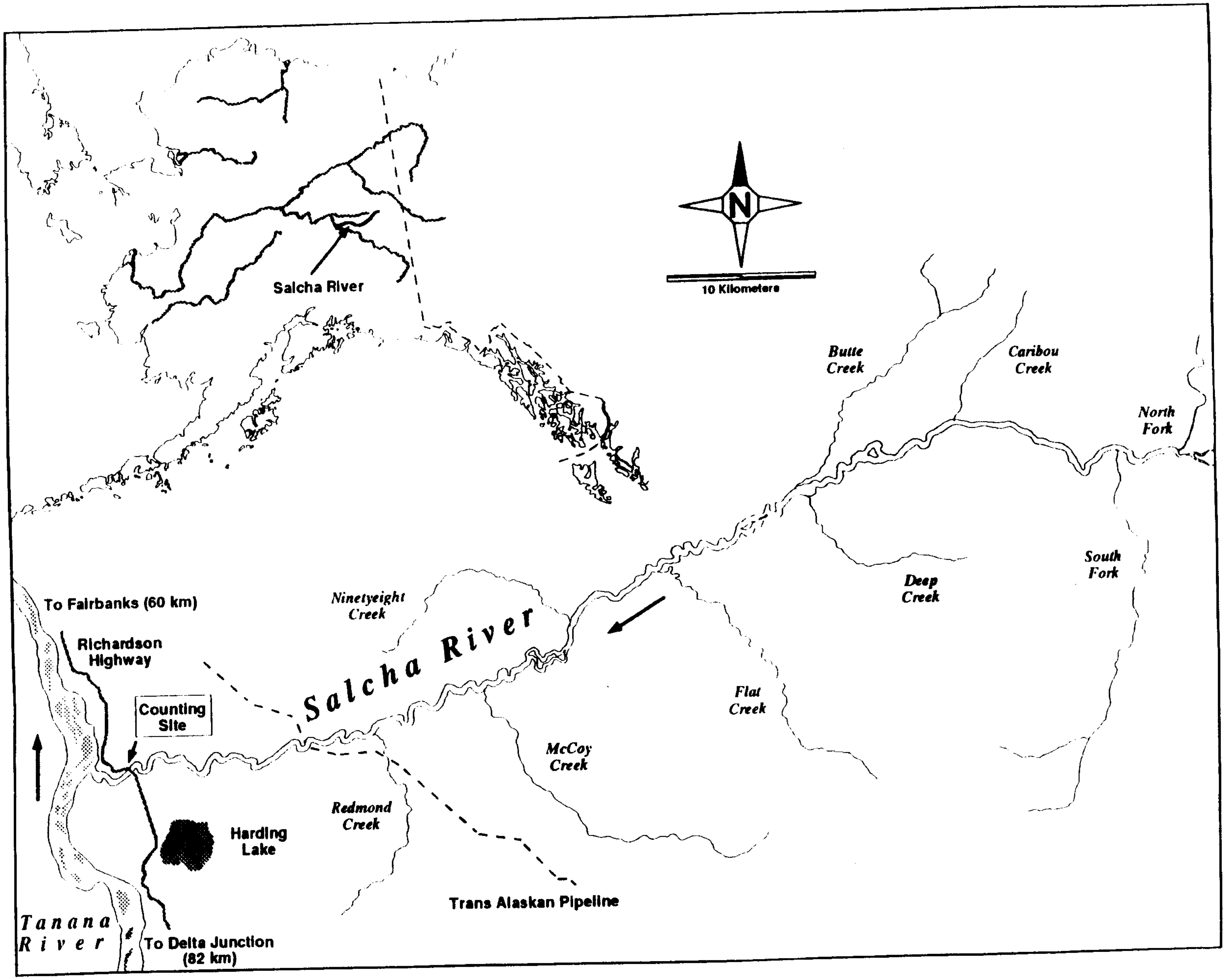


Figure 1.-Salcha River study area.

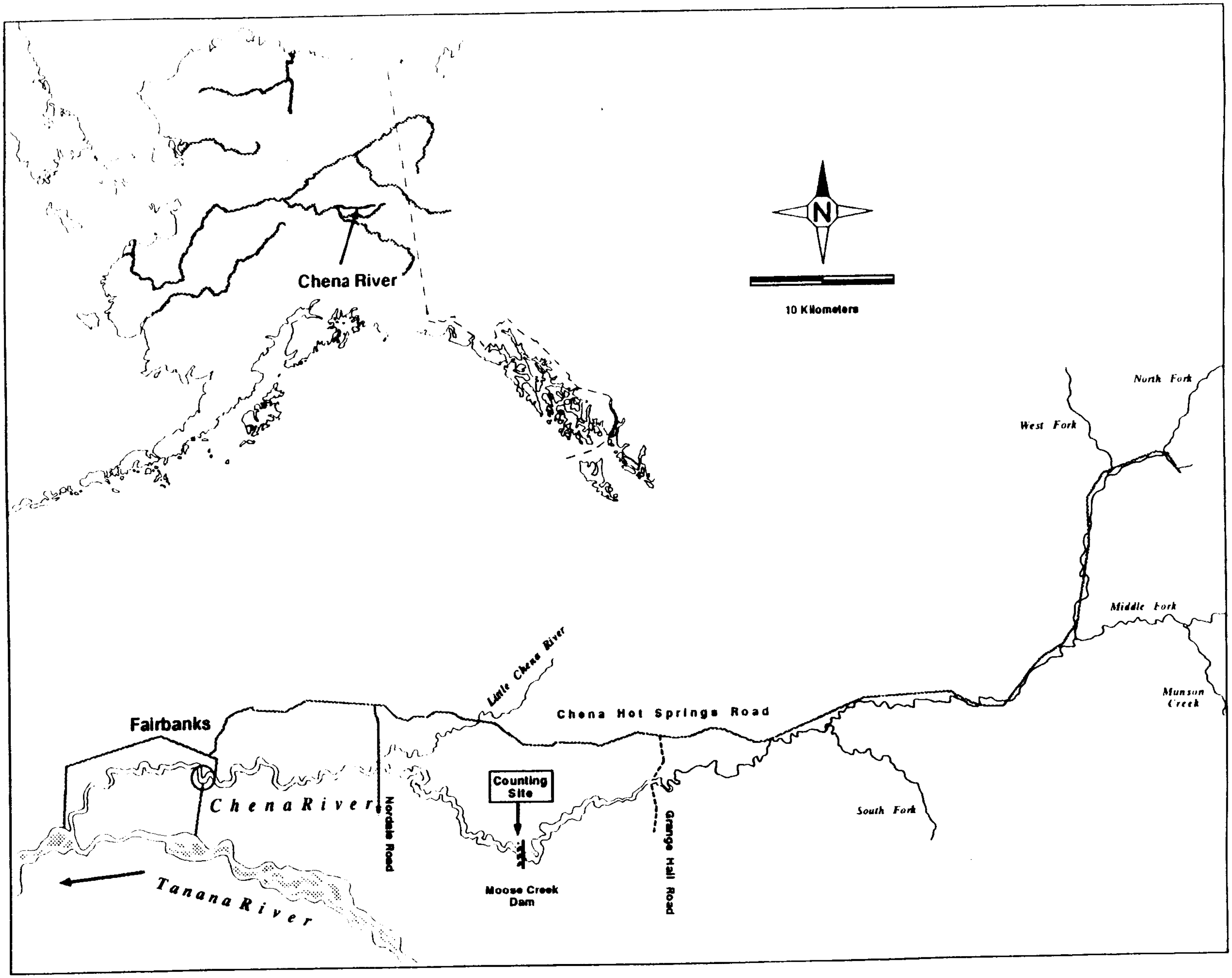


Figure 2.-Chena River study area.

Table 1.-Harvests of anadromous chinook salmon by sport, commercial, subsistence, and personal use fisheries, Tanana River drainage, 1978 - 1994.

	On Site Sport Harvest Estimates[a]		Statewide Survey Estimates of Sport Harvest[b]						Estimated Harvest by User Group		
Year	Chena River	Salcha River	Chena River	Salcha River	Chatanika River	Nenana River	Other Streams	All Waters	Commercial Harvests[c]	Subsistence and Personal Use Harvests[c]	Total Known Harvest
1978	none	none	23	105	35	none	0	163	635	1,231	2,029
1979	none	none	10	476	29	none	0	515	772	1,333	2,620
1980	none	none	0	904	37	none	0	941	1,947	1,826	4,714
1981	none	none	39	719	5	none	0	763	987	2,085	3,835
1982	none	none	31	817	136	none	0	984	981	2,443	4,408
1983	none	none	31	808	147	none	10	1,048	911	2,706	4,665
1984	none	none	0	260	78	none	0	338	867	3,599	4,804
1985	none	none	37	871	373	none	75	1,356	1,142	7,375	9,873
1986	none	526	212	525	0	none	44	781	950	3,701	5,432
1987	none	111	195	244	21	7	7	474	3,338	4,096	7,908
1988	567	19	73	236	345	36	54	744	762	5,189[d,e]	6,695
1989	685	123	375	231	231	39	87	963	1,741	1,546[d,e]	4,250
1990	24	200	64	291	37	0	0	439	2,156	3,069[d,e]	5,664
1991	none	362	110	373	82	11	54	630	1,072	2,515[d,e]	4,217
1992	none	4	39	47	16	0	0	118	752	2,438[d,e]	3,308
1993	none	54	733	601	192	0	19	1,573	1,445	2,098[d,e]	5,156
1994	none	NA[f]	NA	NA	NA	NA	NA	NA	2,607[d]	NA	NA

[a] Creel census estimates from Clark and Ridder (1987), Baker (1988, 1989), Merritt et al. (1990), and Hallberg and Bingham (1991-1994).

[b] Sport fishery harvest estimates from Mills (1979-1994).

[c] Commercial, subsistence, and personal use estimates (Schultz et al. 1994, and, Schultz, Keith. 1994). Personal Communication. Alaska Department of Fish and Game, Sport Fish Division, 1300 College Road, Fairbanks, AK 99701.

[d] Preliminary data and subject to change.

[e] The personal use designation was implemented in 1988 to account for non-rural fishermen participating in this fishery. Harvests by personal use fishermen were 623, 453, 451,0, and 0 for 1988-1992, respectively.

[f] NA means data not available at this time.

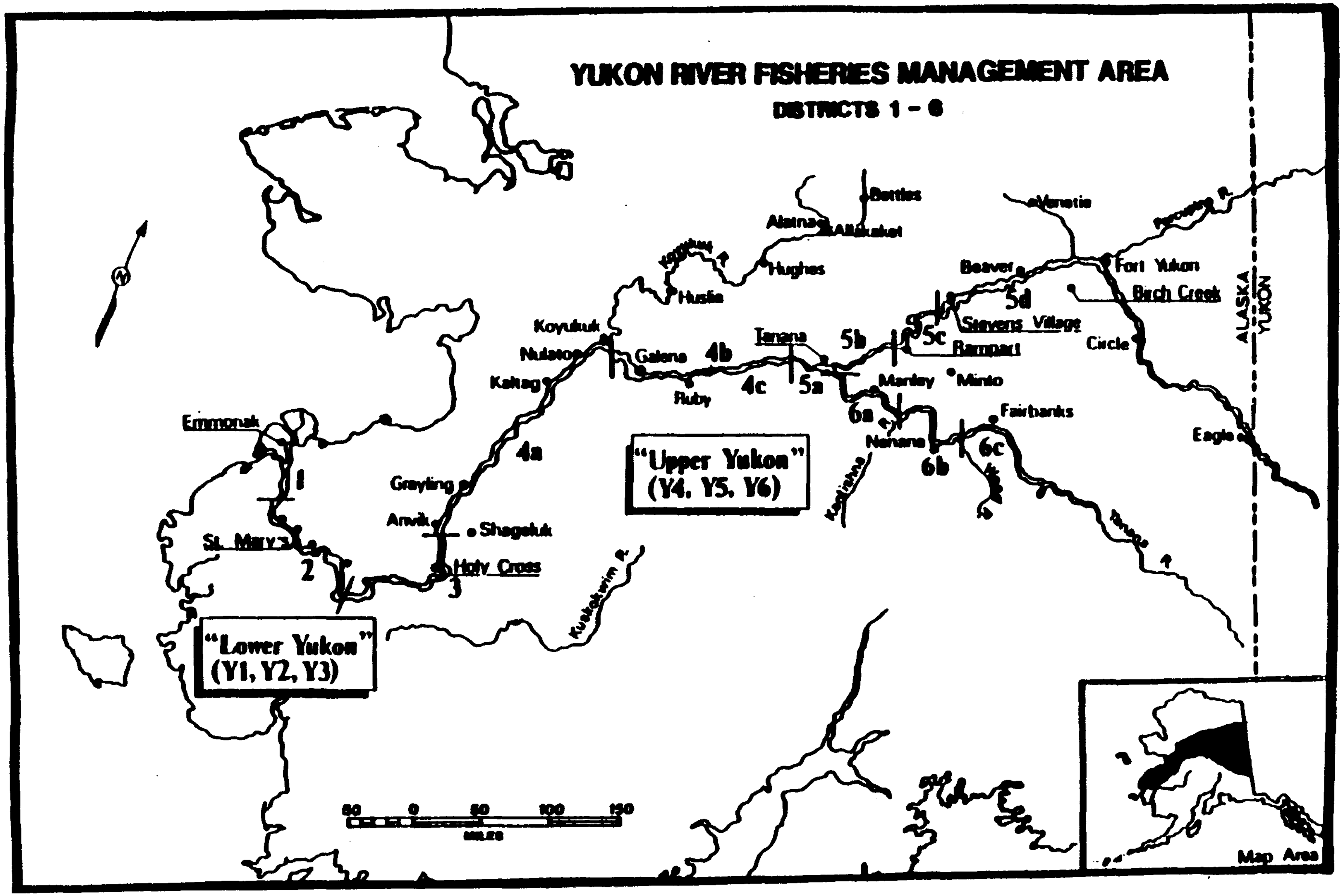


Figure 3.-Fishing districts in the Yukon River drainage.

sport fisheries on these stocks of chinook salmon. However, these methods provide fishery managers with limited information that can be used during the fishing season. Aerial surveys and mark-recapture experiments occur after most of the escapement has passed through the various fisheries. These methods only inform fishery managers if the escapement objectives were met.

Minimum escapement guidelines for chinook salmon returning to the Salcha and Chena rivers are 2,500 and 1,700, respectively, counted during aerial surveys (established by the Department of Fish and Game). Using counts from aerial surveys and abundance estimates of escapement, the minimum escapement guidelines for aerial surveys were expanded into actual abundance. The minimum escapement guidelines for abundance of chinook salmon are 7,100 for the Salcha River and 6,300 for the Chena River.

In 1987 the Board of Fisheries recognized the need to regulate the harvest of chinook salmon caught by sport anglers in the Salcha and Chena rivers. The Board imposed a sport harvest guideline of 300 to 700 chinook salmon for the Salcha River and 300 to 600 chinook salmon for the Chena River. The harvest by anglers is monitored with creel surveys. By counting chinook salmon as they enter the spawning streams, the Division of Sport Fish can regulate the sport fisheries during the fishing season to insure that the sport harvest does not adversely impact the escapement.

Chum salmon returning to the Salcha and Chena rivers also are harvested in local sport fisheries. The migration timing of chum salmon is later than that for chinook salmon, but does overlap the chinook salmon migration. Because sport fisheries exist on these stocks, the abundance of the chum salmon escapements also was monitored to insure that the sport harvest did not adversely impact the escapement. Currently there are no established harvest guidelines for chum salmon in either river. There is an escapement objective of 3,500 chum salmon from aerial surveys for the Salcha River, but no escapement objective exists for the Chena River.

The objectives of the chinook salmon projects in 1994 were to:

(1) estimate the escapements of chinook salmon in the Salcha and Chena rivers; and,

(2) estimate age, sex, and length compositions of the escapements of chinook salmon in the Salcha and Chena rivers.

In addition, there were three tasks:

(1) generate daily estimates of the number of chinook salmon that pass the counting sites in each river;

(2) generate absolute and relative cumulative frequency distributions using daily counts of chinook salmon past the counting sites in each river; and,

(3) count chum salmon in the Salcha and Chena rivers in conjunction with counting chinook salmon.

METHODS

Tower Counts

Chinook and chum salmon returning to the Salcha and Chena rivers were estimated by counting fish as they passed beneath counting sites (the Richardson Highway Bridge on the Salcha River and the Moose Creek Dam on the Chena River; Figures 1 and 2). Little, or no spawning takes place downstream from these sites. Counting was conducted daily from 8 July through 12 August for the Chena River and from 5 July through 12 August for the Salcha River. High water levels in both rivers, and removal of a large log jam at the Chena River site postponed the starting dates for counting in both rivers beyond the planned start date of 1 July. Light colored cloth panels were placed on the river bottom downstream from the counting structures to make fish more visible as they crossed beneath the structures. Lights were suspended from the counting structures and were used during low ambient light. Because salmon often will avoid areas with unusual substrate or illuminated with artificial lighting, the panels and overhanging lights were positioned to form a continuous band from bank to bank. Once the artificial lighting was turned on it was left on until the ambient light level was high enough to observe salmon without the aid of artificial lighting. This was done in case salmon would not enter the illuminated area during a 20 min count, but would move upstream between counts if the lights were turned off.

Four persons were assigned to each river to conduct counts. Personnel were assigned 8 h shifts and counted salmon the first 20 min of every hour. This was a stratified systematic sampling design. The counts were limited to 20 min to alleviate eye strain and fatigue associated with this type of work. A week consisted of 21, eight hour shifts (three shifts each day). Shift I started at 0000 h (midnight) and ended at 0800 h; Shift II started at 0800 h and ended at 1600 h; Shift III started at 1600 h and ended at 2400 h. Initially, out of these 21 possible shifts each week, 17 were worked, and four were not. These four noncounting shifts were randomly assigned each week, but with the following constraints: 1) two or more noncounting shifts would not occur consecutively; 2) noncounting shifts would not occur during the same shift on two consecutive days; and, 3) each of the three shifts would receive at least one noncounting shift each week. This design was continued until the chinook run was essentially completed (early August). After this time, personnel and financial constraints reduced the number of counting shifts each week (Appendix A). Counting during this latter time was primarily conducted to enumerate the chum salmon escapement. However, counts were terminated before the chum escapements were completed.

Abundance Estimator

Estimates of abundance were stratified by day to provide managers with a timely description of escapement. Daily estimates of abundance were considered a two-stage direct expansion where the first stage was 8 h shifts within a day and the second stage was 20 min counting periods within a shift. The second stage was considered systematic sampling because the 20 min counting periods were not chosen randomly.

For each day sampled, the number of salmon to pass by the tower was estimated:

$$\hat{N}_h = \bar{Y}_h D_h \quad (1)$$

$$\hat{V}\left[\hat{N}_h\right] = (1 - f_{1h}) D_h^2 \frac{s_{1h}^2}{d_h} + f_{1h}^{-1} \sum_{i=1}^{d_h} \left[M_{hi}^2 (1 - f_{2hi}) \frac{s_{2hi}^2}{m_{hi}} \right] \quad (2)$$

where:

$$\bar{Y}_h = \frac{\sum_{i=1}^{d_h} Y_{hi}}{d_h} \quad (3)$$

$$s_{1h}^2 = \frac{\sum_{i=1}^{d_h} \left(Y_{hi} - \bar{Y}_h\right)^2}{d_h - 1} \quad (4)$$

$$s_{2hi}^2 = \frac{\sum_{j=2}^{m_{hi}} \left(y_{hij} - y_{hij-1}\right)^2}{2\left(m_{hi} - 1\right)} \quad (5)$$

$$f_{1h} = \frac{d_h}{D_h} \quad (6)$$

$$f_{2hi} = \frac{m_{hi}}{M_{hi}} \quad (7)$$

h = day;

i = 8 h shift;

j = 20 min counting period;

Y = number of chinook or chum salmon counted (total number moving upstream minus total number moving downstream);

m = number of 20 min counting periods sampled;

M = total number of possible 20 min counting periods;

d = number of 8 h shifts sampled;

D = total number of possible 8 h shifts;

L = total number of possible days during the sampling period;

f_1 = fraction of 8 h shifts sampled;

f_2 = fraction of 20 min counting periods sampled;

s_2^2 = estimated variance of total across counting periods; and,

s_1^2 = estimated variance of total across shifts.

The total abundance was then estimated using:

$$\hat{N} = \sum_{h=1}^{L} \hat{N}_h \quad (8)$$

$$\hat{V}(\hat{N}) = \sum_{h=1}^{L} \hat{V}(\hat{N}_h) \tag{9}$$

For days when only one shift was worked, there was no estimate of the shift to shift variation. In these cases, a coefficient of variation (CV) was calculated for each river and species using all days when more than one shift was worked. The average CV for each river and species was then used to estimate the daily variation for those days when only one shift was worked. The coefficient of variation was used because it is independent of the magnitude of the estimate and was relatively constant throughout the run. The CV was calculated for each river and species as:

$$cv = \frac{s}{N_h} * 100\% \tag{10}$$

For days that were not sampled at all, the daily estimate for each river and species was calculated as the average of the day before and the day after the missed day. The estimate of the daily variation for missed days was also calculated using Equation 10.

Age-Sex-Length Compositions

Chinook salmon carcasses were collected from a drifting river boat using long-handled spears. Carcasses were collected in the Salcha River 50 to 96 km from the mouth and in the Chena River 145 to 72 km from the mouth. Carcasses were collected during 3-5 August. All collected carcasses were examined to determine sex and measured from mid-eye to fork-of-tail (ME-FT). Three scales were removed from each fish and placed directly on gum cards for later age determination. Scales were removed from the left side approximately two rows above the lateral line along a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Welander 1940). Ages were determined from scale patterns as described by Mosher (1969).

Mean lengths were estimated for combinations of age and sex using the sample mean and sample variance of the mean (Zar 1984). Proportions of female and male chinook salmon by ocean-age or 10 mm length category and the associated variances were estimated for each river using:

$$\hat{p}_g = \frac{n_g}{n} \tag{11}$$

$$\hat{V}(\hat{p}_g) = \frac{\hat{p}_g(1 - \hat{p}_g)}{n - 1} \tag{12}$$

where:

$\hat{p}_g$ = estimated proportion of chinook salmon;

g = the group of interest (i.e. age, sex, length category);

n_g = number of chinook salmon of category g in the sample; and,

n = number of chinook salmon in the sample.

The abundance of female and male chinook salmon by age or length class was estimated:

$$\hat{N}_g = \hat{p}_g \hat{N} \tag{13}$$

where $\hat{N}$ = population abundance estimate.

The associated variance was estimated using Goodman's (1960) formula for the exact variance of a product of two independent estimates:

$$\hat{V}(\hat{N}_g) = \hat{N}^2 \hat{V}(\hat{p}_g) + \hat{p}_g^2 \hat{V}(\hat{N}) - \hat{V}(\hat{p}_g)\hat{V}(\hat{N}) \tag{14}$$

The Chi-squared test statistic from a contingency table was used to compare the sex ratios of chinook salmon between rivers and the Kolmogorov-Smirnov test statistic was used to compare the length compositions of chinook salmon between rivers.

Potential Egg Production

Fecundity of chinook salmon that returned to the Salcha and Chena rivers in 1994 was estimated using parameters from a linear regression model that described the relation between fecundity and length (Skaugstad and McCracken 1991). These parameters were estimated from a sample of 49 female chinook salmon collected from the Tanana River during 1989 and are designated with a subscript "o":

$$\hat{F}_g = a_o + b_o L_g \tag{15}$$

$$\hat{V}(\hat{F}_g) = MSE_o \left\{ 1 + \frac{1}{n_o} + \frac{(L_g - \bar{L}_o)^2}{\sum L_{of}^2 - \left(\sum L_{of}\right)^2 / n_o} \right\} \tag{16}$$

where:

$\hat{F}_g$ = estimated fecundity of the smallest possible female in the 10 mm length interval g;

L_g = lower limit of the 10 mm length interval g;

$\bar{L}_o$ = mean length of the females from sample **o** (902 mm);

L_{of} = length of fish f in sample **o**;

n_o = size of sample **o** (49);

a_o = y-intercept of sample **o** (-7,937.5);

b_o = slope of sample **o** (19.97);

MSE_o = mean square error from the regression of F on L from sample **o** (2,656,900); and,

$\hat{V}(\hat{F}_g)$ = variance of $\hat{F}_g$.

Potential egg production of the population of chinook salmon that spawned was estimated by multiplying the estimated abundance of all females in a 10 mm length interval by the estimated fecundity of the smallest possible female in the length interval:

$$\hat{E} = \sum \hat{N}_g \hat{F}_g \tag{17}$$

$$\hat{V}(\hat{E}) = \sum \left[\hat{N}_g^2 \hat{V}(\hat{F}_g) + \hat{F}_g^2 \hat{V}(\hat{N}_g) - \hat{V}(\hat{N}_g)\hat{V}(\hat{F}_g)\right] \tag{18}$$

where:

$\hat{E}$ = potential egg production of the spawning chinook salmon population;

$V(\hat{E})$ = variance of $\hat{E}$;

$\hat{N}_g$ = estimated number of females within length interval g (Equation 13);

$\hat{V}(\hat{N}_g)$ = variance of $\hat{N}_g$ (Equation 14);

$\hat{F}_g$ = estimated fecundity for the smallest fish in length interval g (Equation 15); and,

$\hat{V}(\hat{F}_g)$ = variance of $\hat{F}_g$.(Equation 16).

Relation of Aerial Counts to Abundance Estimates

Personnel from the Fairbanks office of the Division of Commercial Fisheries of the Alaska Department of Fish and Game counted live and dead adult chinook salmon in the Salcha and Chena rivers during the salmon migration. Counts were made from low flying, fixed-wing aircraft. Barton (1987b) described the methods used for these aerial surveys. The proportion of salmon counted by the aerial survey was calculated as:

$$\hat{p} = \frac{C}{\hat{N}} \tag{19}$$

where:

$\hat{p}$ = estimated proportion of chinook salmon counted by aerial survey;

C = aerial survey count; and,

$\hat{N}$ = estimated abundance of chinook salmon using data from counting sites (Equation 1).

Data for these analyses are archived as described in Appendix B.

RESULTS

Extreme high water during late June and early July postponed installation of flash panels five days in the Salcha River and eight days in the Chena River from the planned start date of 1 July. Water levels and turbidity in both rivers were low throughout most of the counting period except for the final four days of July. No counts were conducted on 29 July in the Chena River due to poor visibility caused by high water levels and increased turbidity. Water levels and turbidity were low and visibility was good for the carcass surveys in both rivers during 3-5 August.

Tower Counts

Chinook salmon were observed on the first day of counting, (8 July) in the Chena River, but not until the second day of counting (6 July) in the Salcha River. The highest daily estimates of passage were on 14 and 15 July in the Chena and Salcha rivers, respectively (Tables 2 and 3; Figure 4). Few chinook salmon were observed after 28 July in the Chena river or after 1 August in the Salcha River. Cumulative distributions of daily abundance were similar in configuration for both rivers, but migration timing past the counting sites was about 1-2 days earlier for Chena River chinook salmon (Figure 5).

Chum salmon were first observed passing by the Salcha River counting site on 8 July and by the Chena River counting site on 11 July (Tables 2 and 3; Figures 4 and 5). Daily counts of chum salmon increased substantially after 20 July, and reached a peak count on 23 July in the Chena River and 25 July in the Salcha River. Run strength had decreased by 1 August, but chum salmon were still passing by the counting sites when the project was terminated on 12 August.

Abundance Estimates

The estimated abundance of chinook salmon moving past the counting site in the Salcha River was 18,399 (SE = 549). The estimated abundance of chinook salmon in the Chena River was 11,877 (SE = 347). The estimated abundance of chum salmon in the Salcha River was 39,450 (SE = 740) and in the Chena River was 9,984 (SE = 347).

Age-Sex-Length Compositions of Chinook Salmon in the Salcha River

Six-hundred eighteen chinook salmon carcasses were collected from the Salcha River. Of these, 330 (53%) were male and 288 (47%) were female. Abundances calculated from these proportions were 9,825 (SE = 449) male and 8,574 (SE = 472) female chinook salmon.

Age was estimated for 520 fish (84% of the sample). To determine whether the aged sample was similar to the total sample, two tests were performed. First, a chi-square goodness of fit test comparing aged and not-aged male and female fish indicated that relatively more females than males were not-aged ($\chi^2 = 4.24$; df = 1; P = 0.04). Second, a Kolmogorov-Smirnov two sample test indicated that length distributions of aged and not-aged fish were similar (dn = 0.07; P = 0.88). Because the differences in sex compositions between aged and not-aged fish were slight, and because length distributions were similar, it is assumed that bias associated with age compositions would also be slight. Therefore, proportions and abundance by sex and age class were calculated. Males were most represented by age 1.3 fish (31% of total sample) while

Table 2.-Daily counts and estimates of the number of chum and chinook salmon passing by the counting site in the Salcha River during 1994.

	Shifts	Chum			Chinook		
Date	Sampled	Count	Daily Passage	SE	Count	Daily Passage	SE
7/5/94	1	0	0	0	0	0	0
7/6/94	3	0	0	0	5	15	9
7/7/94	3	4	6	4	22	33	6
7/8/94	0	0	3	0	0	48	11
7/9/94	2	0	0	0	14	63	15
7/10/94	2	0	0	0	77	347	36
7/11/94	2	3	14	10	85	383	57
7/12/94	2	3	14	7	86	387	107
7/13/94	3	74	222	26	506	1,518	252
7/14/94	3	122	366	68	562	1,686	157
7/15/94	2	92	414	44	395	1,778	151
7/16/94	2	74	302	46	261	1,126	202
7/17/94	3	38	124	22	124	385	77
7/18/94	2	118	531	72	334	1,503	156
7/19/94	2	95	428	64	164	738	112
7/20/94	3	230	690	81	321	963	118
7/21/94	3	374	1,122	91	401	1,203	120
7/22/94	2	217	977	119	138	621	68
7/23/94	2	417	1,877	150	160	720	88
7/24/94	3	802	2,406	157	350	1,050	136
7/25/94	2	694	3,123	250	241	1,085	116
7/26/94	2	599	2,696	263	108	486	68
7/27/94	3	936	2,808	163	228	684	77
7/28/94	2	539	2,426	134	125	563	67
7/29/94	2	470	2,115	184	68	306	25
7/30/94	3	855	2,565	166	85	255	37
7/31/94	3	1027	3,081	124	51	153	22
8/1/94	1	123	1,107	173	3	27	6
8/2/94	1	176	1,584	248	10	90	21
8/3/94	1	97	873	136	6	54	13
8/4/94	0	0	972	152	0	32	7
8/5/94	1	262	1,071	167	7	9	2
8/6/94	3	150	786	58	7	21	6
8/7/94	2	130	675	64	3	32	8
8/8/94	2	251	585	73	4	14	7
8/9/94	2	319	1,130	100	1	18	7
8/10/94	3	216	957	106	1	3	3
8/11/94	2	96	972	55	0	5	4
8/12/94	2	0	432	43	16	0	0
Total	82	9,722	39,454	740	4,970	18,404	549

Table 3.-Daily counts and estimates of the number of chum and chinook salmon passing by the counting site in the Chena River during 1994.

	Shifts	Chum			Chinook		
Date	Sampled	Count	Daily Passage	SE	Count	Daily Passage	SE
7/8/94	1	0	0	0	5	45	13
7/9/94	2	0	0	0	8	36	16
7/10/94	2	0	0	0	12	54	27
7/11/94	2	8	36	16	26	117	34
7/12/94	2	7	32	10	16	72	19
7/13/94	2	14	63	10	106	477	80
7/14/94	3	15	45	17	449	1,347	151
7/15/94	2	29	131	36	416	1,872	192
7/16/94	2	18	81	47	285	1,283	284
7/17/94	3	43	129	28	288	864	137
7/18/94	2	74	333	39	248	1,116	99
7/19/94	2	46	207	20	159	716	71
7/20/94	3	145	435	41	187	561	82
7/21/94	3	74	222	35	208	624	143
7/22/94	2	61	275	36	64	288	39
7/23/94	2	269	1,211	136	51	230	30
7/24/94	3	183	549	120	116	348	45
7/25/94	2	105	473	62	198	891	99
7/26/94	2	146	657	99	91	410	54
7/27/94	3	192	576	61	101	303	36
7/28/94	3	8	24	6	1	3	3
7/29/94	0	0	30	6	0	2	0
7/30/94	1	4	36	8	0	0	0
7/31/94	2	30	135	38	2	9	5
8/1/94	0	0	308	66	0	18	5
8/2/94	0	0	308	66	0	18	5
8/3/94	2	107	482	51	6	27	10
8/4/94	2	78	351	62	7	32	14
8/5/94	2	54	243	56	10	45	13
8/6/94	2	149	671	83	11	50	14
8/7/94	1	19	171	36	0	0	0
8/8/94	1	10	90	19	1	9	2
8/9/94	1	79	711	152	1	9	2
8/10/94	2	113	509	63	0	0	0
8/11/94	2	68	306	41	1	5	4
8/12/94	2	35	158	36	0	0	0
Total	68	2,183	9,988	347	3,074	11,881	479

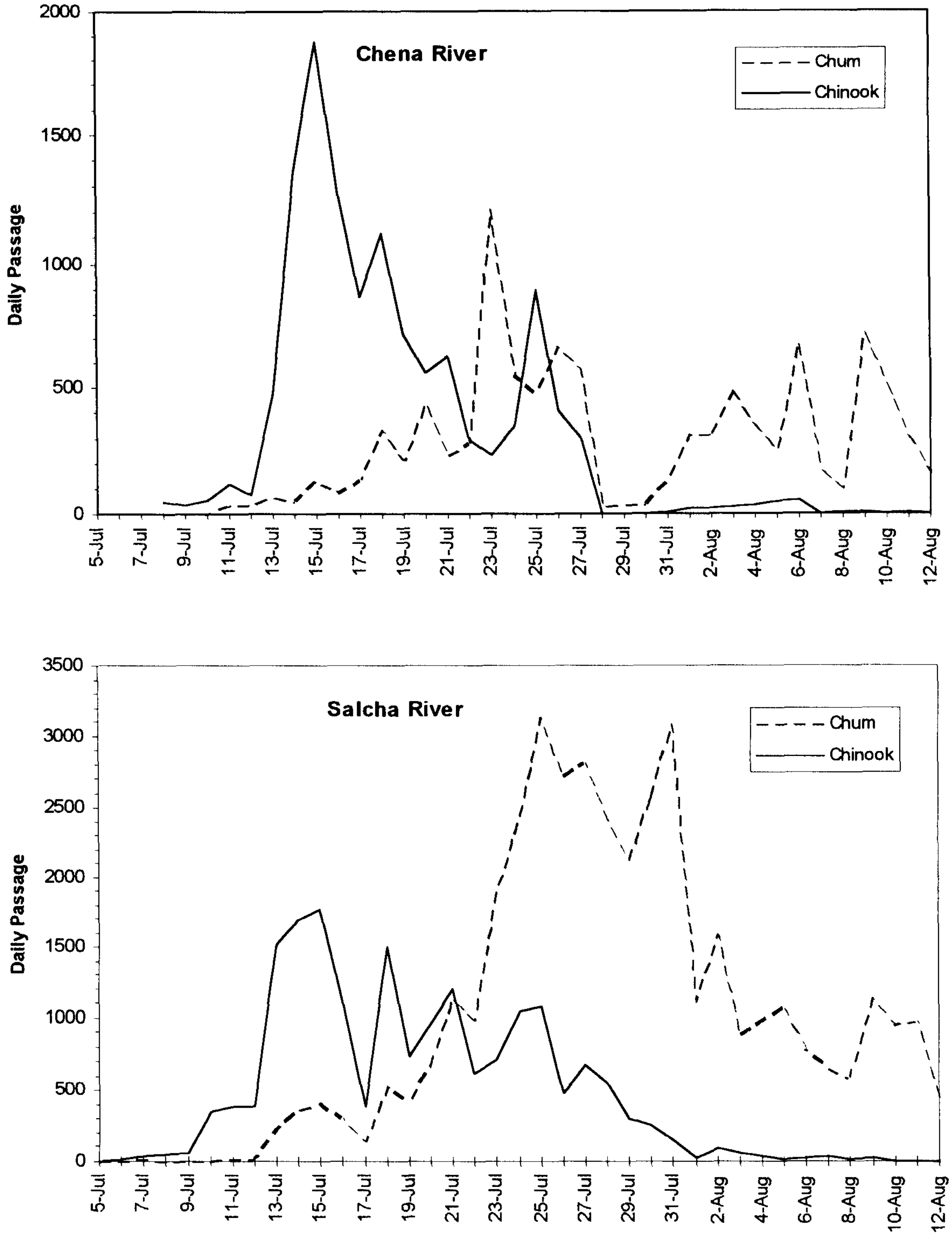


Figure 4.-Daily estimates of passage for chinook and chum salmon past the counting sites on the Chena and Salcha rivers during 1994.

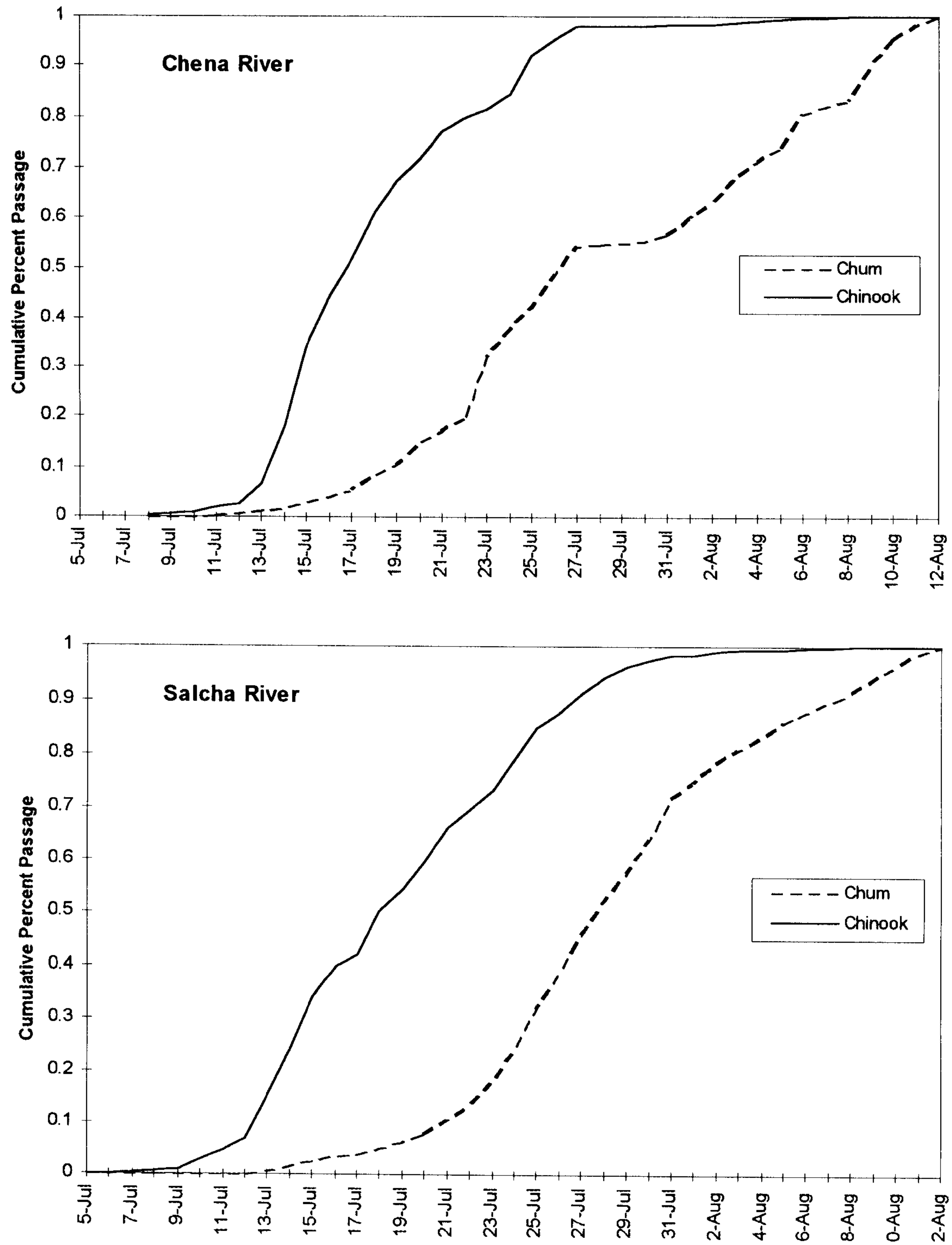


Figure 5.-Cumulative frequency distributions of daily estimates of passage for chinook and chum salmon past the counting sites in the Chena and Salcha rivers during 1994.

females were most represented by age 1.4 fish (32% of total sample). These two age classes represented 92% of the total sample. Mean lengths at age were also calculated (Table 4).

Lengths were obtained from the 618 carcasses sampled. Lengths of males ranged from 355 to 1,080 mm, and lengths of females ranged from 525 to 995 mm (Figure 6).

Age-Sex-Length Compositions of Chinook Salmon in the Chena River

Six-hundred one chinook salmon carcasses were collected from the Chena River. Of these, 326 (54%) were male and 275 (46%) were female. Abundances calculated from these proportions were 6,442 (SE = 355) and 5,434 (SE = 326) for males and females respectively.

Age was estimated for 512 fish (85% of the sample). To determine whether the aged sample was similar to the total sample, two tests were performed. First, a chi-square goodness of fit test indicated that the proportions of not-aged males and females were similar to those that were aged ($\chi^2 = 0.57$; df = 1; P = 0.45). Second, a Kolmogorov-Smirnov two sample test indicated that length distributions of aged and not-aged fish were similar (dn = 0.06; P = 0.88). Therefore, proportions and abundance by sex and age class were calculated. Males were most represented by age 1.3 fish (35% of total sample) while females were most represented by age 1.4 fish (32% of total sample). These two age classes represented 94% of the total sample. Mean lengths at age were also calculated (Table 5).

Lengths were obtained from all 601 carcasses. Lengths of males ranged from 375 to 1,085 mm. Lengths of females ranged from 650 to 1,045 mm (Figure 6).

Length distributions from the Chena and Salcha rivers were statistically dissimilar (dn = 0.10; P = 0.01), but plotted distributions did not appear substantially different (Figure 7). Sex compositions were similar in both rivers ($\chi^2 = 0.09$; df = 1; P = 0.77).

Potential Egg Production

Estimated total potential egg production of the spawning population of chinook salmon was 74.9 million eggs (SE = 5.4 million) in the Salcha River and 48.0 million eggs (SE = 3.6 million) in the Chena River. These estimates are the highest on record for both rivers (Table 6).

Relation of Aerial Counts to Abundance Estimates

During aerial surveys conducted on 25 July, 11,823 chinook salmon were counted in the Salcha River and 1,570 were counted in the Chena River. These aerial counts were about 64% and 13% of the respective abundance estimates. The survey was rated "good" for the Salcha River and "fair-poor" for the Chena River. Since 1986, the proportion of the population observed during aerial surveys has ranged from 0.19 to 0.71 for the Salcha River and 0.13 to 0.59 for the Chena River (Table 7).

DISCUSSION

This was the second consecutive year tower counting methodology was used to estimate escapements of chinook salmon in the Chena and Salcha rivers. Tower counts offer a number of advantages over mark-recapture techniques or aerial surveys. The first obvious advantage is that tower counts allow managers to manipulate the fisheries before escapement is completed based on reaching or not reaching escapement goals. In fact, the sport fishing bag limit was increased by emergency order regulation from one to two chinook salmon per day in both 1993 and 1994 as a result of large, early escapements. Aerial surveys also offer managers the ability to manage in-

Table 4.-Estimated proportions, abundance, and mean length by age class of male and female chinook salmon in the Salcha River during 1994.

	Age[a]	Sample Size	Proportion	SE	Abundance	SE	Length Mean	Length SE	Length Min	Length Max
Male										
	1.1	3	0.01	0.00	106	61	397	43	355	440
	1.2	10	0.02	0.01	354	111	573	41	520	665
	1.3	161	0.31	0.02	5,697	410	738	55	615	895
	1.4	105	0.20	0.02	3,715	343	855	70	680	1,000
	1.5	8	0.02	0.01	283	100	943	110	805	1,080
Female										
	1.2	4	0.01	0.00	142	71	609	78	525	675
	1.3	43	0.08	0.01	1,521	227	751	66	640	875
	1.4	168	0.32	0.02	5,944	417	865	48	750	1,000
	1.5	17	0.03	0.01	602	145	911	56	805	995
	2.3	1	0.00	0.00	35	35	840		840	840

[a] The notation xx represents the number of annuli formed during river residence and ocean residence (i.e. an age of 2.3 represents two annuli formed during river residence and three annuli formed during ocean residence). One annulus is formed each year.

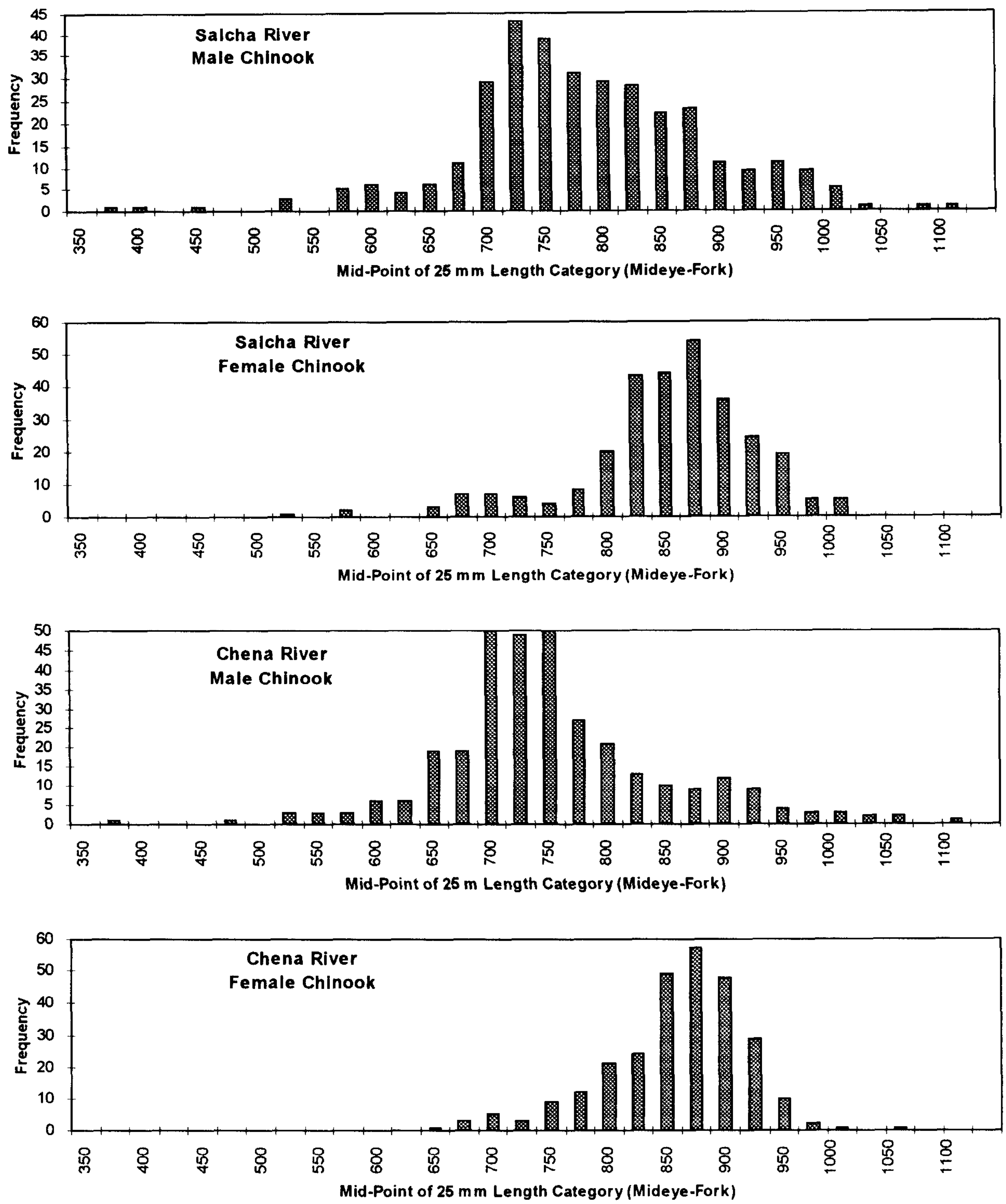


Figure 6.-Length frequency distributions of male and female chinook salmon carcasses collected in the Chena and Salcha rivers during 1994.

Table 5.-Estimated proportions, abundance, and mean length by age class of male and female chinook salmon in the Chena River during 1994.

	Age[a]	Sample Size	Proportion	SE	Abundance	SE	Length Mean	Length SE	Length Min	Length Max
Male	1.2	15	0.03	0.01	348	90	579	64	475	700
	1.3	181	0.35	0.02	4,199	303	718	60	595	1,030
	1.4	82	0.16	0.02	1,902	207	820	79	680	1,005
	1.5	2	0.00	0.00	46	33	1,045	57	1,005	1,085
	2.3	1	0.00	0.00	23	23	730			
Female	1.3	42	0.08	0.01	974	149	777	71	650	920
	1.4	178	0.35	0.02	4,129	300	864	44	750	1,045
	1.5	10	0.02	0.01	232	73	900	44	810	950
	2.3	1	0.00	0.00	23	23	815			

[a] The notation xx represents the number of annuli formed during river residence and ocean residence (i.e. an age of 2.3 represents two annuli formed during river residence and three annuli formed during ocean residence). One annulus is formed each year.

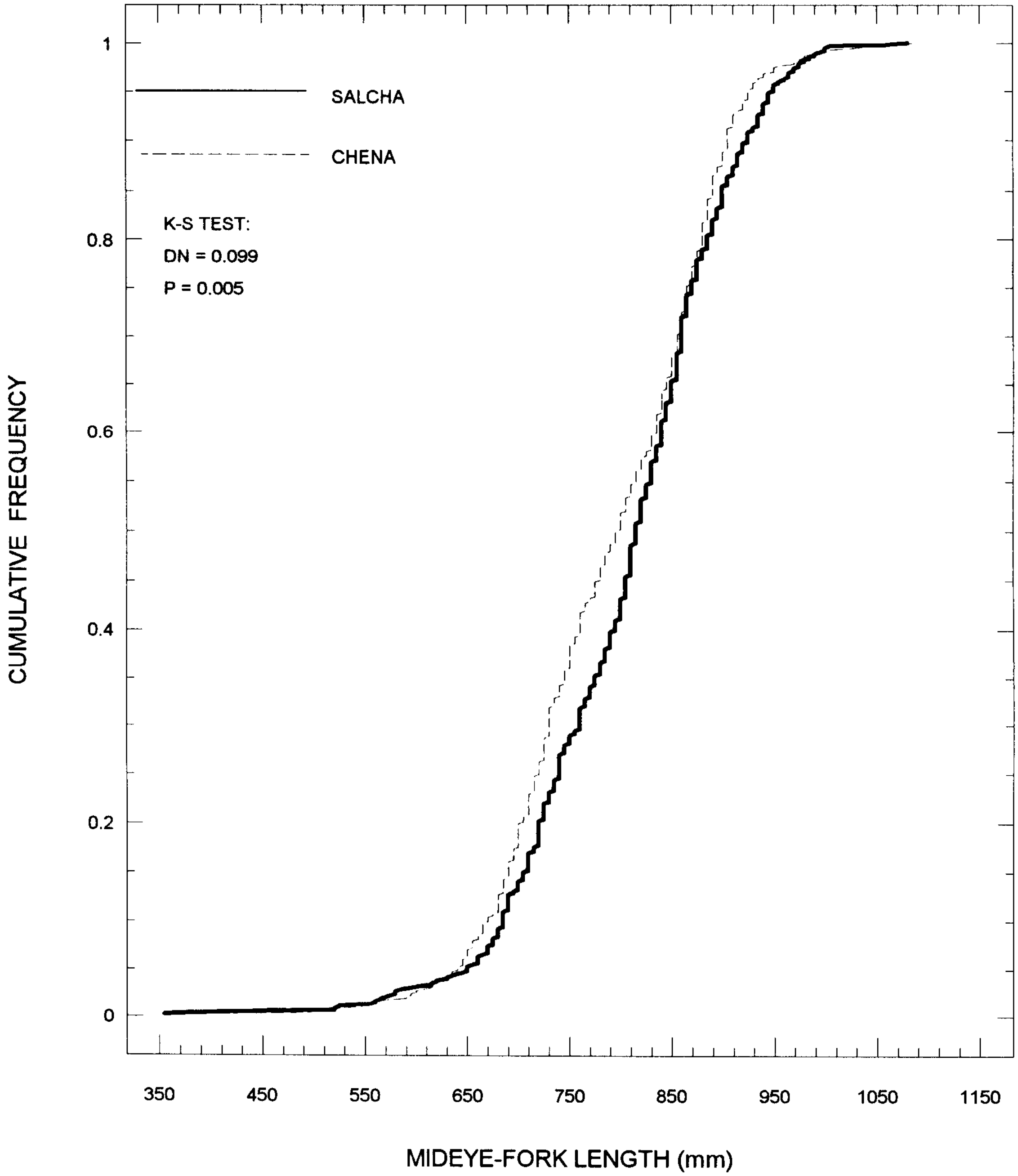


Figure 7.-Results of a Kolmogorov-Smirnov two sample test comparing cumulative length frequency distributions of chinook salmon carcasses collected in the Salcha and Chena rivers during 1994.

Table 6.-Estimated potential egg production of chinook salmon in the Salcha River and Chena River, 1986-1994.

River:	Estimated Abundance				Estimated Production (millions)	
Year	Population	(SE)	Females	(SE)	Eggs	(SE)
Salcha:						
1987	4,771	504	2,481	349	25.9	3.2
1988	4,562	556	1,525	197	16.2	2.8
1989	3,294	630	1,704	484	16.6	1.8
1990	10,728	1,405	5,322	735	52.0	2.7
1991	5,608	644	2,522	197	23.0	1.7
1992	7,862	975	2,842	373	27.2	2.1
1993	10,007	360	2,761	233	23.0	2.1
1994	18,399	549	8,574	472	74.9	5.4
Chena:						
1986	9,065	1,080	2,301	538	NR[a]	NR
1987	6,404	557	3,501	416	NR	NR
1988	3,346	556	NA	NA	NR	NR
1989	2,666	249	1,039	145	9.8	0.8
1990	5,603	1,164	2,633	564	24.7	1.4
1991	3,025	282	954	99	8.5	0.6
1992	5,230	478	1,607	162	14.9	1.1
1993	12,241	387	3,233	249	NR	NR
1994	11,877	347	5,434	326	48.0	3.6

[a] Means estimate was not reported or not calculated due to bias in sex composition estimates.

Table 7.-Estimated abundance, highest counts during aerial surveys, aerial survey conditions, and proportion of the population observed during aerial surveys for chinook salmon escapement in the Salcha (1987-1994) and Chena (1986-1994) rivers.

River Year	Estimated Abundance[a]	SE	Aerial Survey Count	Aerial Survey Condition[b]	Proportion of Population Observed for Aerial Survey
Salcha:					
1987	4,771[c]	504	1,898	Fair	0.40
1988	4,562[c]	556	2,761	Good	0.61
1989	3,294[c]	630	2,333	Good	0.71
1990	10,728[c]	1,404	3,744	Good	0.35
1991	5,608[c]	664	2,212	Poor	0.39[d]
1992	7,862[c]	975	1,484	Fair-Poor[e]	0.19
1993	10,007[f]	360	3,636	Fair	0.36
1994	18,399[f]	549	11,823	Good	0.64
Chena:					
1986	9,065[c]	1,080	2,031	Fair	0.22
1987	6,404[c]	557	1,312	Fair	0.20
1988	3,346[cg]	556	1,966	Fair-Poor[e]	0.59
1989	2,666[c]	249	1,180	Fair-Good[e]	0.44
1990	5,603[c]	1,164	1,436	Fair-Poor[e]	0.26
1991	3,025[c]	282	1,276	Poor	0.42
1992	5,230[c]	478	825	Fair-Poor[e]	0.16
1993	12,241[f]	387	2,943	Fair	0.24
1994	11,877[f]	479	1,570	Fair-Poor	0.13

[a] Details of estimates can be found in Barton (1987a and 1988); Barton and Conrad (1989); Burkholder (1991); Evenson (1991, 1992, and 1993); and, Skaugstad (1988, 1989, 1990a, 1990b, 1992, 1993, and 1994).

[b] During these surveys, conditions were judged on a scale of "poor, fair, good, excellent" unless otherwise noted.

[c] Estimate was obtained from mark-recapture techniques.

[d] Aerial survey was made a few days before spawning peaked.

[e] During these surveys, conditions were judged to vary by area on a scale of "poor, fair, and good".

[f] Estimate was obtained from tower counts.

[g] Original estimate was 3,045 (SE = 561) for a portion of the river. The estimate was expanded based on the distribution of spawners observed during an aerial survey.

season, and are usually less expensive than tower counts. However, in the Chena and Salcha rivers the relationship between aerial counts and actual abundance is unclear as counts can vary considerably (imprecise) depending upon water visibility (affected by turbidity, wind, or light conditions), and have been in all cases substantially lower (inaccurate) than estimates obtained using mark-recapture techniques or tower counts.

The precision of the four estimates obtained from tower counts (from the Chena and Salcha rivers in 1993 and 1994) were also substantially better than the precision of 13 mark-recapture estimates obtained from prior years (six from the Salcha River and seven from the Chena River; see Table 7). The tower counts have also been, especially in the Chena River, substantially higher than the mark-recapture estimates from previous years. This suggests that either escapements have actually been substantially larger during the last two years, or that mark-recapture methods underestimated escapements. Skaugstad (1994) suggested that sampling during the mark-recapture experiments did not cover the entire portion of river where spawning occurred, and may have occurred at a time before all fish were in the river, and thus the mark-recapture experiments likely did underestimate abundance.

Although the tower count estimates seem to be more accurate and more precise than the mark-recapture or aerial survey estimates, the largest drawback is that it can only be assumed that a representative carcass sample is being taken to estimate age-sex-length compositions. Mark-recapture techniques allow for detection of, and possibly correction of, bias. Past experiments (a total of 10 have been conducted in the Chena and Salcha rivers where carcass sampling was used as a capture technique) have shown that size composition estimates were biased during two (20%) experiments, and sex composition estimates were biased during three (30%) experiments. In one of the two cases where size composition was biased (Chena River during 1992), the bias was not substantial enough to alter the estimated abundance and was thus not considered biologically significant (Evenson 1993). The extent of the bias associated with sex compositions in terms of its effect on estimates of population proportions is not known. To alleviate the risk of bias in future carcass samples, the sampling design should be modified such that samples are collected over an extended period of time (two or more weeks), and should be collected over the entire course of river where spawning occurs.

Estimates of chum salmon abundances for the Chena and Salcha rivers populations were minimal estimates because only the first part of the migration was counted. Currently there is an escapement objective of 3,500 chums from aerial survey for the Salcha River, and there is no escapement objective for the Chena River. It may be of value in future years to extend tower counts of chum salmon in order to get complete estimates of escapement such that minimum escapement policies can be developed for both rivers.

COHO SALMON STUDY IN THE DELTA CLEARWATER RIVER

INTRODUCTION

The Delta Clearwater River has the largest known coho salmon escapements in the Yukon River drainage (Table 8; Parker 1991). The river is a spring-fed tributary to the Tanana River located near Delta Junction about 160 km southeast of Fairbanks (Figure 8). The main river is 32 km, with a 10 km north fork. There are a number of small, shallow spring areas adjacent to the

Table 8.-Peak escapements of coho salmon into the Delta Clearwater River and Clearwater Lake Outlet, 1972-1994.

		Delta Clearwater River				Clearwater
Year	Survey Date	Lower River[a]	Upper River[b]	Total[c]	Sport Harvest[d]	Lake Outlet[c]
1972	9 Nov	NA[e]	NA	632	NA	417[f]
1973	20 Oct	NA	NA	3,322	NA	551
1974	NA	NA	NA	3,954[f]	NA	560[f]
1975	24 Oct	NA	NA	5,100	NA	1,575
1976	22 Oct	NA	NA	1,920	NA	1,500
1977	25 Oct	2,331	2,462	4,793	31	730
1978	26 Oct	2,470	2,328	4,798	126	570
1979	23 Oct	3,407	5,563	8,970	0	1,015
1980	28 Oct	2,206	1,740	3,946	25	1,545
1981	21 Oct	4,110	4,453	8,563[g]	45	459
1982	3 Nov	4,015	4,350	8,365[g]	21	NA
1983	25 Oct	3,849	4,170	8,019[g]	63	253[f]
1984	6 Nov	5,434	5,627	11,061	571	1368[f]
1985	13 Nov	NA	NA	6,842[f]	722	750[f]
1986	21 Oct	5,490	5,367	10,857	1,005	1,800
1987	27 Oct	11,700	10,600	22,300	1,068	4,225
1988	28 Oct	5,300	16,300	21,600	1,291	825
1989	25 Oct	5,400	7,200	12,600	1,049	1,600
1990	26 Oct	4,525	3,800	8,325	1,375	2,375
1991	23 Oct	11,525	12,375	23,900	1,721	3,150
1992	26 Oct	1,118	2,845	3,963	615	229
1993	21 Oct	3,425	7,450	10,875	48	550[h]
1994	24 Oct	19,450	43,225	62,675[i]	NA	3,425

[a] Mile 0 to Mile 8.

[b] Mile 8 to Mile 17.5.

[c] Boat survey by Alaska Department of Fish and Game, Division of Sport Fish unless otherwise noted.

[d] Data were obtained from Mills (1979-1994).

[e] Means data is not available.

[f] Survey by Alaska Department of Fish and Game, Division of Commercial Fisheries.

[g] Population estimate.

[h] Clearwater Lake Outlet was not surveyed on 21 October 1993. A survey was conducted on 29 October 1993.

[i] Estimate does not include nonboatable portions of the river. Total estimate was 80,240.

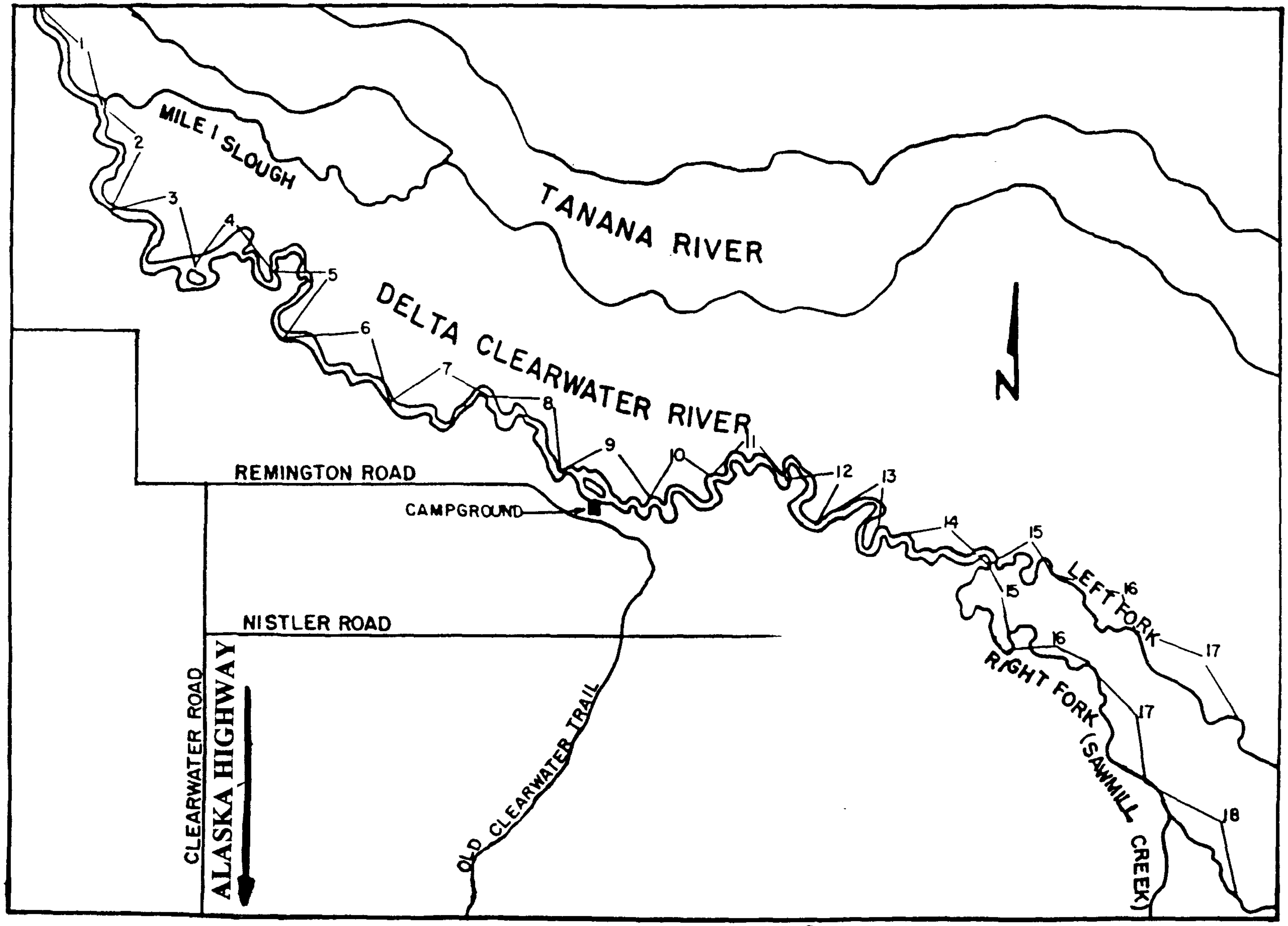


Figure 8.-Delta Clearwater River study area.

mainstem river. Spawning occurs throughout the mainstem river and in the spring areas. The river supports an increasingly popular fall sport fishery. Annual harvests have exceeded 1,000 coho salmon from 1986 - 1991 (Mills 1979-1994; Table 8). Before reaching their spawning grounds, the coho salmon travel about 1,693 km from the ocean and pass through six different commercial fishing districts in the Yukon and Tanana rivers (Figure 3). Subsistence and personal use fishing also occur in each district.

Escapements of coho salmon into the Delta Clearwater River have been monitored by counting fish from a drifting river boat. This information has been used to evaluate management of the commercial, subsistence, and personal use fisheries. The information is also used to regulate the harvest of coho salmon in the Delta Clearwater River sport fishery by opening and closing the season and changing the bag limit. The present bag limit is three coho salmon per day and three in possession. ADF&G has established a minimum escapement of 9,000 coho salmon to the Delta Clearwater River. When counts indicate that the escapement is low, the sport fishery is regulated by reducing the bag limit or closing the fishery. When the count exceeds the minimum escapement then the bag limit may be increased.

The objective of the coho salmon escapement project for the Delta Clearwater River in 1994 was to estimate age, sex, and length compositions of the escapement of coho salmon in the Delta Clearwater River. In addition, there was one task: to count coho salmon in the Delta Clearwater River from a drifting riverboat at weekly intervals throughout the run.

METHODS

Counts

Adult coho salmon were counted from a drifting riverboat equipped with an observation platform, which was about 2 m above the water. The Delta Clearwater River was divided into 1.6 km (1 mi) sections and fish were counted by section (Figure 8). The sections were numbered from the mouth (mile 0) upstream. Many coho salmon spawn in shallow spring areas adjacent to the mainstem river. These areas historically have not been included in the surveys. To determine the proportion of fish which spawn in these areas relative to the main river, an aerial survey was conducted using a Robertson (R22) helicopter, and flying at approximately 100 m above ground level.

Age-Sex-Length Compositions

Coho salmon carcasses were collected from river kilometer 24 (mile 15) to 14 (mile 9) on 16 November 1994. In a drifting river boat, one person collected carcasses with a long handled spear while two others measured length, determined sex, and collected scale samples. Length was measured from mid-eye to fork-of-tail (ME-FT) to the nearest 5 mm. Sex was determined from observation of body morphology or by cutting into the body cavity to examine the gonads. Scales were removed from the left side approximately two rows above the lateral line along a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Scarnecchia 1979).

Ages were determined from scale patterns as described by Mosher (1969). The proportions of the population represented by combinations of age and sex were estimated using Equations 11 and 12. Mean lengths were estimated for combinations of age and sex using the sample mean and variance (Zar 1984).

RESULTS

Counts

The first count was made on 5 October, but only the portion of the mainstem Delta Clearwater River from river kilometer 4.8 (mile 3) through 14 (mile 8.5) was covered. During this count visibility was considered good, and no platform was used. A total of 9,700 coho salmon were counted. Because this count was larger than the minimum escapement goal (9,000), another count was not conducted until it was felt that complete escapement had been reached.

The second count, conducted on 24 October, covered the entire mainstem river (river kilometer 0-28; mile 0-17.5). This count also included the 2.4 km outlet to Clearwater Lake, which is in close proximity to the Delta Clearwater River. The total count for the mainstem Delta Clearwater River was 62,675. Coho salmon were distributed throughout the entire stretch in densities ranging from 825 to 6,450 fish per mile (Table 9).

The aerial survey was conducted on 27 October. The total count for the nonboatable springs and tributaries was 17,565, or 22% of the total count of 80,240 coho salmon. Counts for individual spring areas ranged from 5 to 4,325 (Table 9).

Age-Sex-Length Compositions

Three hundred eighty-four coho salmon carcasses were collected and measured. The sex and length were determined and scale samples were collected from all carcasses. Age was determined for only 317 (83%) of these samples. Brood year 1990 (age 2.1) comprised 67% of the sample, while brood year 1991 (age 1.1) comprised the remainder of the sample (Table 10). Mean lengths ranged from 554 to 565 mm by sex and age combinations. Males had a wider range in length than females by age but the mean lengths of females were larger than for males by age (Table 10 and Figure 9).

DISCUSSION

Even excluding the aerial survey counts of the nonboatable portions of the river, the count in 1994 was approximately three-fold higher than any previous count. The reasons for this extreme escapement are unclear. Commercial, subsistence, and personal use harvests were lower than normal. Commercial harvest for the entire Yukon drainage during 1994 was estimated to be 4,452. The previous five year average harvest was 7,181 although no harvest occurred during 1993. Subsistence and personal use harvests in the Yukon drainage, which are typically much greater than commercial harvests, are not available yet for 1994. However, it is believed that catches during 1994 were also considerably less than the previous five year average of 54,186. Run strength for the entire Yukon drainage was believed to be higher than average based on test fishing conducted through 8 September (Schultz et al. 1994). Brood years 1990 and 1991 comprised the majority of the 1994 return. Although escapement during 1990 was average or below average (8,325), escapement during 1991 was the second highest on record (23,900; Table 8).

This year was the first year that aerial surveys were conducted to estimate the number of coho salmon in the nonboatable waters adjacent to the mainstem river. This count indicated that a substantial portion (22%) of the escapement spawns in these areas. Similar counts should be conducted in future years to obtain a more accurate estimate of total escapement as well as to determine if the distribution of spawners in these areas varies annually.

Table 9.-Counts of adult coho salmon in the Delta Clearwater River, 1994.

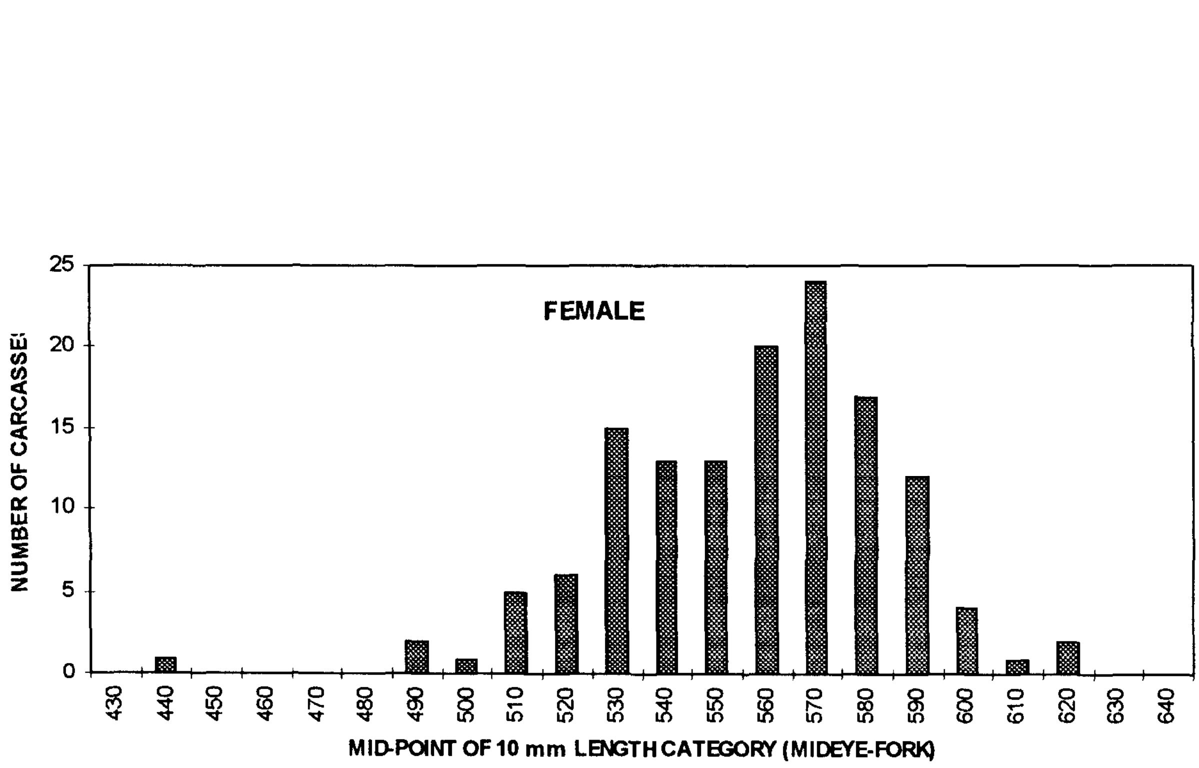
Mainstem River (Boat Survey)		Nonboatable Portion (Aerial Survey)	
River Mile	Count (24 Oct)	Name of Spring	Count (27 Oct)
17-16	5,925	Sawmill Creek	1,950
16-15	4,800	Andersen's Spring	25
15-14	6,450	Granite Creek	250
14-13	5,975	South Clearwater	1,700
13-12	5,725	Middle Clearwater	2,025
12-11	4,625	Peckham's Spring	100
11-10	4,375	Clearwater-Sec 1	2,175
10-9	3,625	Clearwater-Sec 2	4,325
9-8	1,725	Fronty's Spring	175
8-7	2,450	Jan's Spring	200
7-6	1,050	Jennie's Spring	250
6-5	3,025	Jesse's Spring	25
5-4	3,300	Chad's Spring	100
4-3	4,075	Buns' Spring	200
3-2	1,550	Patty's Spring	20
2-1	3,175	Dave's Spring	25
1-0	825	Travis's Spring	175
		Dubois' Spring	10
Summary		Christie's Spring	25
17.5-8	43,225	Caleb's Spring	325
8-0	19,450	Isaac's Slough	700
14-0	45,500	Parker's Spring	775
17.5-0	**62,675**	Kenna's Spring	350
		Backy Spring	15
Visibility	Poor-Fair	Barb's Spring	90
		Ridder's Spring	300
		Pearse's Spring	1,175
		Mallard Spring	5
		Total	**17,565**

Table 10.-Statistics by age and sex for coho salmon carcasses collected from the Delta Clearwater River, 1994.

	Male		Female	
Age[a]	1.1	2.1	1.1	2.1
Brood Year	1991	1990	1991	1990
Count[b]	38	77	67	135
Minimum Length (mm)	430	445	510	445
Maximum Length (mm)	645	640	600	625
Mean Length (mm)	556	554	565	556
Standard Error	4	4	6	4

[a] The notation X.X represents the number of annuli formed during river residence and ocean residence (i.e. an age of 2.1 represents two annuli formed during river residence and one anuli formed during ocean residence). One annulus is formed each year.

[b] Coho salmon were not included when age was not determined due to missing or unreadable scales.



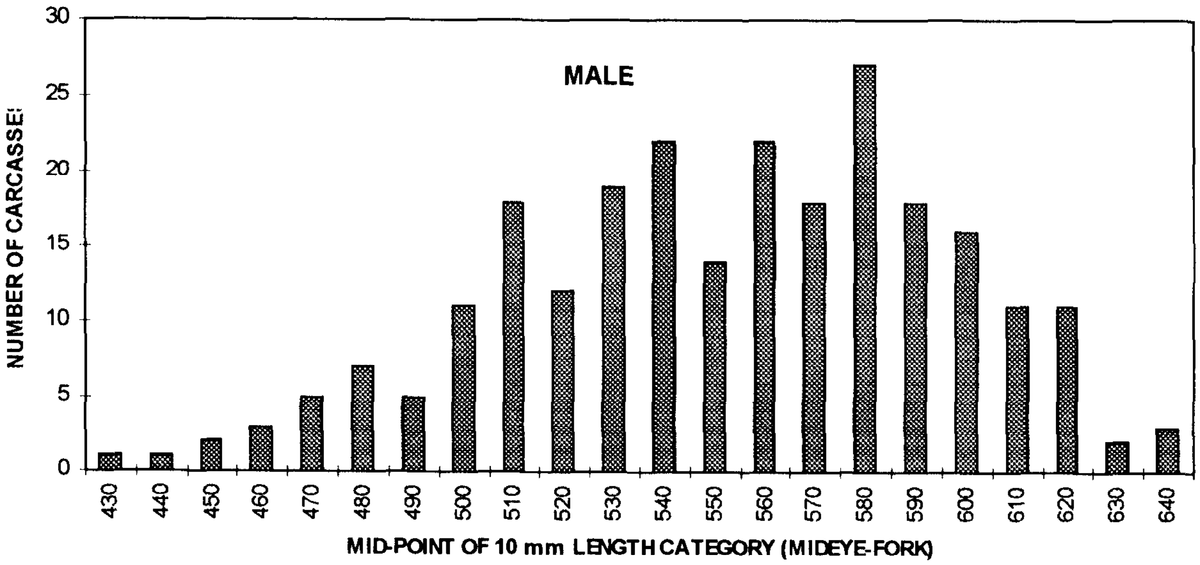


Figure 9.-Length frequency distributions of male and female coho salmon carcasses collected in the Delta Clearwater River during 1994.

Counts of escapements are primarily conducted to ensure that the minimum escapement goal (9,000 coho salmon) is achieved. In cases when this escapement objective is not met, the sport fishery can be closed to maximize escapement. In cases of extreme abundance, as was the case this year, modifying sport fishing bag limits would likely be of little consequence. Current regulations already allow for three coho salmon bag and possession limit. In addition, most of the fish caught are released; few fish are harvested. It is not likely that increasing the bag and possession limit would cause a substantial increase in harvest.

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APPENDIX A. COUNTING SCHEDULES FOR THE SALCHA AND CHENA RIVERS DURING 1994

Appendix A1.-Schedule for counting salmon in the Salcha River during 1994.

4-10 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800			COUNT	COUNT	COUNT		COUNT
0800-1600			COUNT	COUNT		COUNT	COUNT
1600-0000		COUNT	COUNT		COUNT	COUNT	COUNT

11-17 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT		COUNT	COUNT	COUNT	COUNT	COUNT
0800-1600		COUNT	COUNT	COUNT	COUNT		COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT		COUNT	COUNT

18-24 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT	COUNT	COUNT	COUNT	COUNT		COUNT
0800-1600	COUNT		COUNT	COUNT		COUNT	COUNT
1600-0000		COUNT	COUNT	COUNT	COUNT	COUNT	COUNT

25-31 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT		COUNT	COUNT		COUNT	COUNT
0800-1600		COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
1600-0000	COUNT	COUNT	COUNT		COUNT	COUNT	COUNT

1-7 August	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800						COUNT	COUNT
0800-1600		COUNT	COUNT		COUNT	COUNT	
1600-0000	COUNT					COUNT	COUNT

8-14 August	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT		COUNT	COUNT			
0800-1600		COUNT	COUNT	COUNT	COUNT		
1600-0000	COUNT	COUNT	COUNT		COUNT		

Appendix A2.-Schedule for counting salmon in the Chena River during 1994.

4-10 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800						COUNT	COUNT
0800-1600					COUNT	COUNT	COUNT
1600-0000							COUNT

11-17 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT			COUNT	COUNT	COUNT	COUNT
0800-1600		COUNT	COUNT	COUNT	COUNT		COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT		COUNT	COUNT

18-24 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT	COUNT	COUNT	COUNT	COUNT		COUNT
0800-1600	COUNT	COUNT	COUNT	COUNT		COUNT	COUNT
1600-0000			COUNT	COUNT	COUNT	COUNT	COUNT

25-31 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT		COUNT	COUNT	High H_2O	COUNT	COUNT
0800-1600		COUNT	COUNT	COUNT	High H_2O		
1600-0000	COUNT	COUNT	COUNT	High H_2O	High H_2O	COUNT	COUNT

1-7 August	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800			COUNT	COUNT			
0800-1600					COUNT	COUNT	COUNT
1600-0000			COUNT	COUNT	COUNT	COUNT	

8-14 August	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800			COUNT	COUNT			
0800-1600					COUNT		
1600-0000	COUNT	COUNT	COUNT	COUNT	COUNT		

APPENDIX B

Appendix B.-Data files used to estimate parameters of chinook, chum, and coho salmon populations during 1994.

Data File	Description
U0020TA4.ARC[a]	Hourly counts of adult chinook and chum salmon past the counting site on the Chena River, 1994.
CHENKG94.AWL[a]	Data file of length, sex, and age data for chinook salmon carcass collected from the Chena River, 1994.
U0050TA4.ARC[a]	Hourly counts of adult chinook and chum salmon past the counting site on the Salcha River, 1994.
SALCKG94.AWL[a]	Data file of length, sex, and age data for chinook salmon carcass collected from the Chena River, 1993.
SALMAWL.XLS[b]	Excel worksheet file of length and sex data for chinook salmon from the Chena and Salcha rivers, 1994.
SALM94.XLS[b]	Excel worksheet file of tower count data from the Chena and Salcha rivers, 1994
DCLRCO94.AWL[a]	Data file of length, sex, and age data for coho salmon carcasses collected from the Delta Clearwater River, 1994.
DCRCOHO.XLS[b]	Excel worksheet file of length, sex, and age data for coho salmon carcasses collected from the Delta Clearwater River, 1994

[a] Data files have been archived at, and are available from, the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, 99518-1599.

[b] Data files available from the author: Alaska Department of Fish and Game, Sport Fish Division, 1300 College Rd., Fairbanks, AK, 99701-1599.