Fishery Data Series No. 97-31

Salmon Studies in Interior Alaska, 1996

by

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and

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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

FISHERY DATA SERIES NO. 97-31

SALMON STUDIES IN INTERIOR ALASKA, 1996

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ABSTRACT

Escapements of chinook salmon *Oncorhynchus tshawytscha* in the Salcha and Chena rivers near Fairbanks, Alaska in 1996 were estimated using mark-recapture techniques. Estimates were 7,570 (SE = 1,238) chinook salmon for the Salcha River and 7,153 (SE = 913) for the Chena River. Females comprised only 0.26 of the escapement in the Salcha River and only 0.27 in the Chena River. Age class 1.3 comprised most of the males sampled in both rivers, while ages 1.3, 1.4, and 1.5 comprised most of the females in the samples. Estimates of escapement were attempted using tower counting techniques, however high, turbid water resulting from excessive rainfall prohibited counting during much of the run. Aerial survey counts of chinook salmon at peak escapement were 4,866 for the Salcha River and 2,233 for the Chena River populations. These aerial counts were 0.64 and 0.31 of the respective abundance estimates.

A boat count was conducted in a section of the Chatanika River to index peak escapement of chinook salmon. The count was 198 chinook salmon. One hundred eight carcasses were collected on this survey. Males comprised 0.56 (SE = 0.05) of this sample. Both males and females were most represented by age class 1.3.

Coho salmon *O. kisutch* in the mainstream Delta Clearwater River near Delta Junction were counted from a drifting river boat at peak escapement on 29 October. Counts in spring areas adjacent to the mainstream river and in tributaries not accessible by boat were conducted from a helicopter on 22 October. The total count for the entire river was 17,375 coho salmon. The count of coho salmon in the mainstream river was 14,075, while the count in tributaries and spring areas was 3,300. Four hundred carcasses were collected on two separate sampling occasions to estimate age, size and sex composition. Females comprised 0.49 of the sample. Age 2.1 comprised 0.97 of the sample.

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

CHINOOK AND CHUM SALMON STUDIES IN THE SALCHA , CHENA, AND CHATANIKA RIVERS

The Salcha and Chena rivers (Figures 1 and 2) have some of the largest chinook salmon *Oncorhynchus tshawytscha* escapements in the Yukon River drainage (Schultz et al. 1994). Popular sport fisheries occur in the lower 3 km of the Salcha River and in the lower 72 km of the Chena River. Annual harvest estimates since 1978 have ranged from 47 to 904 fish in the Salcha River, and from 0 to 1,448 chinook salmon in the Chena River (Mills 1979-1994 and Howe et al. 1995 and 1996; Table 1). The Chatanika River (Figure 3) supports a small run of chinook salmon, however recent estimates of sport harvests (Table 1) have indicated that relative exploitation may be large. Before reaching their spawning grounds in the mid to upper reaches of these rivers, 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 4). Subsistence and personal use fishing also occur in each district.

Prior to 1993, the escapements of the chinook salmon 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 use, and sport fisheries on these stocks. However, these methods provide fishery managers with limited information that can be used during the fishing season. Mark-recapture experiments occur after most of the escapement has passed through the various fisheries, and aerial surveys

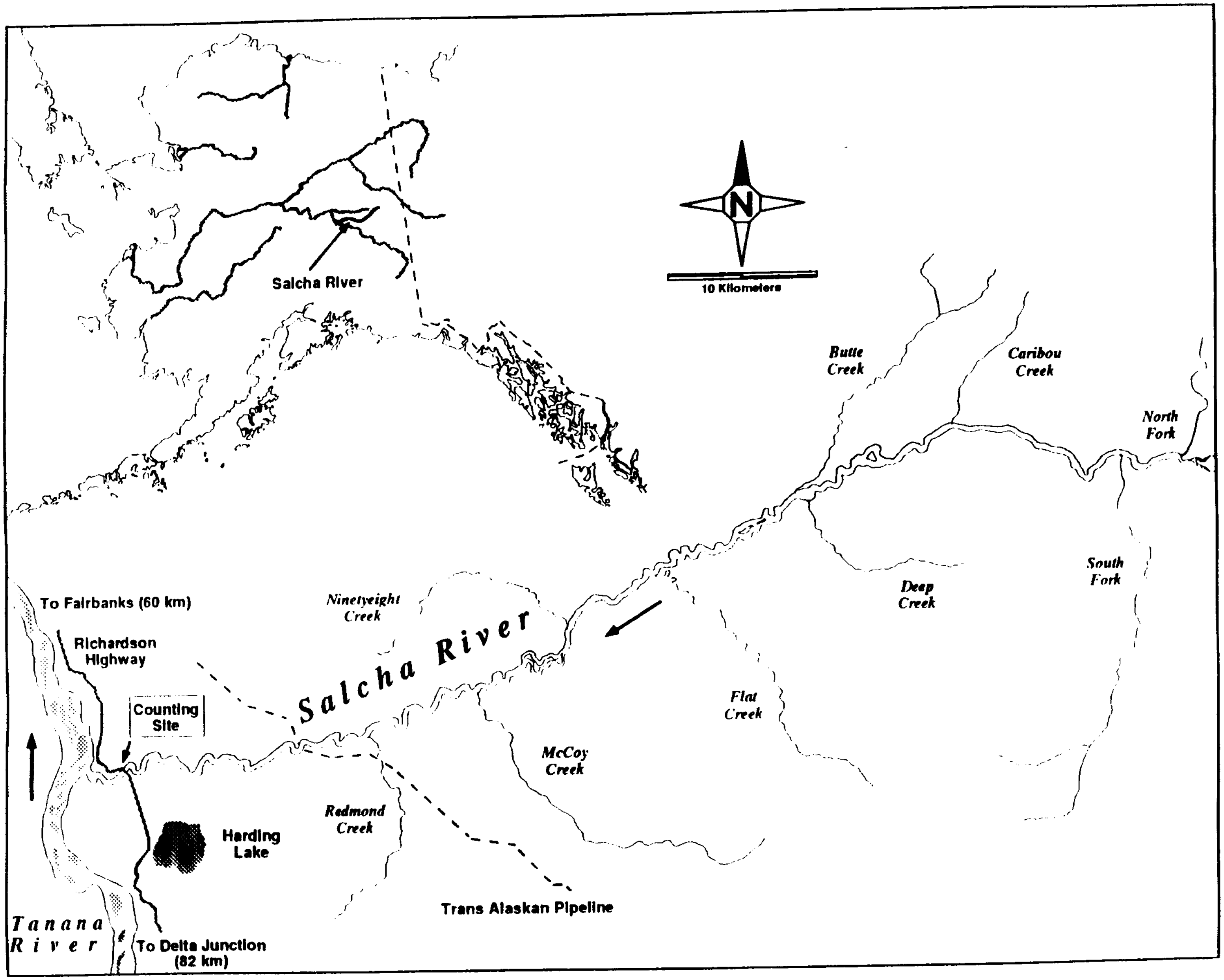

Figure 1.-Salcha River study area

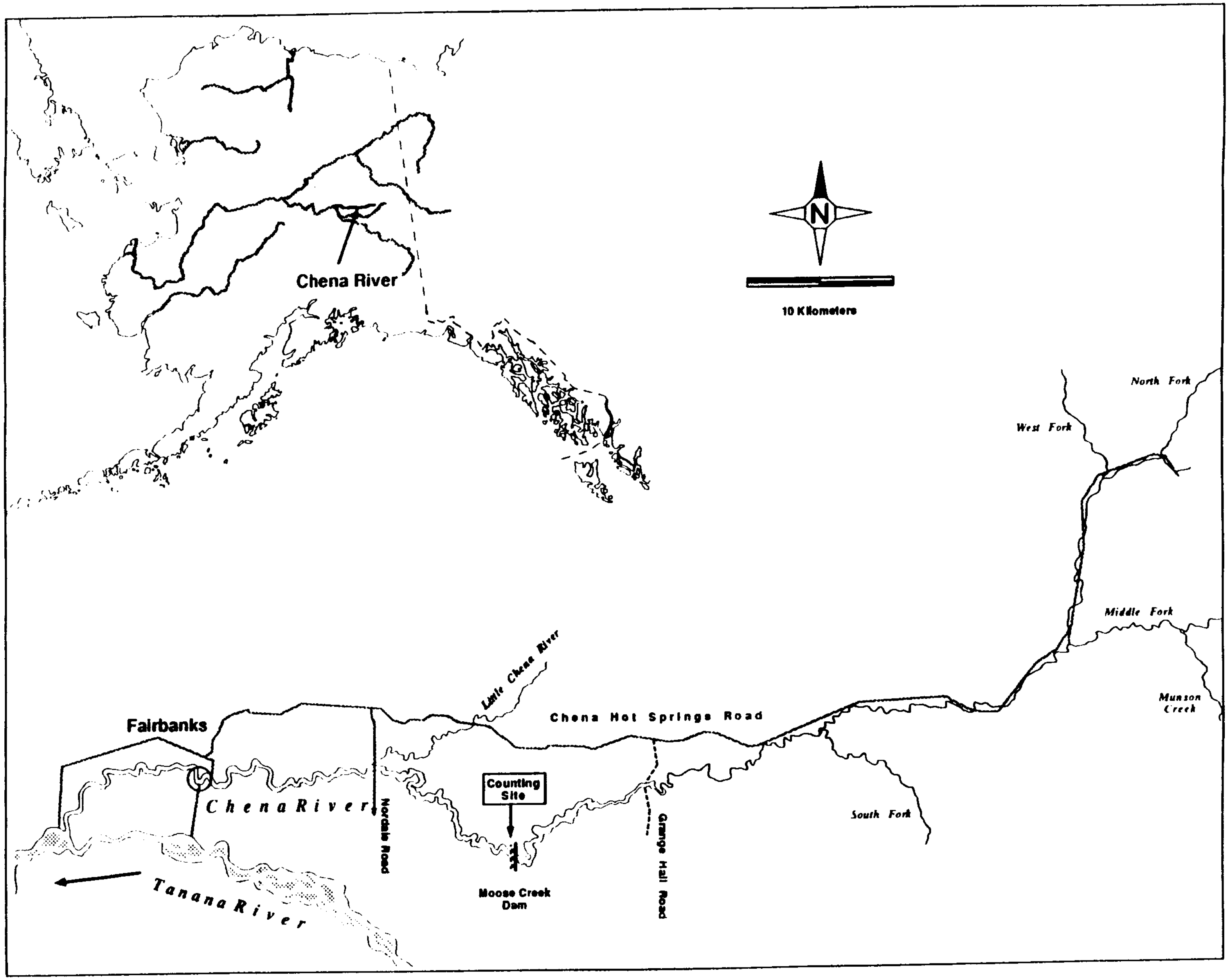

Figure 2.-Chena River study area.

Table 1.-Harvests of anadromous chinook salmon by sport, commercial, subsistence, and personal use fisheries, Tanana River drainage, 1978 - 1996.

	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]	5,156
1994	None	776	993	714	105	0	59	1,871	2,606	2,568[d]	7,045
1995	None	811	622	1,448	58	0	320	2,488	2,747	2,178[d]	7,413
1996	None	none	1,280[d]	1,136[d]	499[d]	49[d]	138[d]	3,102[d]	447[d]	NA[f]	NA[f]

a Creel census estimates from Clark and Ridder (1987), Baker (1988, 1989), Merritt et al. (1990), and Hallberg and Bingham (1991-1996).

b Sport fishery harvest estimates from Mills (1979-1994) and Howe et al. 1995 and 1996.

c Commercial, subsistence, and personal use estimates (Schultz et al. 1994, and, Keith Schultz, 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.

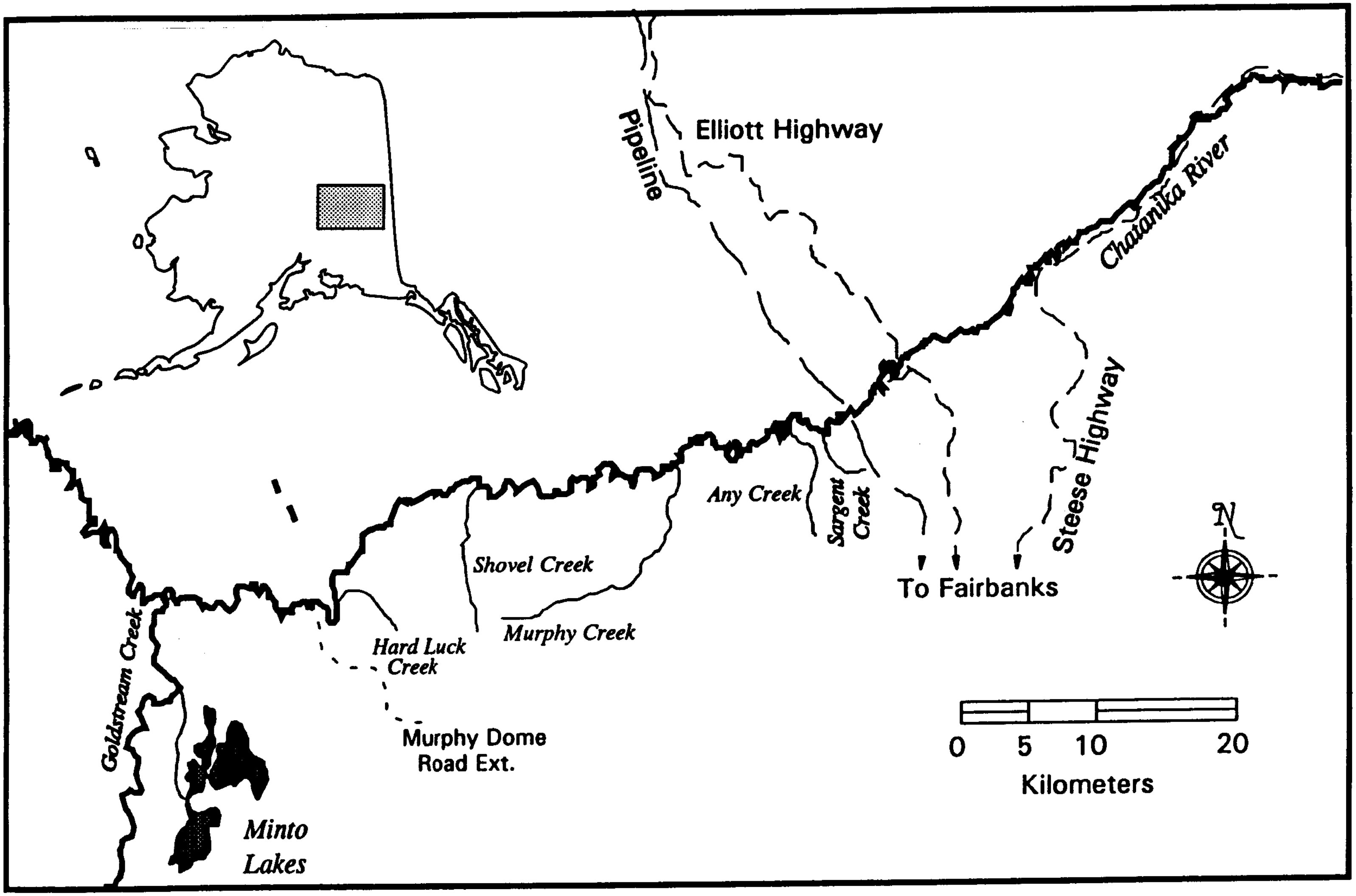

Figure 3.-Chatanika River study area.

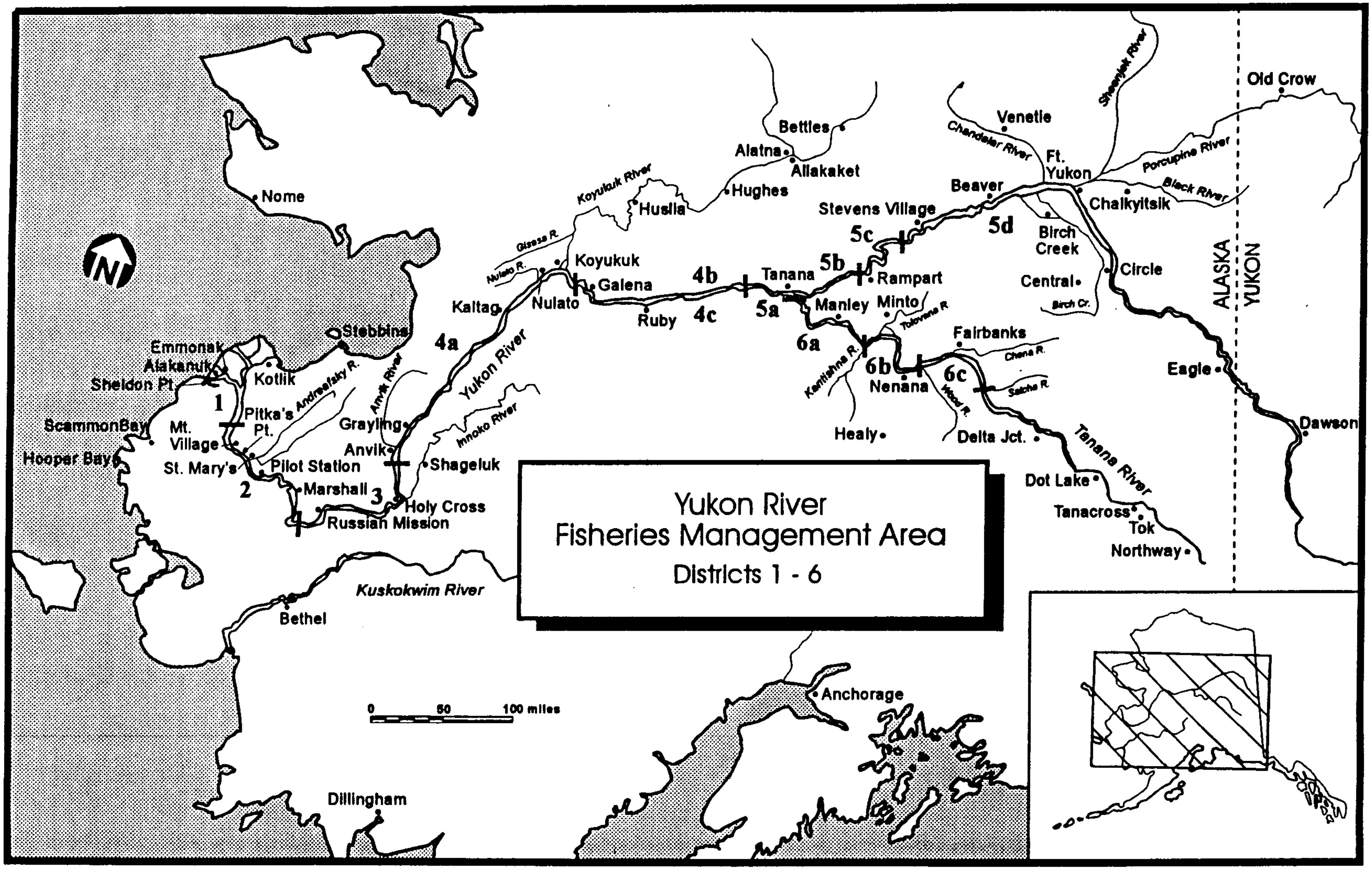

Figure 4.-Fishing districts in the Yukon River drainage.

do not provide consistent indices of escapement. Tower counting methodology was initiated Escapements of chinook salmon in the Chatanika River have historically been assessed on a semi-annual basis with aerial surveys from fixed wing aircraft. This methodology seems to be inadequate as survey estimates from some years are less than harvest estimates for the same years.

Minimum escapement objectives for chinook salmon returning to the Salcha and Chena rivers have been established by the Alaska Department of Fish and Game (ADF&G). Objectives are to achieve aerial counts of 2,500 fish in the Salcha River and 1,700 fish in the Chena River. Using counts from aerial surveys and abundance estimates of escapement, the minimum escapement guidelines for aerial surveys were expanded into actual abundance (see Evenson 1996). The minimum escapement guidelines using these expansions are 7,100 for the Salcha River and 6,300 for the Chena River (Evenson 1996). No escapement guidelines have been developed based on tower count estimates for the Chena or Salcha rivers, nor have escapement objectives of any kind been established for the Chatanika River.

In 1987 the Board of Fisheries 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 in the Salcha River has historically been monitored with creel surveys, however, given the dispersed nature of the fishery in the Chena River, creel surveys are costly and have not been conducted since 1990.

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 of chinook salmon, but does overlap the chinook salmon migration. Because sport fisheries exploit these stocks, the abundance of the chum salmon escapements is monitored during tower counts to ensure that sport harvests do not adversely impact 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 1996 were to:

1. estimate the escapement of chinook salmon in the Salcha and Chena rivers using tower counting techniques;
2. estimate the escapement of chinook salmon in the Salcha and Chena rivers using mark-recapture techniques;
3. test the hypothesis that estimated abundance from mark-recapture experiments is the same as that estimated from tower counts for both populations;
4. estimate the proportion of carcasses in the lower stratum in the Chena River that are available for capture at the time of sampling;
5. estimate age, sex, and length compositions of the escapement of chinook salmon in the Salcha and Chena rivers; and,
6. estimate age, sex, and length compositions of chinook salmon in the Chatanika River.

In addition to the objectives there were four tasks:

1. count chum salmon in the Salcha and Chena rivers in conjunction with the chinook salmon tower counts;
2. count chinook salmon in the Chatanika River from a drifting riverboat and from a helicopter at peak escapement; and,
3. assess the accuracy of counts conducted during the tower counting program by implementing a second counter during periods of high chinook salmon passage and during periods when chinook and chum salmon are migrating simultaneously.

METHODS

Tower Counts

Daily escapements of chinook and chum salmon returning to the Salcha and Chena rivers were estimated by counting fish as they passed beneath elevated 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 initiated on 8 July, and was terminated on 28 July for both rivers. High water levels in both rivers postponed the starting dates for counting beyond the planned start date of 1 July. For the Chena River, a subsequent rainfall and high water event prevented counting from 0800 hours on 11 July through 1500 hours on 15 July (104 hours). Similarly, on the Salcha River, rainfall and high water prevented counting from 2100 hours on 10 July through 1500 hours on 15 July (115 hours), and again from 0000 hours to 2400 hours on 24 July (24 hours). Due to the large number of missed counts on both rivers, a meaningful total estimate of escapement could not be calculated for either river. Therefore, this report presents only expansions of daily counts for those days when counts were conducted, and no extrapolations were made for missing days.

Light-colored fabric panels were placed on the river bottom downstream from the counting structures to improve the visibility of fish moving over the panels. Lights were suspended from the counting towers and were used during periods of low ambient light. Because salmon often will avoid areas with artificial substrate or illumination, 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 ambient light was sufficient to observe salmon. This was done to ensure that salmon would pass over the panels at the same rate during counting periods as during noncounting periods.

A stratified systematic sampling design was used to estimate daily passage of chinook and chum salmon. Four persons were assigned to each river to conduct counts. Personnel were assigned 8 h shifts and counted salmon 20 min of every hour. Counts were limited to 20 min to alleviate eye strain and fatigue. Each river was divided in half by placing a red fabric strip across the panels near the center of the channel. A ten min count of each side was conducted during each hour of the shift. Start times for the first count were chosen randomly within the first ten minutes of the hour. The second count immediately followed the first. A week consisted of 21 possible, eight hour shifts (three shifts each day). Shift I started at 24:00 h (midnight) and ended at 07:59 h; Shift II started at 08:00 h and ended at 15:59 h; Shift III started at 16:00 h and ended at 23:59 h. The sampling design called for counting during 20 of the 21 possible shifts each week. The noncounting shifts were randomly assigned each week. This design was modified, however, due to high water events in both rivers (Appendix A).

The total number of fish passing over the panels during any one 10 min count was recorded as the number of fish moving upstream minus the number of fish moving downstream. Drifting carcasses or obviously spawned-out fish were not counted. In some cases more fish were counted moving downstream than upstream. The resulting negative number was expanded and was used as part of the daily estimate of passage.

Abundance Estimator

Estimates of abundance were stratified by day and by river half. Daily estimates of abundance are considered a two-stage direct expansion where the first stage is 8 h shifts within a day and the second stage is 10 min counting periods within a shift. The second stage is considered systematic sampling because the 10 min counting periods are not chosen randomly.

The number of salmon to pass by the tower per day for each side of the river was estimated:

$$\hat{N}_{sd} = \overline{Y}_{sd} H_{sd} \tag{1}$$

$$\hat{V}\left[\hat{N}_{sd}\right] = \left(1 - f_{sd}\right) H_{sd}^2 \frac{s_{1sd}^2}{h_{sd}} + f_{1sd}^{-1} \sum_{i=1}^{h_d} \left[M_{sdi}^2 \left(1 - f_{2sdi}\right) \frac{s_{2sdi}^2}{m_{sdi}} \right] \tag{2}$$

where:

$$\overline{Y}_{sd} = \frac{1}{h_{sd}} \sum_{i=1}^{m_{sdij}} \frac{\sum_{j=1}^{m_{sdij}} Y_{sdij}}{m_{sdi}} \tag{3}$$

$$s_{1sd}^2 = \frac{\sum_{i=1}^{hsd} \left(Y_{sdi} - \overline{Y}_{sd}\right)}{h_{sd-1}} \tag{4}$$

$$s_{2sdi}^2 = \frac{\sum_{j=2}^{m_{sdij}} \left(y_{sdij} - y_{sdij-1}\right)^2}{2\left(m_{sdi} - 1\right)} \tag{5}$$

$$f_{1sd} = \frac{h_{sd}}{H_{sd}} \tag{6}$$

$$f_{2sdi} = \frac{m_{sdi}}{M_{sdi}} \tag{7}$$

d = day;

i = 8 h shift;

j = 10 min counting period;

s = side of river counted;

Y = number of chinook or chum salmon counted;

m = number of 10 min counting periods sampled;

M = total number of possible 10 min counting periods;

h = number of 8 h shifts sampled;

H = total number of possible 8 h shifts;

D = total number of possible days;

f_1 = fraction of 8 h shifts sampled;

f_2 = fraction of 10 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 abundance of chinook salmon passing across each side of the river (i.e. $\hat{N}_{left}$ and $\hat{N}_{right}$) was then estimated using:

$$\hat{N}_s = \sum_{d=1}^{D} \hat{N}_{sd} \tag{8}$$

$$\hat{V}\left(\hat{N}_s\right) = \sum_{d=1}^{D} \hat{V}(\hat{N}_{sd}) \tag{9}$$

Total abundance and it's associated variance were calculated similarly by summing the estimates from each side.

Duplicate Counts

The abundance estimator and associated variance assume that all fish passing over the panels are seen and are correctly identified. To assess the accuracy of counts, a second counter was implemented for selected counting shifts. A total of 40 ten minute paired counting shifts were conducted. Counters stood next to each other during the counts, but did not communicate with each other. The objective was to determine whether gross discrepancies existed among counters. The counting periods were chosen when additional personnel were available.

Mark-Recapture Experiments

One of the objectives of this study was to test the hypothesis that abundance estimates from tower counts are similar to estimates obtained from mark-recapture experiments. However, because of the large number of missed counts on both the Salcha and Chena rivers due to high water and poor counting conditions, estimates of total chinook salmon passage were deemed inadequate, and two-sample mark-recapture experiments were conducted as the sole estimate of abundance for each system. The sampling timing and procedures were similar for both rivers, and are described below.

Marking Event
A river boat equipped with electrofishing gear (Clark 1985) and long-handled dip nets were used to capture adult chinook salmon. Sex was determined for all captured chinook salmon by partially stripping gametes. Nearly all fish could be sexed by this method. Those fish which did not extrude gametes were sexed from external characteristics (e.g. kypes, body shape). All fish were measured to the nearest 5 mm (mid-eye to fork-of-tail), marked by attaching an individually numbered jaw tag and by removing a fin, and released alive. Fish were marked during two complete passes through the study section. Each pass required four days to complete. The first pass occurred 23-26 July, and the second occurred 30 July - 2 August. The timing of the marking events were centered around the short period after completion of immigration and spawning and before fish began to die. The study areas were divided into three sections roughly equal in length. Due to potential loss of tags, a unique fin clip was given corresponding to time (first or second pass) and location (river section) of tagging.

Recapture Event
One complete survey of the study area was conducted for the recapture events during 5-9 August. Long handled spears were used to collect carcasses. All collected carcasses were examined for tags and missing fins, sex was determined, and length was measured. Three scales were removed from each carcass for age determination. River sections were designated as during the marking events. All carcasses encountered during the survey were cut in a distinctive manner to avoid resampling. Sample sizes for each event were determined using an *a priori* estimate of the population size and the desired precision and accuracy of the estimate (95%, ± 25%) according to Robson and Regier (1964).

Assumptions
An unbiased estimate of abundance from a two-event mark-recapture experiment (Seber 1982) requires that the following two assumptions must be fulfilled:

1. catching and handling the fish does not affect the probability of recapture; and,
2. marked fish do not lose their mark.

Catching and handling the fish should not have affected the probability of recapture because the experiment was designed to mark live fish and later recover carcasses. If jaw tags were lost, the fin clip given each fish would identify the river section where it was marked.

Of the following assumptions, at least one must be fulfilled:

1. every fish has an equal probability of being marked and released during electrofishing;
2. every fish has an equal probability of being collected during the carcass survey; or,
3. marked fish mix completely with unmarked fish between electrofishing and carcass surveys.

The procedures for testing these assumptions and the methods for alleviating bias due to gear selectivity are described in Appendix B.

Abundance Estimator
The Chapman estimator and associated sampling variance (Chapman 1951) were used to estimate abundance:

$$\hat{N}^* = \left[\frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} \right] - 1 \qquad (10)$$

$$V(\hat{N}^*) = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)} \qquad (11)$$

where:

$\hat{N}^*$ = the estimated abundance of chinook salmon;

n_1 = the number of fish marked while electrofishing;

n_2 = the number of carcasses collected during the carcass survey; and,

m_2 = the number of marked carcasses collected during the carcass survey.

Proportion of Carcasses Available for Capture in the Lower Section of the Chena River

The mark-recapture model assumes the population is closed to immigration, and if emigration occurs, that marked and unmarked fish emigrate at the same rate. Previous experiments in the Chena River (Evenson 1991 and 1996) have indicated a low probability of capture in the lower river stratum relative to the upper two sections. To identify the fate of marked fish in the lower section, 12 chinook salmon were implanted with radio transmitters during the same time that fish were being marked during the mark-recapture experiment. Transmitters were implanted through the esophagus and into the stomach using a plastic tube. Transmitters were approximately 1.5 x 4.0 cm in size and weighed approximately 13 g. Frequencies were 149 Mhz. One aerial tracking was conducted just after the recapture event of the mark-recapture experiment, and boat tracking was conducted one week later. During the aerial tracking, fish were identified as being either in the study area or out. During the boat tracking, those fish in the lower river section were categorized as visible or not visible. The proportion of tags in each of these categories was estimated.

Chatanika River Boat Count

Chinook and chum salmon were counted in the Chatanika River during 25-27 July by two persons from a drifting canoe. Salmon were counted from the Cripple Creek confluence (river kilometer 232) downstream to the Elliot Highway Bridge (river kilometer 166; Figure 3). A helicopter survey was originally planned to coincide with the boat count, but was not conducted as aircraft were not available during this time.

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 0 to 96 km from the mouth, in the Chena River 72 to 161 km from the mouth, and in the Chatanika River 166 to 232 km from the mouth. Carcasses were collected in the Chena and Salcha rivers during the recapture event of the mark-recapture experiment. Carcasses were collected in the Chatanika River during the boat count. All collected carcasses were examined to determine sex and measured from mid-eye to fork-of-tail. Three scales were removed from each fish and placed directly on gum cards. 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). Scale impressions were later made on acetate cards and were viewed on a microfiche reader. 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 and the associated variances were estimated for each river using:

$$\hat{p}_{sg} = \frac{n_{sg}}{n_s} \tag{12}$$

$$\hat{V}(\hat{p}_{sg}) = \frac{\hat{p}_{sg}(1-\hat{p}_{sg})}{n_s - 1} \tag{13}$$

where:

$\hat{p}_{sg}$ = estimated proportion of chinook salmon of sex **s** in group **g** (i.e. age or length category);

n = number of chinook salmon; and,

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

$$\hat{N}_{sg} = \hat{p}_{sg}\hat{N}_s \tag{14}$$

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

The associated variance was approximated using the delta method (Seber 1982)

$$\hat{V}(\hat{N}_{sg}) = \hat{N}_s^2\hat{V}(\hat{p}_{sg}) + \hat{p}_{sg}^2\hat{V}(\hat{N}_s) \tag{15}$$

Total population abundance was estimated as:

$$\hat{N} = \sum_s \hat{N}_s \tag{16}$$

$$\hat{V}(\hat{N}) = \sum_s \hat{V}(\hat{N}_s) \tag{17}$$

Aerial Counts

Aerial survey counts were conducted at peak escapement in the Salcha and Chena rivers by Commercial Fisheries Management and Development Division personnel. The surveys were conducted on 19 July. 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 to the total estimated escapement was calculated.

RESULTS

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

Tower Counts: Salcha and Chena Rivers

Chinook and chum salmon were observed in relatively large numbers on the first day of counting (8 July) in both the Salcha and Chena rivers. The largest daily escapements of chinook salmon were 474 (SE=120) in the Salcha River on 9 July and 342 (SE=120) in the Chena River on 11 July. Daily passage of chinook salmon was minimal in both rivers when counts terminated on 28 July (Tables 2 and 3). The largest number of chinook salmon passing during any one 10 min count in the Salcha River was 11 in the right side on 16 July, while the largest number passing during any one count in the Chena River was 15 on the left side on 11 July. Typically, counts were larger for the right side in the Salcha River, but were larger for the left side in the Chena River (Appendices D1-D4). There was no distinct diurnal pattern for passage of chinook salmon on either river, although passage was generally higher during the early morning (02:00-05:00; Figures 5 and 6).

Daily expanded counts of chum salmon were quite large relative to those of chinook salmon. The largest daily escapements of chum salmon were 1,308 (SE=352) in the Chena River on 25 July, and 10,494 (SE=969) in the Salcha River on 15 July. Substantial numbers of chum salmon were still passing when counts were terminated (Tables 4 and 5). The largest number of chum salmon passing during any one 10 min count in the Salcha River was 127 on the left side on 15 July, while the largest number passing during any one count on the Chena River was 43 on the right side on 25 July. Typically, counts were larger for the left side in the Salcha River, but were similar for both sides in the Chena River (Appendices D5-D8). There was no distinct diurnal pattern for passage of chum salmon on either river, although passage was generally lowest during the mid-day hours (08:00-16:00; Figures 7 and 8).

Duplicate Counts

Some small discrepancies in counts occurred when two counters were used. Of the 40 counts, counters agreed on all of the chinook counts, but disagreed on seven counts of chum salmon. The chinook counts were relatively low during this period, but the chum salmon counts were relatively high (Table 6).

Mark-Recapture Experiment: Salcha River

A total of 615 chinook salmon were captured, tagged, and released during the marking event. During the recapture event, 436 carcasses were collected and examined for tags and fin clips. Thirty-six of these fish were marked (Table 7). No marked fish had lost jaw tags.

Equal Probability of Capture by Sex

Recapture rates for males and females differed significantly (males = 0.04; females = 0.11; $\chi^2 = 11.42$, df = 1, $P < 0.01$; Table 8). However, the probabilities of capture during the first event (based on marked to unmarked ratio during the carcass survey) were similar ($\chi^2 < 0.01$, df = 1, $P = 0.99$) for males and females (Table 9).

Equal Probability of Capture by Length

Length distributions of all marked releases and all recaptures obtained during the carcass survey were dissimilar ($DN = 0.344$; $P < 0.01$) as were the length distributions of all marked fish and the

Table 2.-Daily counts and estimates of the number of chinook salmon passing by the counting site in the Salcha River during 1996.

Date	Count Periods	Left Side			Right Side			Total		
		Count	Expanded Count	SE	Count	Expanded Count	SE	Count	Expanded Count	SE
7/8/96	16	23	207	48	23	207	43	46	414	64
7/9/96	24	31	186	29	48	288	74	79	474	80
7/10/96	21	17	117	29	25	171	46	42	288	54
7/11/96	None									
7/12/96	None									
7/13/96	None									
7/14/96	None									
7/15/96	8	6	108	19	6	108	34	12	216	39
7/16/96	24	9	54	23	35	210	107	44	264	110
7/17/96	24	11	66	21	31	186	61	42	252	65
7/18/96	24	14	84	24	41	246	71	55	330	75
7/19/96	24	18	108	20	37	222	47	55	330	51
7/20/96	16	5	45	19	6	54	22	11	99	29
7/21/96	24	6	36	15	23	138	55	29	174	57
7/22/96	24	14	84	29	24	144	65	38	228	71
7/23/96	24	10	60	17	17	102	47	27	162	50
7/24/96	None									
7/25/96	24	13	78	26	5	30	14	18	108	29
7/26/96	24	1	6	8	8	48	27	9	54	28
7/27/96	24	2	12	13	5	30	17	7	42	21
7/28/96	16	2	18	8	0	0	10	2	18	13

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Table 3.-Daily counts and estimates of the number of chinook salmon passing by the counting site in the Chena River during 1996.

Date	Count Periods	Left Side Count	Left Side Expanded Count	Left Side SE	Right Side Count	Right Side Expanded Count	Right Side SE	Total Count	Total Expanded Count	Total SE
7/8/96	8	5	90	14	0	0	0	5	90	14
7/9/96	24	41	246	93	12	72	55	53	318	108
7/10/96	24	49	294	84	2	12	8	51	306	84
7/11/96	8	19	342	120	0	0	0	19	342	120
7/12/96	None									
7/13/96	None									
7/14/96	None									
7/15/96	8	1	18	13	0	0	0	1	18	13
7/16/96	24	13	78	51	0	0	0	13	78	51
7/17/96	24	7	42	19	2	12	12	9	54	22
7/18/96	24	32	192	49	0	0	12	32	192	50
7/19/96	24	32	192	68	4	24	14	36	216	70
7/20/96	16	23	207	57	1	9	8	24	216	58
7/21/96	24	19	114	39	2	12	17	21	126	43
7/22/96	24	17	102	66	2	12	20	19	114	69
7/23/96	16	9	81	23	-2	-18	10	7	63	26
7/24/96	24	12	72	57	-2	-12	8	10	60	57
7/25/96	24	9	54	38	-1	-6	8	8	48	39
7/26/96	24	5	30	28	0	0	12	5	30	30
7/27/96	24	4	24	30	0	0	0	4	24	30
7/28/96	24	-2	-12	25	-1	-6	8	-3	-18	26

Figure 5.-Average hourly escapement of chinook salmon on the Salcha River, 1996.

Figure 6.-Average hourly escapement of chinook salmon on the Chena River, 1996.

Table 4.-Daily counts and estimates of the number of chum salmon passing by the counting site in the Salcha River during 1996.

Date	Count Periods	Left Side Count	Left Side Expanded Count	Left Side SE	Right Side Count	Right Side Expanded Count	Right Side SE	Total Count	Total Expanded Count	Total SE
7/8/96	16	264	2,376	183	113	1,017	122	377	3,393	220
7/9/96	24	440	2,640	284	239	1,434	194	679	4,074	344
7/10/96	21	257	1,850	233	149	1,073	178	406	2,923	293
7/11/96	None									
7/12/96	None									
7/13/96	None									
7/14/96	None									
7/15/96	8	441	7,938	529	142	2,556	812	583	10,494	969
7/16/96	24	446	2,676	330	303	1,818	451	749	4,494	559
7/17/96	24	461	2,766	312	235	1,410	331	696	4,176	455
7/18/96	24	698	4,188	343	295	1,770	368	993	5,958	503
7/19/96	24	519	3,114	209	226	1,356	231	745	4,470	312
7/20/96	16	235	2,115	187	184	1,656	446	419	3,771	484
7/21/96	24	483	2,898	274	233	1,398	183	716	4,296	330
7/22/96	24	629	3,774	261	305	1,830	307	934	5,604	403
7/23/96	24	407	2,442	279	253	1,518	291	660	3,960	404
7/24/96	None									
7/25/96	24	419	2,514	229	177	1,062	235	596	3,576	328
7/26/96	24	348	2,088	175	307	1,842	224	655	3,930	284
7/27/96	24	500	3,000	259	296	1,776	313	796	4,776	407
7/28/96	16	289	2,601	143	259	2,331	367	548	4,932	394

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Table 5.-Daily counts and estimates of the number of chum salmon passing by the counting site in the Chena River during 1996.

Date	Count Periods	Left Side			Right Side			Total		
		Count	Expanded Count	SE	Count	Expanded Count	SE	Count	Expanded Count	SE
7/8/96	8	40	720	96	2	36	6	42	756	97
7/9/96	24	31	186	100	5	30	17	36	216	101
7/10/96	24	115	690	174	34	204	118	149	894	210
7/11/96	8	21	378	58	9	162	48	30	540	75
7/12/96	None									
7/13/96	None									
7/14/96	None									
7/15/96	8	12	216	24	6	108	23	18	324	34
7/16/96	24	25	150	53	27	162	74	52	312	91
7/17/96	24	15	90	41	10	60	31	25	150	51
7/18/96	24	49	294	106	51	306	205	100	600	231
7/19/96	24	81	486	182	96	576	135	177	1062	227
7/20/96	16	44	396	93	53	577	69	97	873	116
7/21/96	24	25	150	72	43	258	131	68	408	150
7/22/96	24	17	102	50	48	288	104	65	390	115
7/23/96	16	29	261	79	58	435	97	87	783	125
7/24/96	24	66	396	103	93	558	179	159	954	207
7/25/96	24	93	558	193	125	750	294	218	1308	352
7/26/96	24	90	540	173	88	528	265	178	1068	316
7/27/96	24	47	282	131	122	732	186	169	1014	228
7/28/96	24	69	414	225	124	744	206	193	1158	305

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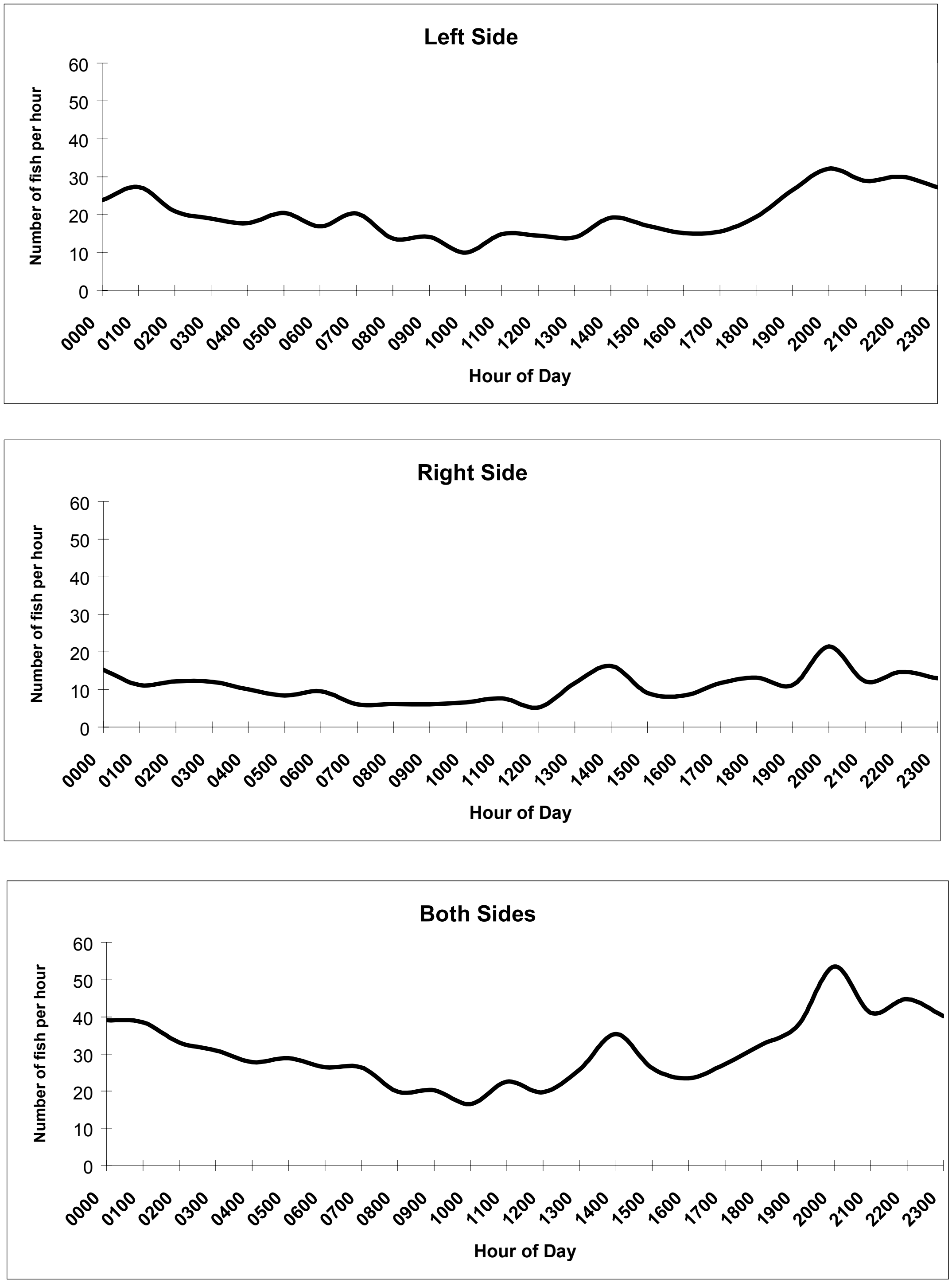

Figure 7.-Average hourly escapement of chum salmon on the Salcha River, 1996.

Figure 8.-Average hourly escapement of chum salmon on the Chena River, 1996.

Table 6.-Duplicate counts of chinook and chum salmon for selected counting periods at the counting sites in the Chena and Salcha rivers during 1996.

River	Date	Chinook Left Side		Chinook Right Side		Chum Left Side		Chum Right Side	
		Counter #1	Counter #2	Counter #1	Counter #2	Counter #1	Counter #2	Counter #1	Counter #2
Chena	7/23	0	0	0	0	0	0	2	2
		1	1	0	0	0	0	**5**	**4**
		0	0	0	0	1	1	0	0
		0	0	0	0	2	2	6	6
		1	1	0	0	0	0	14	14
		1	1	0	0	**0**	**1**	16	16
		0	0	0	0	3	3	9	9
		3	3	0	0	0	0	0	0
Chena	7/24	0	0	0	0	4	4	0	0
		1	1	0	0	**0**	**2**	3	3
		1	1	0	0	0	0	1	1
		0	0	0	0	0	0	**2**	**5**
		0	0	0	0	6	6	12	12
		1	1	0	0	6	6	6	6
		0	0	0	0	0	0	0	0
		0	0	0	0	8	8	3	3
Salcha	7/23	1	1	0	0	**15**	**14**	5	5
		0	0	0	0	7	7	3	3
		0	0	0	0	**8**	**10**	**11**	**10**
		0	0	1	1	11	11	7	7
Total		10	10	1	1	71	75	105	106

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Table 7.-Summary of capture histories of chinook salmon caught during the mark-recapture experiment in the Salcha River during 1996 for total fish, males and females.

	Section Tagged	Section Recaptured: Upper	Middle	Lower	Total Recaptured	Number not Recaptured	Total Marked
	Upper	22	2	0	24	283	307
	Middle	0	10	0	10	200	210
Total	Lower	0	0	2	2	96	98
Fish	Total	22	12	2	36	579	615
	Unmarked Carcasses	231	132	73	436	Total Number of Unique Fish Examined 1,051	
	Total Carcasses	253	144	75	472		

	Section Tagged	Section Recaptured: Upper	Middle	Lower	Total Recaptured	Number not Recaptured	Total Marked
	Upper	12	1	0	13	209	222
	Middle	0	3	0	3	151	154
	Lower	0	0	2	2	71	73
Males[a]	Total	12	4	2	18	431	449
	Unmarked Carcasses	115	68	34	217	Total Number of Unique Fish Examined 666	
	Total Carcasses	127	72	36	235		

	Section Tagged	Section Recaptured: Upper	Middle	Lower	Total Recaptured	Number not Recaptured	Total Marked
	Upper	10	1	0	11	68	79
	Middle	0	7	0	7	47	54
	Lower	0	0	0	0	25	25
Females[a]	Total	10	8	0	18	140	158
	Unmarked Carcasses	116	63	39	218	Total Number of Unique Fish Examined	
	Total Carcasses	126	71	39	236	376	

[a] Total marked and recaptured males and females do not sum up to equal the total fish because sex could not be deciphered for several chinook.

Table 8.-Contingency table analysis of recapture rates of male and female chinook salmon caught during the mark-recapture experiment in the Salcha River during 1996.

	Female	Male	Total
Recaptured	18	18	36
Not Recaptured	140	431	571
Total	158	449	607
Recapture Rate	0.11	0.04	0.06

$\chi^2 = 11.42$, df = 1; $P < 0.01$

Table 9.-Contingency table analysis of marked to unmarked ratios of male and female chinook salmon caught during the second sample of the mark-recapture experiment in the Salcha River during 1996.

	Female	Male	Total
Marked	18	18	36
Unmarked	218	217	435
Total	236	235	471
Marked:Unmarked	0.08	0.08	0.08

$\chi^2 = .0002$, df = 1; $P = 0.99$

length distribution of all fish captured during the carcass survey ($DN = 0.231$; $P < 0.01$; Figure 9). This indicated there was size-selectivity during the carcass survey, but the status of size-selectivity during the first event was unknown (Appendix B). Because of the differences in recapture rates of male and female chinook salmon, differences in length distributions were tested separately for males and females. The results of these tests indicated length distributions of marked releases and all recaptures obtained during the carcass survey were similar for males and females ($DN = 0.315$; $P = 0.06$ for males; and, $DN = 0.265$; $P = 0.21$ for females). However, the length distribution of marked fish differed significantly from the length distribution of fish captured during the carcass survey for males and females ($DN = 0.205$; $P < 0.01$ for males; and, $DN = 0.142$; $P < 0.01$ for females; Figure 10). This indicated that length distributions were unbiased during the carcass survey when stratified by sex..

Equal Probability of Capture by River Area

The results of the chi-square tests of consistency for the Petersen estimator indicated that geographic stratification was not warranted. The marked-to-unmarked ratios of chinook salmon were similar among the three river areas during the carcass sampling event ($\chi^2 = 3.13$, df = 2, $P = 0.21$). There was movement out of sections between mark and recapture, but all movements were downstream. Recapture rates were similar in all three sections ($\chi^2 = 5.19$, df = 2, $P = 0.07$) and were 0.08, 0.05, and 0.02 for the upper, middle, and lower sections, respectively (Table 10).

Abundance Estimate

Based on the results of these tests, the Petersen estimator (Chapman 1951) stratified by sex was used to estimate abundance. Because of the differences in length distributions between the two sampling events, only length distributions from the carcass survey were considered unbiased. Proportions and abundance at age were calculated separately by sex (Appendix B). Estimated abundance of male chinook salmon was 5,588 (SE=1,172), and estimated abundance of female chinook salmon was 1,982 (SE=399). Total abundance was 7,570 (SE=1,238).

Mark-Recapture Experiment: Chena River

A total of 696 chinook salmon were captured, tagged, and released during the marking event. During the recapture event, 614 carcasses were collected and examined for tags and fin clips. Sixty-two of these fish were marked (Table 11). No marked fish had lost jaw tags.

The following results were based on data from the mark-recapture experiment to test the hypotheses of equal probability of capture by sex, length, and river area during at least one sampling event (described in Appendix B).

Equal Probability of Capture by Sex

Recapture rates for males and females differed significantly (males = 0.06; females = 0.14; $\chi^2 = 10.22$, df = 1, $P < 0.01$; Table 12). However, the probabilities of capture during the first event (based on marked to unmarked ratio during the carcass survey) were similar for males and females ($\chi^2 = 2.57$, df = 1, $P = 0.11$; Table 13).

Equal Probability of Capture by Length

Length distributions of all marked releases and all recaptures obtained during the carcass survey were similar ($DN = 0.148$; $P = 0.16$). However, the length distribution of all marked fish

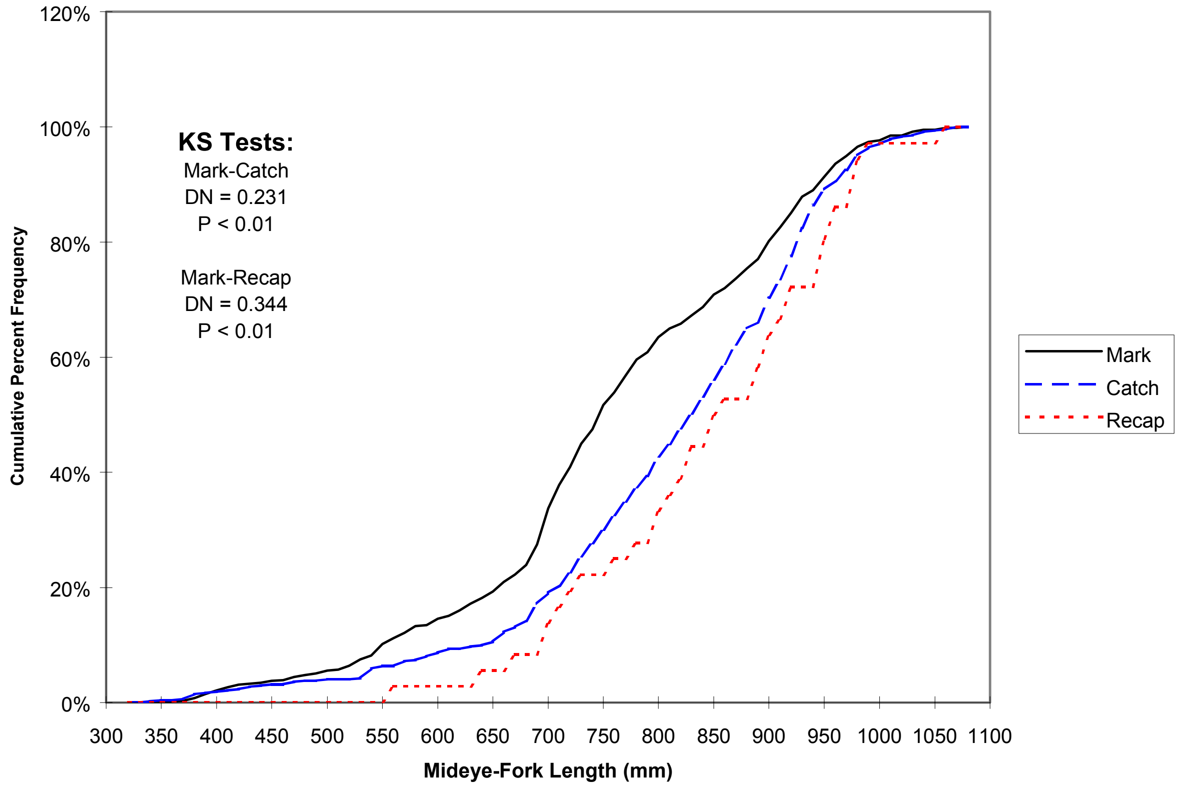
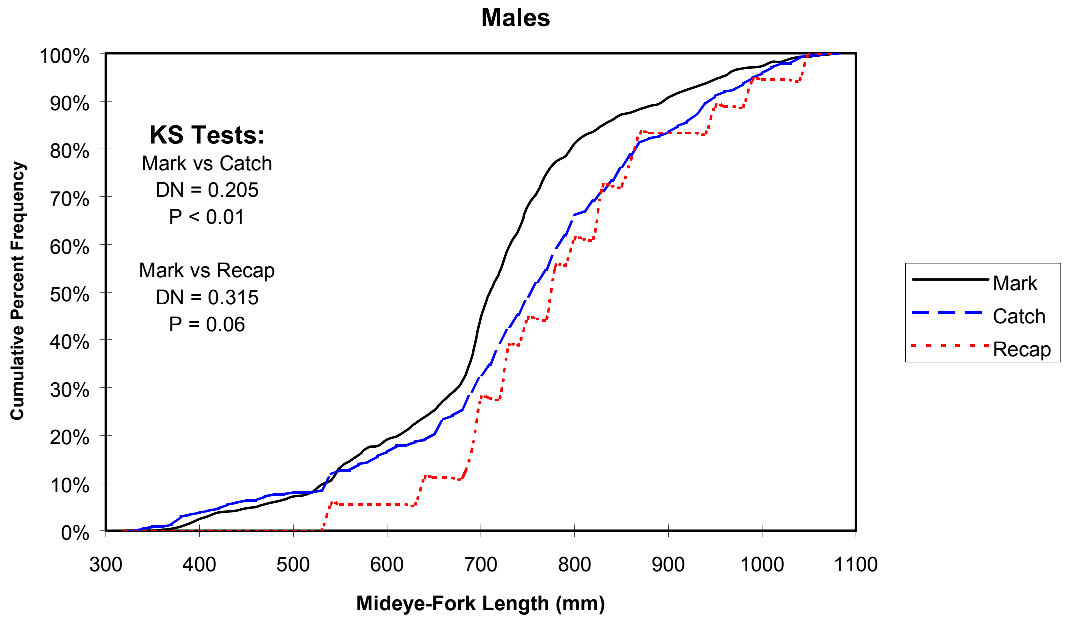


Figure 9.-Cumulative frequency distributions comparing all chinook salmon caught during the first event to all caught during the second event and to all recaptured during the second event from the mark-recapture experiment in the Salcha River during 1996.



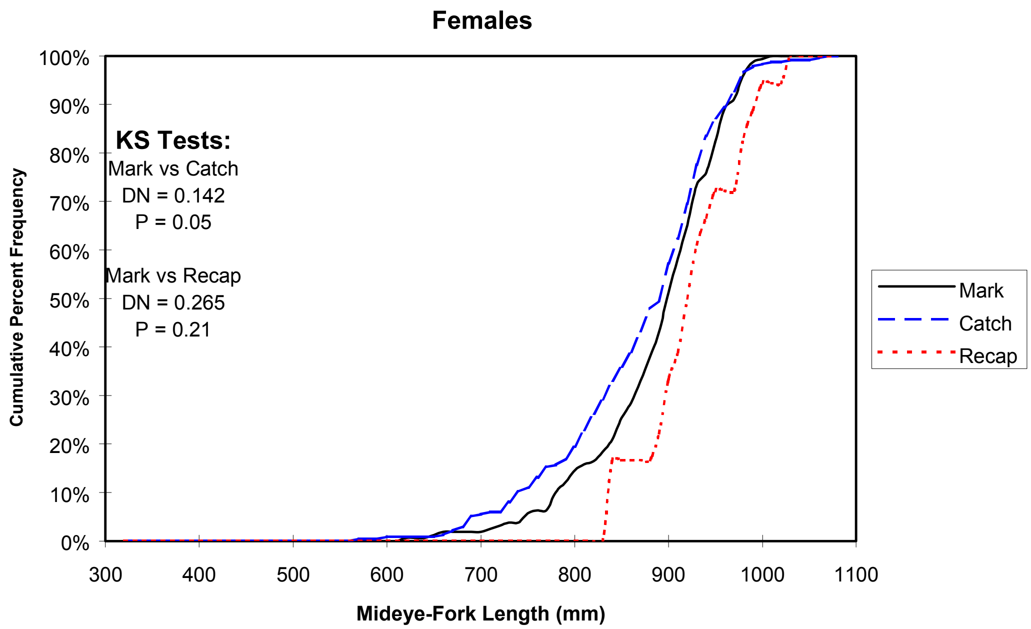


Figure 10.-Cumulative frequency distributions comparing male and female chinook salmon sampled during the first event to those sampled during the second event and to those recaptured from the mark-recapture experiment in the Salcha River during 1996.

Table 10.-Chi-square tests of consistency[a] for chinook salmon sampled in the Salcha River during 1996.

	First Event River Section	Second Event: River Section Upper	Middle	Lower	Not Recaptured	
TEST I[b]	Upper	22	2	0	283	
	Middle	0	10	0	200	
	Lower	0	0	2	96	
						$\chi^2 = 46$, df = 6; P < 0.01

		River Section Where Marked: Upper	Middle	Lower	
TEST II[c]	Recaptured	24	10	2	
	Not Recaptured	283	200	96	
					$\chi^2 = 5.19$, df = 2; P = 0.07

		Captured During Second Event River Section: Upper	Middle	Lower	
TEST III[d]	Marked	22	12	2	
	Unmarked	231	132	73	
					$\chi^2 = 3.13$, df = 2; P = 0.21

a The tests for consistency were taken from Seber (1982). At least one hypothesis needs to be accepted in order for the Petersen model (Chapman 1951) to be valid.

b This tests the hypothesis that movement probabilities are the same among sections: H_1: $\theta_{ij} = \theta_j$. Theta applies to both marked and unmarked salmon.

c This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities between the three river areas: H_2: $\Sigma_j \theta_{ij} p_j = d$. Theta applies to both marked and unmarked salmon.

d This tests the homogeneity on the columns of the 2-by-t contingency table with respect to the probability of movement of marked fish in stratum *I* to the unmarked fraction in *j*: H_4: $\Sigma_i a_i \theta_{ij} = kU_j$. Theta does not apply to both marked and unmarked salmon.

Table 11.-Summary of capture histories of chinook salmon caught during the mark-recapture experiment in the Chena River during 1996 for total fish, males, and females.

	Section Tagged	Section Recaptured Upper	Middle	Lower	Total Recaptured	Number not Recaptured	Total Marked
	Upper	26	11	0	37	264	301
	Middle	0	16	6	22	294	316
Total	Lower	0	0	3	3	76	79
Fish	Total	26	27	9	62	634	696
	Unmarked Carcasses	238	226	88	552	Total Number of Unique Fish Examined 1,248	
	Total Carcasses	264	253	97	614		

	Section Tagged	Section Recaptured Upper	Middle	Lower	Total Recaptured	Number not Recaptured	Total Marked
	Upper	9	9	0	18	175	193
	Middle	0	6	3	9	200	209
	Lower	0	0	2	2	48	50
Males[a]	Total	9	15	5	29	423	452
	Unmarked Carcasses	112	153	52	317	Total Number of Unique Fish Examined 769	
	Total Carcasses	121	168	57	346		

	Section Tagged	Section Recaptured Upper	Middle	Lower	Total Recaptured	Number not Recaptured	Total Marked
	Upper	17	2	0	19	89	108
	Middle	0	10	3	13	92	105
	Lower	0	0	1	1	27	28
Females[a]	Total	17	12	4	33	208	241
	Unmarked Carcasses	126	73	36	235	Total Number of Unique Fish Examined 476	
	Total Carcasses	143	85	40	268		

[a] Total marked and recaptured males and females do not sum up to equal the total fish because sex could not be deciphered for several chinook.

Table 12.-Contingency table analysis of recapture rates of male and female chinook salmon caught during the mark-recapture experiment in the Chena River during 1996.

	Female	Male	Total
Recaptured	33	29	62
Not Recaptured	208	423	631
Total	241	452	693
Recapture Rate	0.14	0.06	0.09

$\chi^2 = 10.22$, df = 1; $P < 0.01$

Table 13.-Contingency table analysis of marked to unmarked ratios of male and female chinook salmon caught during the second sample of the mark-recapture experiment in the Chena River during 1996.

	Female	Male	Total
Marked	33	29	62
Unmarked	235	317	552
Total	268	346	614
Marked:Unmarked	0.14	0.08	0.10

$\chi^2 = 2.57$, df = 1; P = 0.11

differed significantly from the length distribution of all fish captured during the carcass survey (*DN* = 0.115; $P < 0.01$; Figure 11). This indicated there was size selectivity during the marking event, but not during the carcass survey. Because of the differences in recapture rates of male and female chinook salmon, differences in length distributions were tested separately for males and females. The results of these tests were similar to the unstratified tests. Length distributions of marked releases and all recaptures obtained during the carcass survey were similar for males and females (*DN* = 0.206; $P = 0.20$ for males; and, *DN* = 0.109; $P = 0.88$ for females). However, the length distribution of marked fish differed significantly from the length distribution of fish captured during the carcass survey for males and females (*DN* = 0.145; $P < 0.01$ for males; and, *DN* = 0.196; $P < 0.01$ for females; Figure 12).

Equal Probability of Capture by River Area

The results of the chi-square tests of consistency for the Petersen estimator indicated that geographic stratification was not warranted. The marked-to-unmarked ratios of chinook salmon were similar among the three river areas during the carcass sampling event ($\chi^2 = 0.18$, df = 2, $P = 0.91$). There was movement out of sections between mark and recapture, but all movements were downstream. Recapture rates were 0.12, 0.07, and 0.04 for the upper, middle, and lower sections, respectively (Table 14).

Proportion of Carcasses Available for Capture in Lower Section

Of the twelve radio tags deployed, two (0.17) were recaptured during the carcass survey in the lower section (did not move). The remaining ten tags were searched for during the aerial tracking immediately after the recapture event had concluded. Nine of the ten tags were located. One moved upstream into the middle section, one moved downstream out of the study area, and seven remained in the lower section. A tracking from a riverboat was then conducted and revealed that of the seven fish which remained in the lower section, none were visible (i.e. were in deep, turbid water, or covered with silt). This indicates that the low probability of capture in the lower section is mostly an artifact of poor visibility as opposed to marked fish leaving the study area.

Abundance Estimate

Based on the results of these tests, the Petersen estimator (Chapman 1951) stratified by sex was used to estimate abundance. Because of the differences in length distributions between the two sampling events, only length distributions from the carcass survey were considered unbiased (Appendix B). Estimated abundance of male chinook salmon was 5,239 (SE=869), and estimated abundance of female chinook salmon was 1,914 (SE=280). Total abundance was 7,153 (SE=913).

Boat Count: Chatanika River

A total of 198 chinook salmon were counted during the boat survey of the Chatanika River. Of these, 108 were dead and 90 were live. A total of 1,059 chum salmon were counted, of which 730 were live and 329 were dead. Fifty-one chinook salmon (0.26 of total) and 646 chum salmon (0.61 of total) were counted between Cripple Creek and the Steese Highway Bridge. This count is the lowest of the three boat counts on record (Table 15).

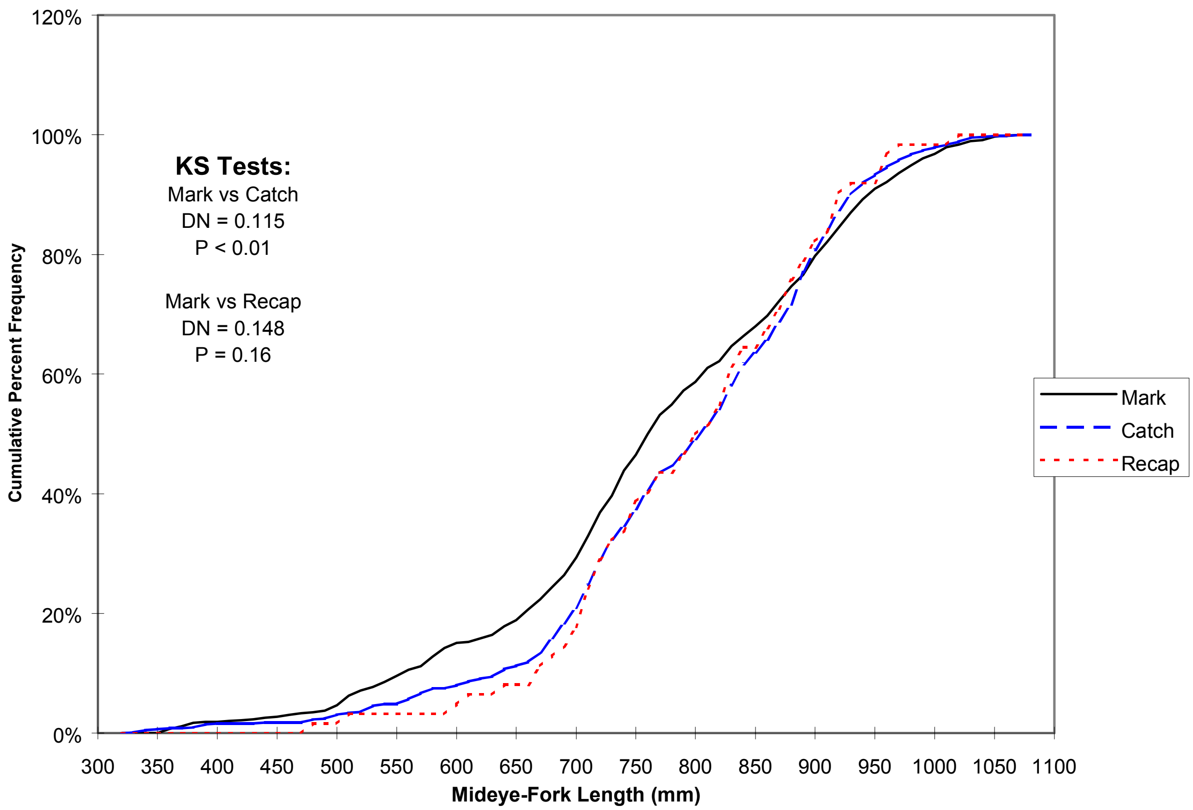
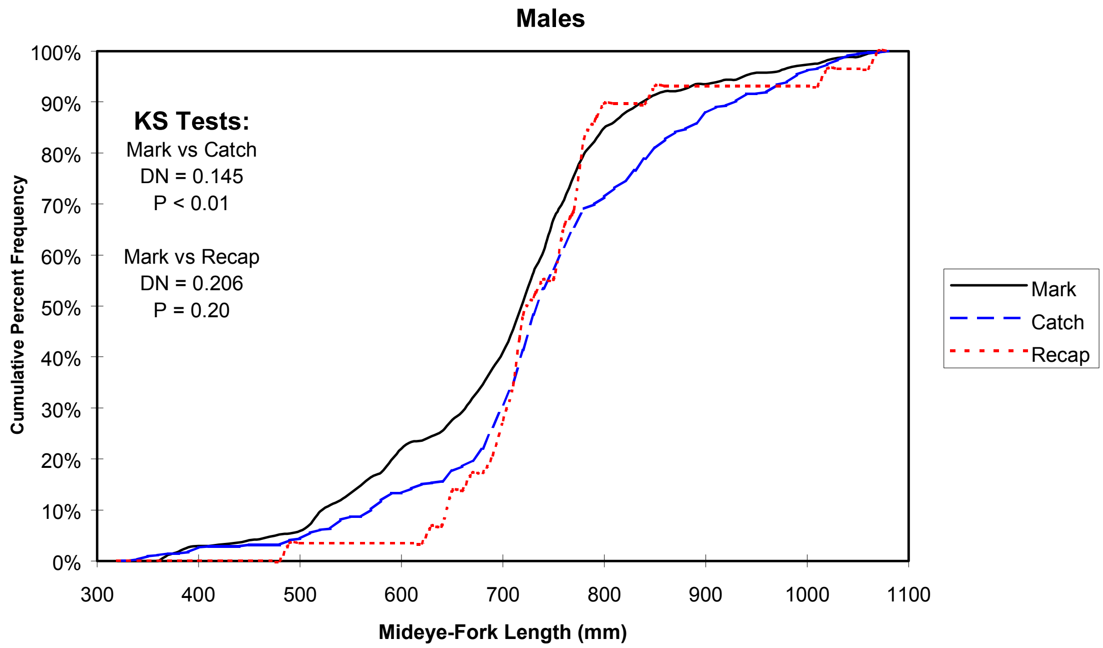


Figure 11.-Cumulative frequency distributions comparing all chinook salmon caught during the first event to all caught during the second event and to all recaptured during the second event from the mark-recapture experiment in the Chena River during 1996.



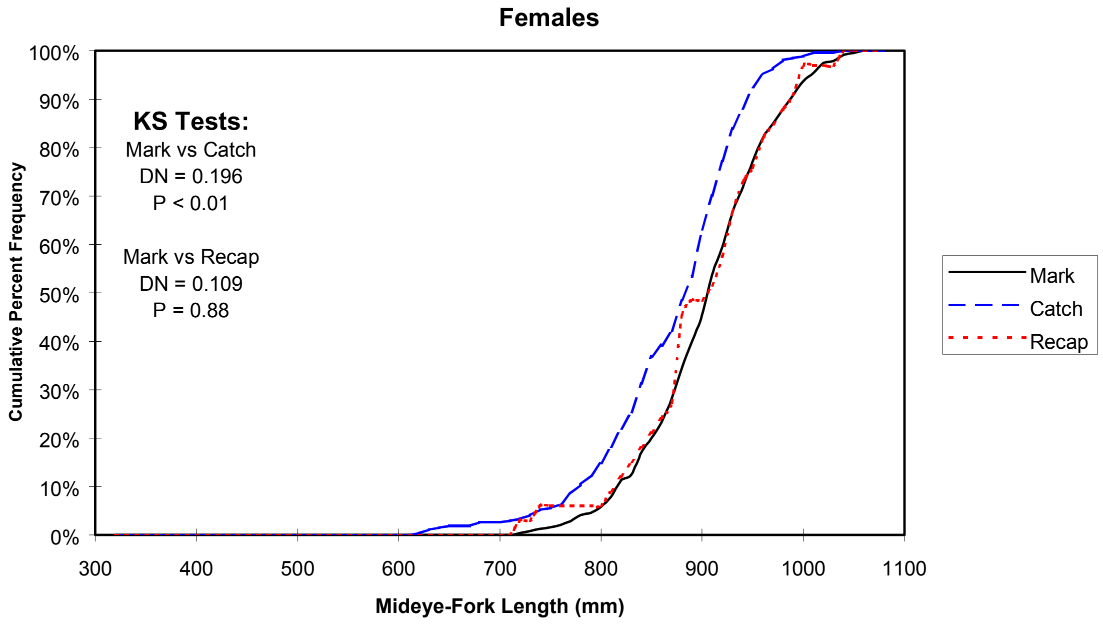


Figure 12.-Cumulative frequency distributions comparing male and female chinook salmon sampled during the first event to those sampled during the second event and to those recaptured fish from the mark-recapture experiment in the Chena River during 1996.

Table 14.-Chi-square tests of consistency[a] of chinook salmon sampled in the Chena River during 1996.

	First Event River Section	Second Event River Section Upper	Middle	Lower	Not Recaptured	
TEST I[b]	Upper	26	11	0	264	
	Middle	0	16	6	294	
	Lower	0	0	3	76	
						$\chi^2 = 47.72$, df = 6; P < 0.01

		River Section Where Marked Upper	Middle	Lower	
TEST II[c]	Recaptured	37	22	3	
	Not Recaptured	264	294	76	
					$\chi^2 = 8.27$, df = 2; P = 0.02

		Captured During Second Event River Section Upper	Middle	Lower	
TEST III[d]	Marked	26	27	9	
	Unmarked	238	226	88	
					$\chi^2 = 0.18$, df = 2; P = 0.91

[a] The tests for consistency were taken from Seber (1982). At least one hypothesis needs to be accepted in order for the Petersen model (Chapman 1951) to be valid.

[b] This tests the hypothesis that movement probabilities are the same among sections: H_1: $\theta_{ij} = \theta_j$. Theta applies to both marked and unmarked salmon.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities between the three river areas: H_2: $\Sigma_j \theta_{ij} p_j = d$. Theta applies to both marked and unmarked salmon.

[d] This tests the homogeneity on the columns of the 2-by-t contingency table with respect to the probability of movement of marked fish in stratum *I* to the unmarked fraction in *j*: H_4: $\Sigma_i a_i \theta_{ij} = kU_j$. Theta does not apply to both marked and unmarked salmon.

Table 15.-Aerial survey counts, boat counts, and sport harvest and catch estimates of chinook salmon in the Chatanika River, 1980-1996.

Year	Method	Lower[a]	Middle[b]	Upper[c]	Total	Survey Condition	Sport Harvest[d]	Sport Catch[d]
1980	Aerial	NA[e]	NA	NA	37	Fair	37	NE[f]
1981			No Survey				5	NE
1982	Aerial	NA	NA	NA	159	Fair-Good	136	NE
1983			No Survey				147	NE
1984	Aerial	NA	NA	NA	9	Poor	78	NE
1985			No Survey				373	NE
1986	Aerial	NA	NA	NA	79	Fair	0	NE
1987			No Survey				21	NE
1988			No Survey				345	NE
1989	Aerial	NA	NA	NA	75	Fair	231	NE
1990	Aerial	10	46	5	61	Fair-Poor	37	164
1991	Aerial	2	84	18	104	Fair	82	181
1992	Aerial	NC[g]	78	NC[g]	78[h]	Fair	16	31
1993	Aerial	6	46	23	75	Fair	192	625
1993	Boat	NC	253	NC[g]	253[h]	Good	192	625
1994	Aerial	49	NC	NC[g]	372	Fair	105	278
1995	Boat	NC	326	118	444[h]	Fair-Good	58	134
1996	Boat	NC	147	51	198[h]	Fair-Good	499	1,164

[a] Lower section runs from the Trans Alaska Pipeline upstream to the Elliott Highway Bridge.

[b] Middle section runs form the Elliott Highway Bridge upstream to the Steese Highway Bridge.

[c] Upper section runs from the Steese Highway Bridge upstream to the confluence of Faith and McManus Creeks (Figure 3).

[d] Data from Mills (1981-1994) and Howe et al. (1995 and 1996).

[e] NA = section subtotals are not available.

[f] NE = no estimate is available.

[g] NC = no count was conducted during this survey.

[h] Incomplete survey.

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

The mark-recapture experiment indicated that the carcass sample was biased for sex compositions, but the first sample was not. Sex composition from the marking sample was 0.74 male and 0.26 female (SE=0.02 for both estimates). Four hundred seventy-two chinook salmon carcasses were collected from the Salcha River. Age was determined for 413 fish (0.88 of the sample). Males were most represented by age classes 1.3 (0.57), while the age distribution of females was more evenly spread over age classes 1.3 (0.20), 1.4 (0.39), and 1.5 (0.40). Lengths were obtained from all 472 carcasses. Lengths of males ranged from 340 to 1,070 mm. Lengths of females ranged from 570 to 1,070 mm. Mean lengths at age were also calculated (Table 16).

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

The mark-recapture experiment indicated that the carcass sample was biased for sex compositions, but the first sample was not. Sex composition from the marking sample was 0.73 male and 0.27 female (SE=0.02 for both estimates). Six-hundred fourteen chinook salmon carcasses were collected from the Chena River. Age was determined for 515 fish (0.84 of the sample). Males were most represented by age classes 1.3 (0.63), while the age distribution of females was more evenly spread over age classes 1.3 (0.21), 1.4 (0.36), and 1.5 (0.43). Lengths were obtained from all 614 carcasses. Lengths of males ranged from 335 to 1,080 mm, while lengths of females ranged from 620 to 1,040 mm. Mean lengths at age were also calculated (Table 17).

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

One hundred eight carcasses were collected during the sampling event in the Chatanika River. Of these, ages were determined for 82 samples (0.75). The sex composition of the entire sample was 0.56 males and 0.44 females. Age 1.3 was the dominant age class for both males and females (Table 18). Lengths of males ranged from 520 to 1,025 mm. Lengths of females ranged from 570 to 925 mm.

Aerial Surveys: Salcha and Chena Rivers

During aerial surveys conducted on 19 July, 2,233 chinook salmon were counted in the Chena River and 4,866 were counted in the Salcha River. Visibility during the surveys ranged from poor to good in the Chena River and fair to good in the Salcha River. These aerial counts represent about 0.31 and 0.64 of the respective abundance estimates. Since 1986, the proportion of the population observed during aerial surveys has ranged from 0.19 to 0.71 and averaged 0.46 for the Salcha River and ranged from 0.13 to 0.59 and averaged 0.30 for the Chena River (Table 19).

DISCUSSION

This was the fourth consecutive year tower counting methodology was used to attempt 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 give managers in-season information which can be used to manipulate the fisheries. 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-season and are usually less expensive than tower counts. However, in the Chena and Salcha rivers the

Table 16.-Estimated proportions, abundance, and mean length by age class of male and female chinook salmon in the Salcha River during 1996.

	Age[a]	Sample Size	Proportion	SE	Abundance	SE	Length Mean	Length SE	Length Min	Length Max
Male										
	1.1	11	0.05	0.02	303	64	380	25	340	425
	1.2	24	0.12	0.02	661	139	544	59	425	660
	1.3	115	0.57	0.03	3,166	673	741	76	440	995
	1.4	36	0.18	0.03	991	210	881	77	670	1,015
	1.5	17	0.08	0.02	468	99	984	57	880	1,070
	Total	203	1.00		5,588	1,172	743	159	340	1,070
Female										
	1.2	1	<0.01	<0.01	9	<1	570			
	1.3	43	0.20	0.03	406	12	751	61	600	865
	1.4	82	0.39	0.03	774	27	880	56	745	1,030
	1.5	84	0.40	0.03	793	28	928	43	820	1,070
	Total	210	1.00		1,982	399	871	86	570	1,070
Total		413			7,570	1,238	808	142	340	1,070

[a] The notation x.x represents the number of annuli formed during river residence and ocean residence (i.e. an age of 2.4 represents two annuli formed during river residence and four annuli formed during ocean residence).

Table 17.-Estimated proportions, abundance, and mean length by age class of male and female chinook salmon in the Chena River during 1996.

		Sample					Length			
	Age[a]	Size	Proportion	SE	Abundance	SE	Mean	SE	Min	Max
Male	1.1	11	0.04	0.01	202	34	403	50	350	485
	1.2	31	0.11	0.02	568	95	560	78	335	750
	1.3	180	0.63	0.03	3,297	555	737	58	610	905
	1.4	39	0.14	0.02	714	119	892	89	690	1,080
	1.5	25	0.09	0.02	458	76	942	84	715	1,060
	Total	286	1.00		5,239	869	744	138	335	1,080
Female	1.2	1	<0.01	<0.01	8	1	630			
	1.3	48	0.21	0.03	401	60	789	69	620	940
	1.4	82	0.36	0.03	685	103	881	50	745	1,040
	1.5	98	0.43	0.03	819	123	910	41	795	1,010
	Total	229	1.00		1,914	280	873	70	620	1,040
Total		515			7,153	913	801	130	335	1,080

[a] The notation x.x represents the number of annuli formed during river residence and ocean residence (i.e. an age of 2.4 represents two annuli formed during river residence and four annuli formed during ocean residence).

40

Table 18.-Estimated proportions and mean length by age class of male and female chinook salmon in the Chatanika River during 1996.

	Age[a]	Sample Size	Proportion	SE	Length Mean	Length SE	Length Min	Length Max
Male	1.2	5	0.11	0.05	579	30	520	685
	1.3	33	0.73	0.07	730	8	645	840
	1.4	6	0.13	0.05	838	56	685	1,025
	1.5	1	0.02	0.02	905			
	All	45	1.00		738	11	520	1,025
Female	1.2	2	0.06	0.04	588	3	585	590
	1.3	28	0.78	0.07	685	10	685	870
	1.4	5	0.14	0.06	795	17	795	885
	1.5	1	0.03	0.03	910			
	All	36	1.00		774	8	585	910

[a] The notation x.x represents the number of annuli formed during river residence and ocean residence (i.e. an age of 1.3 represents one annulus formed during river residence and three annuli formed during ocean residence). One annulus is formed each year.

Table 19.-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 and Chena rivers.

River Year	Estimated Abundance[a]	SE	Aerial Survey Count	Aerial Survey Condition[b]	Proportion Observed During 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
1995	13,643[f]	471	3,978	Fair-Good	0.29
1996	7,570[c]	1,238	4,866	Fair-Good	0.64
					Avg=0.46
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[c,g]	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
1995	9,680[c]	958	3,567	Fair	0.37
1996	7,153[c]	913	2,233	Poor-Good	0.31
					Avg=0.30

a Details of estimates can be found in Barton (1987a and 1988); Barton and Conrad (1989); Burkholder (1991); Evenson (1991, 1992, 1993, 1995, and 1996); 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.

relationship between aerial counts and actual abundance is unclear as counts can vary considerably depending upon water visibility (affected by turbidity, wind, or light conditions), and have been in all cases substantially lower than estimates obtained using mark-recapture techniques or tower counts (Table 19).

The precision of the estimates obtained from tower counts has been substantially better than the precision of mark-recapture estimates obtained from prior years. The high precision of the tower count estimates may, however, be misleading. The variance estimator assumes that during any given 20 min counting period all salmon that pass over the panels are seen, correctly identified and counted. The duplicate counts conducted this season indicated that this is not always true. Although discrepancies appear to be slight in magnitude, the cumulative effect on the overall estimates of abundance and variance may be significant. However, implementing multiple counters to assess the variability among counters would add considerable cost. The bias resulting from fish not seen passing over the panels is negative which makes the estimates conservative. The extent of species misidentification which occurs is unknown, and if it occurs, could bias the estimate either high or low. Another drawback of the tower count method 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 mark-recapture experiments (a total of 12 have been conducted in the Chena and Salcha rivers where carcass sampling was used as a capture technique) have shown that size and sex composition estimates were biased during four 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 affect on estimates of population proportions is not known.

The greatest limitation of tower counting methodology is that it requires low water conditions (good visibility) for most of the run to produce a reliable total estimate of escapement. High water events persisting more than two days add a great deal of uncertainty to the estimate depending on when and how often they occur. Of the eight estimates attempted with tower counts (four each in the Chena and Salcha rivers since 1993), five successful estimates have been generated. However, even in years when a total estimate of escapement cannot be garnished from tower counts, daily escapement estimates can still be used for in-season management purposes, especially during the early portion of the run. If estimating total escapement remains an objective, then mark-recapture experiments should continue to be planned as a back-up means of estimating total escapement.

Mark-recapture techniques should, however, be considered a secondary means of estimating escapement. First, the estimates are obtained after all the fisheries have taken place. Thus, managers must rely on aerial survey estimates as a means of assessing escapement inseason. Second, the mark-recapture experiments likely do not provide a total estimate of escapement. Some chinook salmon spawn in areas upstream from the upper boundaries of the study areas. In the case of the Chena River, these areas are not accessible by river boat. In the case of the Salcha River, fish range extremely far upstream, making a total escapement estimate logistically difficult and costly. An understanding of the proportion of fish estimated during a mark-recapture experiment to the total escapement would be of value. Obtaining paired estimates of tower counts and mark-recapture experiments during the same year is one possible solution.

Estimates of chum salmon abundances for the Chena and Salcha rivers populations were minimal estimates because only the early portion of the migration was counted. However, it appeared that the run was substantially larger than the previous three years, especially in the Salcha River. 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 to get complete estimates of escapement with which to develop escapement goals.

This was the third year a boat count of chinook salmon in the Chatanika River was conducted, and the count was the lowest of the three. Most of the historic counts have been from aerial surveys, and this years boat count was higher than any of the historic aerial counts. Thus, it is likely that a greater proportion of the escapement is counted during a boat survey than during an aerial survey. The only paired counts which exists is from 1993, when 253 were counted during a boat survey and 46 were counted during an aerial survey. Future studies should investigate the relationship of helicopter and boat counts, and determine how these counts relate to actual abundance. An escapement goal based on one of these two methods should be developed.

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 (Parker 1991). The river is a spring-fed tributary to the Tanana River located near Delta Junction about 160 km southeast of Fairbanks (Figure 13). The main river is 32 km, with a 10 km north fork. There are a number of small, shallow spring areas adjacent to the mainstream river. Spawning occurs throughout the mainstream river and in the spring areas. The river supports a popular fall sport fishery. Annual harvests exceeded 1,000 coho salmon from 1986-1991, although in recent years catch has been high, but harvest relatively low (Mills 1979-1994; Howe et al. 1995 and 1996; Table 20). Before reaching spawning grounds, the coho salmon travel about 1,700 km from the ocean and pass through six different commercial fishing districts in the Yukon and Tanana rivers (Figure 4). Subsistence and personal use fishing also occur in each district.

Escapements of coho salmon into the Delta Clearwater River have been historically monitored by counting fish from a drifting river boat. In recent years aerial surveys have been conducted to estimate escapement into non-boatable portions of the river (Table 20). This information has been used to evaluate management of the commercial, subsistence, and personal use fisheries, and 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. The Alaska Department of Fish and Game has established a minimum escapement goal of 9,000 coho salmon for the Delta Clearwater River. When counts indicate that the goal may not be achieved, the bag limit is reduced or the fishery is closed. If the count exceeds the minimum escapement, the bag limit may be increased.

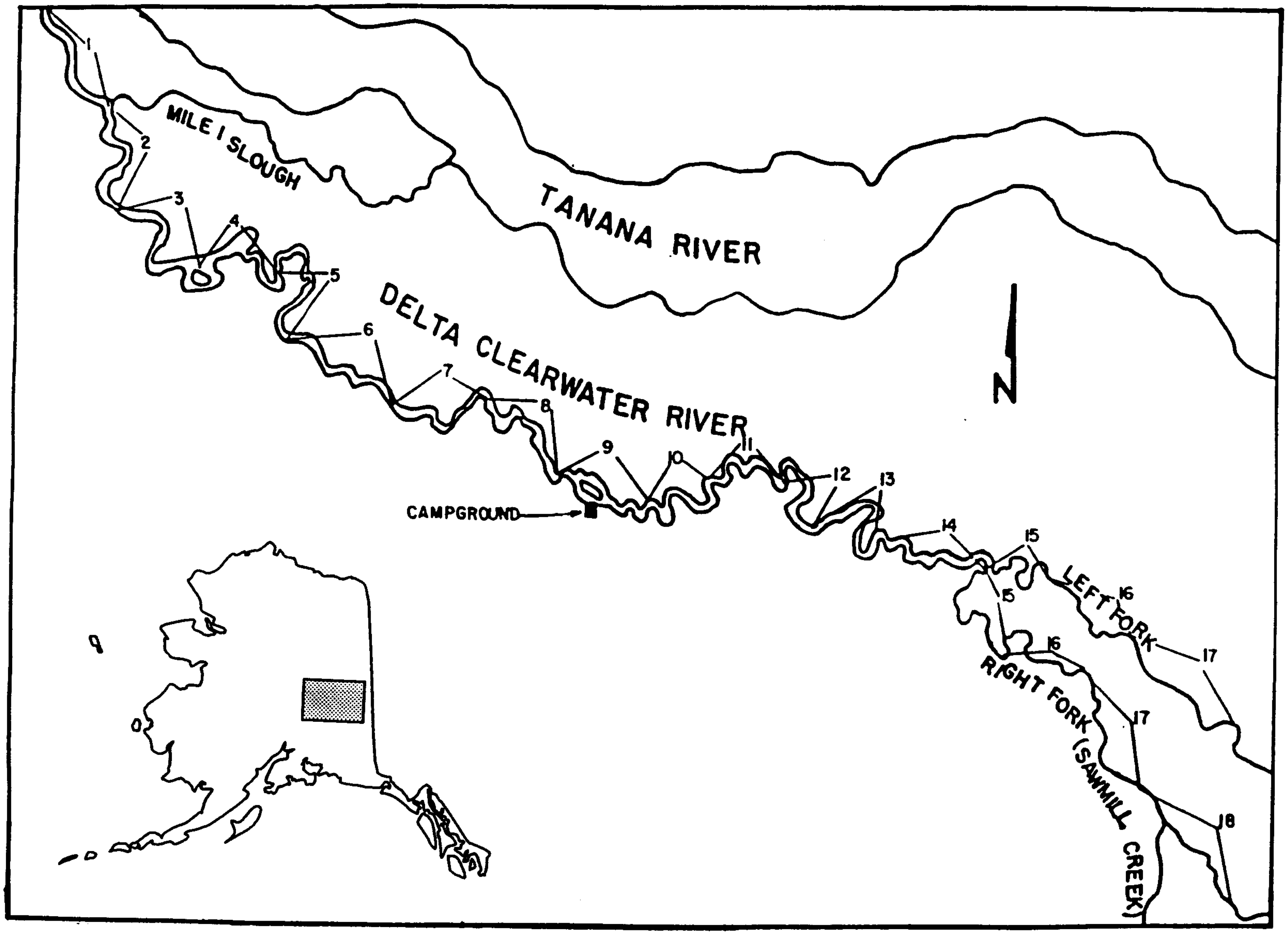


Figure 13.-Delta Clearwater River study area.

Table 20.-Peak escapements, harvests, and catch of coho salmon in the Delta Clearwater River, 1972-1996.

	Peak Escapement Counts							
Year	Survey Date	Lower River[a]	Upper River[b]	Spring Areas	Total[c]	Previous 5 yr Avg.	Sport Harvest[d]	Sport Catch[d]
1972	9 Nov	NA[e]	NA	NA	632		NA	NA
1973	20 Oct	NA	NA	NA	3,322		NA	NA
1974	NA	NA	NA	NA	3,954[f]		NA	NA
1975	24 Oct	NA	NA	NA	5,100		NA	NA
1976	22 Oct	NA	NA	NA	1,920		NA	NA
1977	25 Oct	2,331	2,462	NA	4,793	2,986	31	NA
1978	26 Oct	2,470	2,328	NA	4,798	3,818	126	NA
1979	23 Oct	3,407	5,563	NA	8,970	4,113	0	NA
1980	28 Oct	2,206	1,740	NA	3,946	5,116	25	NA
1981	21 Oct	4,110	4,453	NA	8,563[g]	4,885	45	NA
1982	3 Nov	4,015	4,350	NA	8,365[g]	6,214	21	NA
1983	25 Oct	3,849	4,170	NA	8,019[g]	6,928	63	NA
1984	6 Nov	5,434	5,627	NA	11,061	7,573	571	NA
1985	13 Nov	NA	NA	NA	6,842[f]	7,991	722	NA
1986	21 Oct	5,490	5,367	NA	10,857	8,570	1,005	NA
1987	27 Oct	11,700	10,600	NA	22,300	9,029	1,068	NA
1988	28 Oct	5,300	16,300	NA	21,600	11,816	1,291	NA
1989	25 Oct	5,400	7,200	NA	12,600	14,532	1,049	NA
1990	26 Oct	4,525	3,800	NA	8,325	14,840	1,375	3,271
1991	23 Oct	11,525	12,375	NA	23,900	15,136	1,721	4,382
1992	26 Oct	1,118	2,845	NA	3,963	17,745	615	1,555
1993	21 Oct	3,425	7,450	NA	10,875	14,078	48	1,695
1994	24 Oct	19,450	43,225	17,565[h]	80,240[i]	11,933	509	3,009
1995	23 Oct	7,850	12,250	6,283[h]	26,383[i]	25,461	391	5,195
1996	29 Oct	4,000	10,075	3,300[h]	17,375[i]	29,072	983	2,543

[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) and Howe et al. (1995 and 1996).

[e] Data are not available.

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

[g] Mark-recapture population estimate.

[h] Helicopter Survey by Alaska Department of Fish and Game, Division of Sport Fish.

[i] Combination of boat survey and helicopter survey.

The objectives of the coho salmon escapement project for the Delta Clearwater River in 1995 were to count coho salmon in the Delta Clearwater River from a drifting riverboat at approximately weekly intervals throughout the run, and estimate total escapement through a combination of boat counts and aerial surveys. In addition, age, sex, and length compositions of the escapement were estimated.

METHODS

Counts

Adult coho salmon were counted from a drifting riverboat equipped with an observation platform elevated 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 13). The sections were numbered from the mouth (mile 0) upstream. Many coho salmon spawn in shallow spring areas adjacent to the mainstream river. Prior to 1994, these areas 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 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 two occasions (4 and 15 November). Carcasses were collected from a drifting river boat using long handled spears. Length was measured from mid-eye to fork-of-tail to the nearest 5 mm. Sex was determined from observation of body morphology or by cutting into the body cavity to examine the gonads. Three 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 12 and 13. Mean lengths were estimated for combinations of age and sex using the sample mean and variance (Zar 1984).

RESULTS

Counts

An aerial survey of the entire drainage was conducted on 22 October. During this survey, 11,975 coho salmon were counted in the mainstream river, and 3,300 were counted in the spring areas adjacent to the river. A boat survey of the mainstream river was conducted on 29 October. During this survey 14,075 coho salmon were counted. Coho salmon were distributed throughout the entire stretch in densities ranging from 75 to 1,850 fish per mile (Table 21). Counts for individual spring areas ranged from 0 to 625 (Table 22). Because visibility of the entire mainstream river bottom was thought to be best with the boat survey (overhanging vegetation blocked the near-bank areas from the air), the boat count was used as the estimate for the mainstream river and the aerial survey of the spring areas was added to this count for the total escapement estimate. The total estimated escapement was 17,375 coho salmon. The count in the spring areas comprised 0.19 of the total count.

Table 21.-Counts of adult coho salmon in the Delta Clearwater River, 1996.

River Mile	Mainstream River (Boat Survey) Count (29 Oct)	Mainstream River (Aerial Survey) Count (22 Oct)
17.5-16	1,724	1,225
16-15	1,125	800
15-14	1,850	1,725
14-13	1,425	1,450
13-12	1,200	875
12-11	925	700
11-10	1,000	1,050
10-9	575	900
9-8	250	350
8-7	350	275
7-6	75	125
6-5	725	700
5-4	700	450
4-3	775	550
3-2	150	200
2-1	875	425
1-0	350	175
Summary		
17.5-8	10,075	9,075
8-0	4,000	2,900
14-0	9,375	8,225
17.5-0	**14,075**	**11,975**
Tributaries	na	**3,300**
Clearwater Lake Inlet	na	350
Clearwater Lake Outlet	na	1,125
	Total Count (boat count of mainstream and aerial survey of tributaries)	**17,375**

Table 22.-Aerial survey counts of adult coho salmon in spring areas of the Delta Clearwater River, 1996

Name of Spring	Count (22 Oct)	Description of Location
Sawmill Creek	525	Headwaters to Richard Lake
Andersen	25	South Spring into Sawmill
Granite	0	Headwaters to Sawmill
South Clearwater	300	Headwaters to Reed Lake
Middle Clearwater	300	Headwaters to Reed Lake
Peckham	0	Spring on north side of Clearwater Creek.
Clearwater-Section 1	500	Including Reed Lake, to Peckham
Clearwater-Section 2	625	Peckham to confluence of Sawmill Creek.
Fronty	0	First spring below Granite-South Side
Jan	0	Between Fronty and Jesse
Jesse	0	South side of Sawmill Creek
Jennie	25	North side-near mouth of CH20-DCR
Chad	0	South side of Delta Clearwater River
Buns	0	South side of Delta Clearwater River
Patty	0	North side of Delta Clearwater River
Dave	0	North side of Delta Clearwater River
Travis	50	North side of Delta Clearwater River
Dubois	0	South side of Delta Clearwater River
Christie	200	North side of Delta Clearwater River
Caleb	150	North side of DCR across from camp
Isaac’s Slough	25	Between Caleb and Parker-north side
Parker	250	North side of Delta Clearwater River
Kenna	50	North side of Delta Clearwater River
Dos Gris	0	South side of DCR (Gartz)
Remmington	75	South side of DCR (lodge)
Barb	0	North side of Delta Clearwater River
Backy	0	South side of DCR (Fork)
Ridder	50	North side of Delta Clearwater River
Pearse	75	South side of DCR connects at mile 3
Hodges	0	North side of Delta Clearwater River
Stuga	25	South side of DCR (Al Svenston)
Salmon Alley	50	Loop of north side of DCR
Mallard	0	North side of DCR, above mile one

Age-Sex-Length Compositions

Four hundred coho salmon carcasses were collected and measured on two sampling occasions (200 each). The sex and length were determined and scale samples were collected from all carcasses. Age was determined for 368 (0.92) of these samples. Males comprised 0.51 of the sample. Brood year 1991 (age 2.1) comprised nearly all of the samples for both males and females (Table 23). Males were distributed over a larger length range (420-635 mm) than were females (455-615 mm; Figure 14).

DISCUSSION

Escapement counts in 1996 were considerably lower than the previous two years escapement counts, but was within the range of historical estimates (Table 20). The reasons for this moderate escapement are unclear. Parent year escapement in 1991 was above average, however commercial, subsistence, and sport harvest estimates are not yet available.

This year (1996) was the third year that aerial surveys were conducted to estimate the number of coho salmon in the non-boatable waters adjacent to the mainstream river. The proportions of fish spawning in the spring areas were similar during all years (0.22, 0.24, and 0.19, respectively). Similar counts should be conducted in future years, especially in years of low escapement, to obtain a more accurate estimate of total escapement as well as to determine if the distribution of spawners in these areas varies annually. 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 achieve the goal. In cases of large 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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Table 23.-Statistics by age and sex for coho salmon carcasses collected from the Delta Clearwater River, 1996.

	Male				Female			
Age[a]	1.1	2.1	2.2	3.1	1.1	2.1	2.2	3.1
Brood Year	**1992**	**1991**	**1990**	**1990**	**1992**	**1991**	**1990**	**1991**
Count	5	179	2	1	2	178	1	0
Percent of Sample	0.027	0.957	0.011	0.005	0.011	0.983	0.006	-
Standard Error	0.012	0.015	0.005	0.005	0.008	0.010	0.006	
Minimum Length (mm)	525	445	535	640	555	470	615	-
Maximum Length (mm)	620	660	610	640	620	650	615	-
Mean Length (mm)	574	572	573	640	583	578	615	-
Standard Error	19.68	3.36	37.48	-	27.58	2.25	-	-

[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 annuli formed during ocean residence).

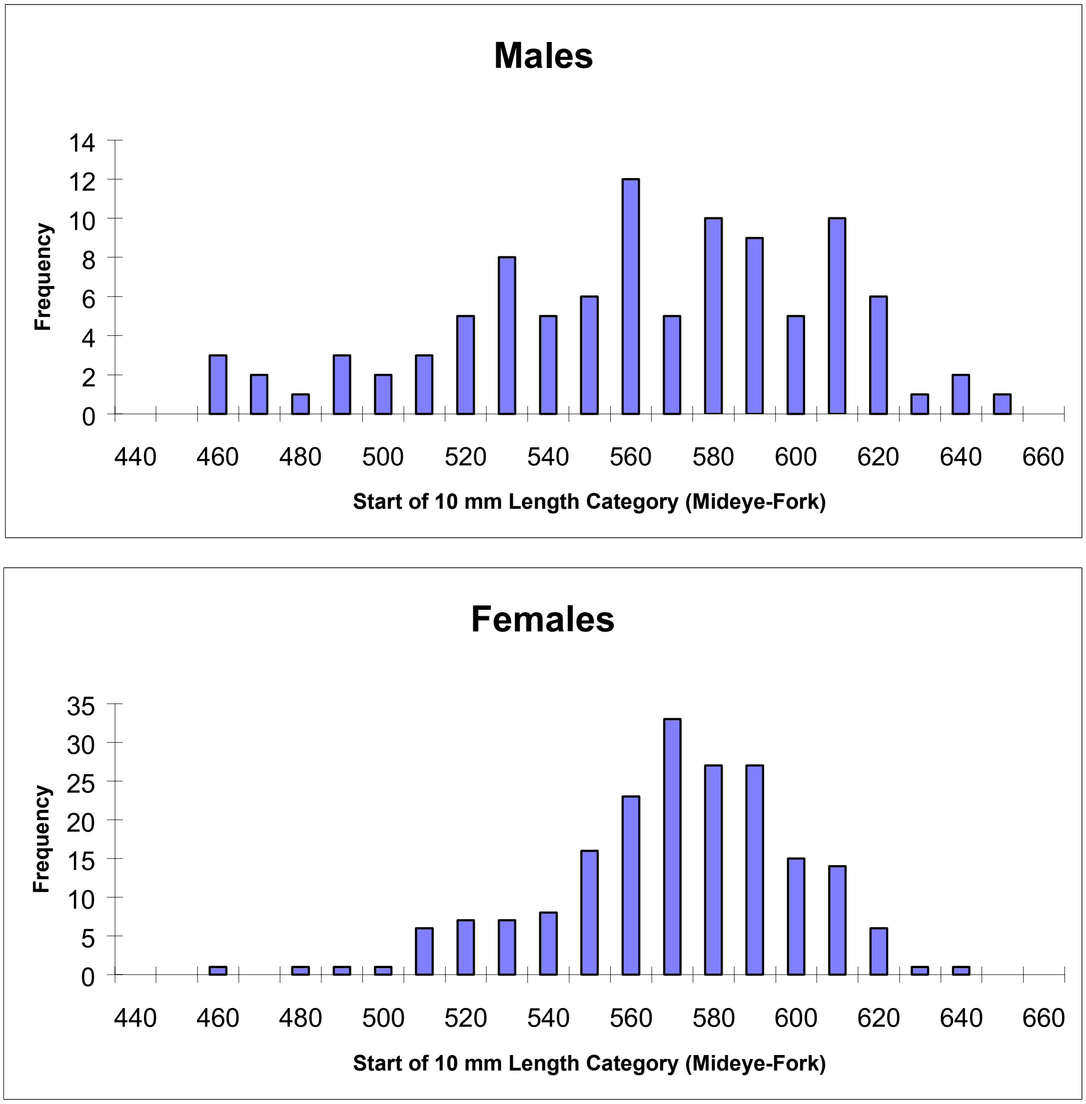

Figure 14.-Length frequency distributions of male and female coho salmon carcasses collected in the Delta Clearwater River during 1996.

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APPENDIX A.
Counting Schedules for the Salcha and Chena Rivers During 1996

Appendix A1.-Schedule for counting salmon in the Salcha River during 1996. Shaded boxes indicate shifts when counts were scheduled, but were not conducted due to high water and poor visibility.

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

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

15-21 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
0800-1600	COUNT	COUNT	COUNT	COUNT	COUNT		COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT

22-28 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	
0800-1600	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT

Appendix A2.-Schedule for counting salmon in the Chena River during 1996. Shaded boxes indicate shifts when counts were scheduled, but were not conducted due to high water and poor visibility.

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

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

15-21 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
0800-1600	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT	COUNT		COUNT

22-28 July	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800	COUNT		COUNT	COUNT	COUNT	COUNT	COUNT
0800-1600	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT	COUNT

APPENDIX B

Appendix B.-Statistical tests for analyzing data for gear bias, and for evaluating the assumptions of a two-event mark-recapture experiment.

The following statistical tests will be used to analyze the data for significant bias due to gear selectivity by sex and length:

1. A test for significant gear bias by sex will be based on a contingency table of the number of males and females that were recaptured and were not recaptured. The chi-square statistic will be used to evaluate the bias.

If Test 1 indicates a significant bias, the following tests will be done for males and females, separately. If Test 1 does not indicate a significant bias, males and females will be combined and the following tests will be done:

2. Tests for significant gear bias by size will be based on: (A) Kolmogorov-Smirnov goodness of fit test comparing the distributions of the lengths of all fish that were marked during electrofishing and all marked fish that were collected during the carcass survey; and, (B) Kolmogorov-Smirnov two sample test comparing the distributions of the lengths of all fish that were captured during electrofishing and all fish that were collected during the carcass survey. The null hypothesis is no difference between the distributions of lengths for Test A or for Test B.

For these two tests there are four possible outcomes:

Case I: Accept $H_o(A)$ Accept $H_o(B)$

There is no size-selectivity during the first sampling event (when fish were marked) or during the second sampling event (when carcasses were collected).

Case II: Accept $H_o(A)$ Reject $H_o(B)$

There is no size-selectivity during the second sampling event but there is size-selectivity during the first sampling event.

Case III: Reject $H_o(A)$ Accept $H_o(B)$

There is size-selectivity during both sampling events.

Case IV: Reject $H_o(A)$ Reject $H_o(B)$

There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.

Depending on the outcome of the tests, the following procedures will be used to estimate the abundance of the population:

Case I: Calculate one unstratified estimate of abundance, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of compositions.

Case II: Calculate one unstratified estimate of abundance, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate the abundance for each stratum. Add the estimates of abundance across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate the abundance for each stratum. Add the estimates of abundance across strata to get a single estimate for the population. Also, calculate a single estimate of abundance without stratification.

Case IVa: If the stratified and unstratified estimates of abundance for the entire population are dissimilar, discard the unstratified estimate. Only use the lengths, ages, and sexes from the second sampling event to estimate proportions in composition, and apply formulae to correct for size bias (*See* Adjustments in Compositions for Gear Selectivity) to data from the second event.

Case IVb: If the stratified and unstratified estimates of abundance for the entire population are similar, discard the estimate with the larger variance. Only use the lengths, ages, and sexes from the first sampling event to estimate proportions in compositions, and do not apply formulae to correct for size bias.

-continued-

TESTS OF CONSISTENCY FOR PETERSEN ESTIMATOR

The following two assumptions must be fulfilled:

1. Catching and handling the fish does not affect the probability of recapture; and,
2. Marked fish do not lose their mark.

Catching and handling the fish should not affect the probability of recapture because the experiment is designed to mark live fish and later recover carcasses. If the jaw tag is lost, the fin clip given each fish will identify the river section where it was marked.

Of the following assumptions, only one must be fulfilled:

1. Every fish has an equal probability of being marked and released during electrofishing;
2. Every fish has an equal probability of being collected during the carcass survey; or,
3. Marked fish mix completely with unmarked fish between electrofishing and carcass surveys.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for the Petersen model (Chapman 1951) to be valid. If all three tests are rejected, a geographically stratified estimator (Darroch 1961) will be used to estimate abundance by river section.

TEST I[b]

First Event River Section Released	Second Event: River Section Recaptured			
	Upper	Middle	Lower	Not Recaptured
Upper				
Middle				
Lower				

TEST II[c]

	Second Event: River Section		
	Upper	Middle	Lower
Recaptured			
Not Recaptured			

TEST III[d]

	Captured During Second Event River Section		
	Upper	Middle	Lower
Marked	22	12	2
Unmarked	231	132	73

a The tests for consistency were taken from Seber (1982). At least one hypothesis needs to be accepted in order for the Petersen to be valid.

b This tests the hypothesis that movement probabilities are the same among sections: H_1: $\theta_{ij} = \theta_j$. Theta applies to both marked and unmarked salmon.

c This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities between the three river areas: H_2: $\Sigma_j \theta_{ij} p_j = d$. Theta applies to both marked and unmarked salmon.

d This tests the homogeneity on the columns of the 2-by-t contingency table with respect to the probability of movement of marked fish in stratum i to the unmarked fraction in j: H_4: $\Sigma_i a_i \theta_{ij} = k U_j$. Theta does not apply to both marked and unmarked salmon.

APPENDIX C

Appendix C.-Data files used to estimate parameters of chinook, chum, and coho salmon populations during 1996.

Data File[a]	Description
U0020LA6.ARC	Data file of length, sex, and tag data for chinook salmon collected during the marking event of the mark-recapture experiment in the Chena River, 1996.
CHENKG96.AWL	Data file of length, sex, tag, and age data for chinook salmon carcass collected during the recapture event of the mark-recapture experiment in the Chena River, 1996.
U0050lA6.ARC	Data file of length, sex, and tag data for chinook salmon collected during the marking event of the mark-recapture experiment in the Salcha River, 1996
SALCKG96.AWL	Data file of length, sex, and age data for chinook salmon carcass collected during the recapture event of the mark-recapture experiment in the Chena River, 1996.
DCRECS96.AWL	Data file of length, sex, and age data for coho salmon carcasses collected from the Delta Clearwater River, 1996.
KING96.XLS	Excel spreadsheet of hourly counts of chinook salmon, daily expansions of escapement, and variance estimates for the Salcha and Chena rivers, 1996
CHUM96.XLS	Excel spreadsheet of hourly counts of chum salmon, daily expansions of escapement, and variance estimates for the Salcha and Chena rivers, 1996

[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.

APPENDIX D

Appendix D1.-Numbers of chinook salmon counted during 10 min periods on the left side of the Salcha River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8									9	0	0	3	0	0	0	4	3	0	0	0	0	2	2	0	23
7/9	6	2	3	3	0	2	0	0	0	0	1	2	0	0	2	3	1	2	1	1	1	0	0	1	31
7/10	4	3	0	2	0	0	2	0	0	1	1	0	0	1	0	0	0	3	0	0	0				17
7/11																									0
7/12																									0
7/13																									0
7/14																									0
7/15																	0	0	0	1	4	1	0	0	6
7/16	0	0	0	2	1	0	0	0	0	0	-1	0	0	0	0	0	0	0	2	0	1	1	3	0	9
7/17	1	1	0	0	1	3	0	0	0	0	0	0	0	2	0	1	0	0	0	1	1	0	0	0	11
7/18	0	0	2	1	0	1	0	0	0	0	0	1	2	3	0	0	0	0	0	0	0	1	3	0	14
7/19	0	1	1	2	0	1	1	1	2	2	0	0	0	0	0	3	1	1	0	0	0	1	0	1	18
7/20	0	3	0	0	0	0	1	0									0	0	1	0	0	0	0	0	5
7/21	0	0	1	1	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	6
7/22	1	0	0	3	0	0	1	1	4	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	14
7/23	0	2	2	2	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10
7/24																									0
7/25	2	0	0	1	2	0	1	0	0	3	0	0	1	0	0	0	0	0	0	2	1	0	0	0	13
7/26	0	0	1	1	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	1
7/27	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	-1	0	0	0	0	2
7/28									0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
Total	14	13	10	18	4	8	6	3	17	6	3	9	4	7	2	11	5	6	6	4	9	6	9	2	182

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Appendix D2.-Numbers of chinook salmon counted during 10 min periods on the right side of the Salcha River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8									4	1	0	1	2	2	0	3	0	0	1	0	4	4	1	0	23
7/9	1	0	6	2	0	1	3	0	0	0	1	2	1	6	2	3	8	5	4	0	3	0	0	0	48
7/10	0	1	5	6	1	0	0	0	1	1	3	2	0	0	0	0	1	3	1	0	0				25
7/11																									
7/12																									
7/13																									
7/14																									
7/15																	0	0	1	1	0	0	4	0	6
7/16	2	0	2	1	0	0	11	0	0	2	7	2	0	0	0	0	0	4	2	0	0	0	1	1	35
7/17	4	2	1	1	2	6	0	3	2	0	0	-1	1	0	0	5	1	0	1	2	0	0	0	1	31
7/18	1	2	3	3	0	2	1	1	1	0	7	1	1	4	3	1	0	0	1	0	0	3	5	1	41
7/19	1	1	3	4	3	0	0	3	4	1	3	1	0	1	2	2	0	1	0	3	1	0	2	1	37
7/20	1	0	0	0	2	0	0	0									0	0	0	0	0	0	2	1	6
7/21	0	0	7	4	2	3	0	0	1	0	1	1	2	0	0	0	0	2	0	0	0	0	0	0	23
7/22	6	0	1	1	1	1	2	0	0	1	1	6	0	0	3	0	0	0	0	0	0	0	0	1	24
7/23	1	2	0	2	3	0	0	2	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	1	17
7/24																									
7/25	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	5
7/26	0	0	3	1	0	0	0	0	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	8
7/27	0	0	1	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5
7/28									0	0	0	0	0	0	-1	0	1	0	0	0	0	0	0	0	0
Total	17	8	32	27	16	13	17	9	15	8	23	16	12	14	10	15	11	15	11	7	9	7	15	7	334

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Appendix D3.-Numbers of chinook salmon counted during 10 min periods on the left side of the Chena River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8																	2	2	0	1	0	0	0	0	5
7/9	6	1	0	1	1	14	9	5	0	1	0	0	2	0	0	0	1	0	1	0	-1	0	0	0	41
7/10	0	2	1	5	7	12	12	1	0	4	2	0	0	0	0	0	0	2	0	0	0	0	1	0	49
7/11	1	0	15	1	1	1	0	0																	19
7/12																									
7/13																									
7/14																									
7/15																	0	0	-1	0	0	1	0	1	1
7/16	0	0	0	0	0	0	-2	1	4	0	4	0	0	1	0	0	0	0	0	0	2	0	2	1	13
7/17	0	0	0	0	0	0	0	0	3	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	7
7/18	0	0	0	1	0	3	0	0	0	1	2	2	1	3	0	2	4	7	5	1	0	0	0	0	32
7/19	4	0	0	1	1	4	1	2	2	2	0	4	1	1	6	0	0	0	0	0	1	0	2	0	32
7/20	0	5	1	1	2	4	8	3	0	-2	0	0	0	0	0	1									23
7/21	0	0	0	0	0	0	0	0	1	1	0	4	2	2	4	0	2	1	1	0	1	0	0	0	19
7/22	1	0	2	2	2	0	-3	1	2	0	1	0	1	0	0	0	1	-1	0	0	5	-1	3	1	17
7/23									0	1	0	0	1	1	0	3	1	1	0	0	0	0	1	0	9
7/24	0	1	1	0	0	1	0	0	2	-2	1	-2	1	1	1	3	1	1	-1	4	1	1	-1	-2	12
7/25	1	0	0	1	1	0	-1	1	3	1	0	0	0	-1	0	0	1	0	0	0	0	-1	3	0	9
7/26	0	0	0	0	0	0	1	1	1	-1	1	0	0	0	2	0	0	0	-1	0	-1	0	1	1	5
7/27	0	0	0	0	0	0	0	0	0	0	-1	1	-1	1	0	0	2	0	0	0	2	0	0	0	4
7/28	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	-2	1	0	-1	-2
Total	13	9	21	13	15	39	25	15	18	7	10	9	9	9	14	9	14	13	4	6	8	1	12	2	295

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Appendix D4.-Numbers of chinook salmon counted during 10 min periods on the right side of the Chena River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8																	0	0	0	0	0	0	0	0	0
7/9	0	0	0	6	0	0	2	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	12
7/10	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7/11	0	0	0	0	0	0	0	0																	0
7/12																									0
7/13																									0
7/14																									0
7/15																	0	0	0	0	0	0	0	0	0
7/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
7/18	0	0	0	0	0	0	0	0	0	1	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0
7/19	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	4
7/20	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0									1
7/21	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
7/22	0	0	1	0	0	0	0	0	0	-1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
7/23									0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	-1	-2
7/24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0	-2
7/25	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
7/26	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-1	0	0	0	0
7/27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-1
Total	0	1	1	7	1	0	2	2	0	2	1	0	1	2	1	1	0	-1	2	0	-1	-1	-1	-1	19

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Appendix D5.-Numbers of chum salmon counted during 10 min periods on the left side of the Salcha River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8									22	1	16	18	12	2	6	24	24	11	14	16	28	20	33	17	264
7/9	21	11	22	22	23	16	29	40	13	6	26	11	22	3	28	14	1	12	10	6	17	9	48	30	440
7/10	30	37	16	7	14	16	9	0	10	3	11	5	1	4	36	6	14	10	20	8	0				257
7/11																									
7/12																									
7/13																									
7/14																									
7/15																	5	3	0	5	127	125	103	73	441
7/16	54	29	17	15	17	5	5	0	5	4	1	0	-1	2	24	12	23	26	18	57	51	7	22	53	446
7/17	10	43	16	25	8	19	4	7	11	3	6	9	5	28	9	19	15	26	27	33	63	41	19	15	461
7/18	43	24	53	26	41	44	11	17	32	8	1	18	13	26	8	14	11	26	28	61	46	61	51	35	698
7/19	28	20	22	40	38	31	30	29	25	37	9	16	1	8	17	8	11	28	35	17	18	17	15	19	519
7/20	25	13	28	12	12	7	9	12									9	12	15	32	8	11	24	6	235
7/21	21	39	16	18	11	16	7	12	12	19	18	27	27	29	35	48	21	5	1	38	9	2	23	29	483
7/22	9	24	17	30	11	26	26	32	23	35	18	38	52	32	23	22	6	9	3	24	50	50	35	34	629
7/23	9	31	20	18	12	31	47	38	8	31	7	29	6	2	7	15	19	0	22	14	15	7	8	11	407
7/24																									
7/25	8	19	18	11	8	17	24	31	14	22	12	14	12	27	32	3	24	5	26	19	29	17	6	21	419
7/26	21	17	17	6	9	13	8	18	4	6	3	11	9	-1	15	29	14	26	12	27	13	17	24	30	348
7/27	30	48	9	16	27	25	11	28	6	8	6	4	27	18	16	23	28	22	32	31	11	24	22	28	500
7/28									7	15	6	8	17	16	12	2	17	28	47	35	29	26	17	7	289
Total	309	355	271	246	231	266	220	264	192	198	140	208	203	196	268	239	242	249	310	423	514	434	450	408	6836

Appendix D6.-Numbers of chum salmon counted during 10 min periods on the right side of the Salcha River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8									4	8	1	5	1	4	5	9	0	13	4	6	11	14	12	16	113
7/9	7	5	15	21	16	15	10	5	0	0	1	1	2	16	9	13	10	13	10	7	18	22	5	18	239
7/10	18	18	8	10	21	5	0	2	3	9	6	3	2	9	15	4	0	6	10	0	0				149
7/11																									
7/12																									
7/13																									
7/14																									
7/15																	1	0	2	0	102	12	25	2	144
7/16	51	3	21	16	18	2	15	0	0	7	17	3	3	2	24	1	21	10	15	21	15	1	4	33	303
7/17	3	4	14	6	4	3	9	0	2	6	-1	1	0	15	2	7	35	9	18	25	42	7	7	17	235
7/18	21	27	13	12	4	7	5	2	4	2	18	12	0	9	24	13	6	45	17	5	19	18	8	4	295
7/19	3	6	21	17	12	3	7	8	8	3	5	13	2	3	9	22	4	25	9	10	5	7	9	15	226
7/20	2	3	4	3	7	11	6	5									6	6	21	14	6	24	64	5	187
7/21	23	13	15	25	10	13	14	8	11	4	1	4	1	12	3	5	11	6	6	3	13	17	9	6	233
7/22	28	12	8	18	7	7	3	11	7	14	15	24	14	34	9	6	0	7	14	5	18	4	11	29	305
7/23	11	20	5	12	9	11	23	11	15	11	17	4	11	3	26	9	0	18	3	8	5	3	11	7	253
7/24																									
7/25	2	3	6	3	2	9	13	7	4	5	2	0	1	18	14	6	6	10	3	3	28	24	4	4	177
7/26	17	8	14	5	10	14	9	11	14	4	4	29	20	26	18	17	5	9	13	19	20	8	3	10	307
7/27	13	24	15	9	11	9	10	9	3	5	5	5	8	10	40	6	17	4	19	21	16	8	15	14	296
7/28									11	7	1	4	8	4	30	10	12	6	46	32	25	14	34	15	259
Total	199	146	159	157	131	109	124	79	86	85	92	108	73	165	228	128	134	187	210	179	343	183	221	195	3721

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Appendix D7.-Numbers of chum salmon counted during 10 min periods on the left side of the Chena River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8																	2	9	0	2	2	2	6	17	40
7/9	7	1	0	0	0	11	1	6	1	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0	31
7/10	29	8	11	14	8	16	15	1	3	0	0	0	0	0	0	0	0	0	3	0	7	0	0	0	115
7/11	2	6	10	2	1	0	0	0																	21
7/12																									
7/13																									
7/14																									
7/15																	1	2	3	0	2	1	1	2	12
7/16	0	1	0	0	0	1	0	1	0	1	1	0	0	2	0	0	0	0	0	4	5	3	6	0	25
7/17	0	-1	0	1	0	1	2	0	2	0	0	1	0	0	0	5	0	0	2	1	0	0	1	0	15
7/18	0	0	0	1	0	1	0	0	4	12	2	3	2	2	0	2	9	2	8	0	1	0	0	0	49
7/19	1	0	0	3	0	-3	0	18	14	1	13	5	4	1	-1	12	0	0	2	0	1	2	1	7	81
7/20	2	1	4	0	3	7	3	0	0	4	2	8	0	4	6	0									44
7/21	0	4	0	0	1	0	-2	0	2	0	2	0	2	0	6	0	2	0	0	0	0	0	3	5	25
7/22	1	4	3	1	1	0	0	0	-1	3	0	0	0	4	0	0	0	0	0	0	0	0	1	0	17
7/23									0	0	1	2	0	1	3	0	1	1	0	8	1	5	1	5	29
7/24	4	2	0	0	6	6	0	8	10	1	1	0	0	6	4	4	3	0	1	0	5	2	2	1	66
7/25	0	12	13	1	1	23	14	5	0	0	3	0	0	0	0	5	3	0	3	2	0	1	7	0	93
7/26	29	3	2	11	14	7	7	5	3	0	0	1	0	0	2	0	0	0	0	0	1	2	4	-1	90
7/27	6	0	8	2	0	4	0	0	-2	0	11	0	0	0	0	0	2	2	5	0	4	1	4	0	47
7/28	2	0	0	3	0	1	1	0	32	0	11	0	0	0	3	0	0	0	10	2	3	1	0	0	69
Total	83	41	51	39	35	75	41	44	68	22	47	20	10	21	23	28	23	16	37	20	32	20	37	36	869

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Appendix D8.-Numbers of chum salmon counted during 10 min periods on the right side of the Chena River, 1996. Counts were conducted near the top of each hour. Negative counts indicate fish movement down river. Shaded areas indicate hours not counted.

Date	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	Total
7/8																	0	0	0	0	0	0	1	1	2
7/9	0	0	0	0	0	1	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
7/10	0	10	4	7	1	11	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	34
7/11	0	6	1	2	0	0	0	0																	9
7/12																									
7/13																									
7/14																									
7/15																	0	1	0	0	0	3	2	0	6
7/16	0	0	0	0	0	0	0	3	1	0	4	0	0	0	0	4	1	7	0	2	3	0	0	2	27
7/17	0	3	1	0	1	1	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	1	0	0	10
7/18	0	23	0	1	0	0	0	0	0	1	4	3	7	1	0	5	0	0	0	0	0	0	6	0	51
7/19	3	0	10	2	6	1	12	8	5	9	8	0	2	2	0	1	2	0	1	0	0	9	7	8	96
7/20	12	5	5	12	8	6	3	0	0	1	0	0	0	1	0	0									53
7/21	0	9	5	0	0	0	0	0	0	14	5	0	0	0	0	1	1	2	0	0	0	0	6	0	43
7/22	2	4	11	7	0	0	0	0	11	1	0	0	2	0	0	0	0	0	6	0	0	0	0	4	48
7/23									2	4	0	6	15	16	9	0	1	0	0	0	2	2	1	0	58
7/24	0	3	1	5	12	6	0	3	1	0	7	0	-1	0	0	11	0	0	0	14	7	5	1	18	93
7/25	1	8	3	12	0	12	43	17	5	0	0	1	0	0	0	0	0	-2	2	3	0	13	0	7	125
7/26	5	4	3	0	1	5	0	6	0	31	1	0	0	4	3	1	0	4	1	2	2	8	4	3	88
7/27	11	6	8	4	15	15	2	16	5	0	0	0	0	0	1	1	-4	2	3	9	0	13	4	11	122
7/28	0	5	8	6	8	13	1	-1	0	2	12	5	0	0	11	9	0	0	1	14	0	15	5	10	124
Total	34	86	60	58	52	71	61	53	31	65	41	16	25	24	27	33	1	14	14	44	14	69	37	64	994

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