Fishery Data Series No. 98-11

Salmon Studies in Interior Alaska, 1997

by

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and

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July 1998

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
Ampere	A
Calorie	cal
direct current	DC
Hertz	Hz
Horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
Volts	V
Watts	W

General

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

Mathematics, statistics, fisheries

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

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SALMON STUDIES IN INTERIOR ALASKA, 1997

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ABSTRACT

Escapements of chinook salmon (*Oncorhynchus tshawytscha*) in the Salcha, Chena and Chatanika rivers near Fairbanks, Alaska were estimated using either mark-recapture and/or counting tower techniques. Tower count estimates were 18,514 (SE=1,043) chinook salmon for the Salcha River and 13,390 (SE=699) for the Chena River. Mark-recapture studies gave estimates of 10,810 (SE=1,160) chinook salmon for the Chena River and 3,809 (SE=1,507) for the Chatanika River. Results of a two-tailed z-test failed to reject the hypothesis (P=0.06) that the tower count estimate for the Chena River is equivalent to the mark-recapture estimate. Aerial survey counts of chinook salmon during the periods of maximum escapement were 3,458 for the Salcha River and 3,495 for the Chena River. These estimates were 0.19 of the Salcha River tower estimate, and 0.32 and 0.26 of the Chena River mark-recapture and tower estimates, respectively. Females comprised 0.48 (SE=0.03) of a sample of chinook salmon carcasses collected in the Salcha River during late August. Proportions of female chinook salmon estimated from mark-recapture experiments were 0.26 (SE=0.04) and 0.09 (SE=0.05) for the Chena and Chatanika rivers, respectively. The majority of males examined from the Salcha River were age 1.4 (0.49), with the rest comprising ages 1.2 (0.26), 1.3 (0.24), and 1.5 (0.01). For the Chena and Chatanika rivers, the majority of males were age 1.2 (0.61) and (0.75), respectively. Females were characteristically older. For the Salcha, Chena and Chatanika rivers the majority of females were age 1.4. Proportions of age 1.4 females were 0.90, 0.93, and 0.80 for the three rivers, respectively. A portion of the Salcha and Chena rivers chum salmon (*Oncorhynchus keta*) escapement was also estimated during the tower counts. Estimated escapement of chum salmon through 7 August was 35,948 (SE=819) for the Salcha River and 9,439 (SE=589) through 3 August for the Chena River.

Escapement of coho salmon (*Oncorhynchus kisutch*) was measured in the mainstream Delta Clearwater River near Delta Junction, Alaska, by means of aerial and boat counts. The boat count of the mainstem river was 11,525 on 24 October, and the helicopter count on 22 October of tributaries which were inaccessible by boat was 2,375. Total escapement of was 13,900. A total of 391 coho salmon were sampled on two different occasions for age, sex and length. Females comprised 0.46 of total fish sampled. The majority of the samples were age 2.1.

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, mark-recapture, counting towers, carcass survey, aerial survey, boat 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 1,448 fish in the Salcha River, and from 0 to 1,280 chinook salmon in the Chena River (Mills 1979-1994 and Howe et al. 1995-1997; Table 1). The Chatanika River (Figure 3) supports a small run of chinook, however recent estimates of sport harvests (0-499; 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 Bering Sea 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

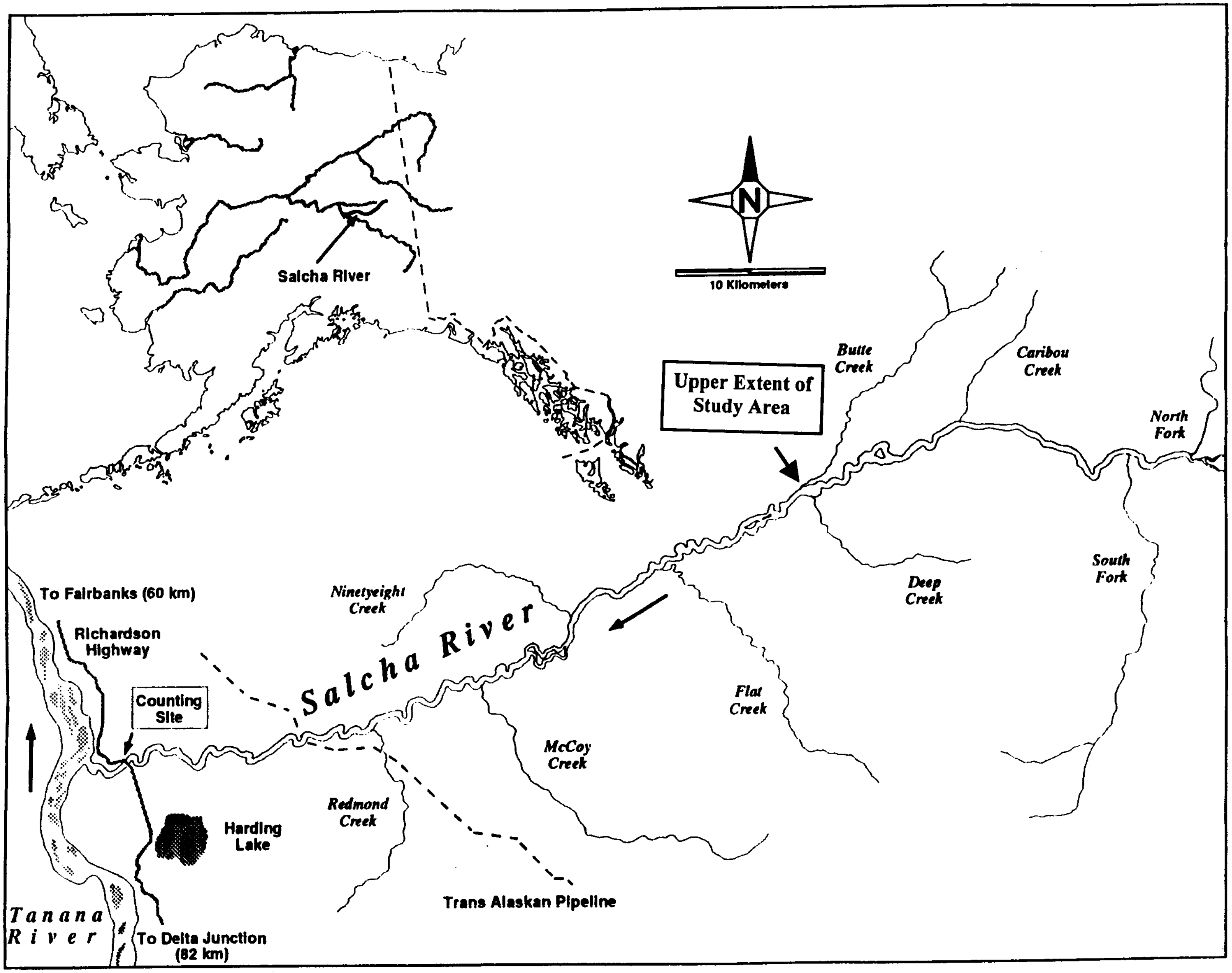


Figure 1.-Salcha River study area.

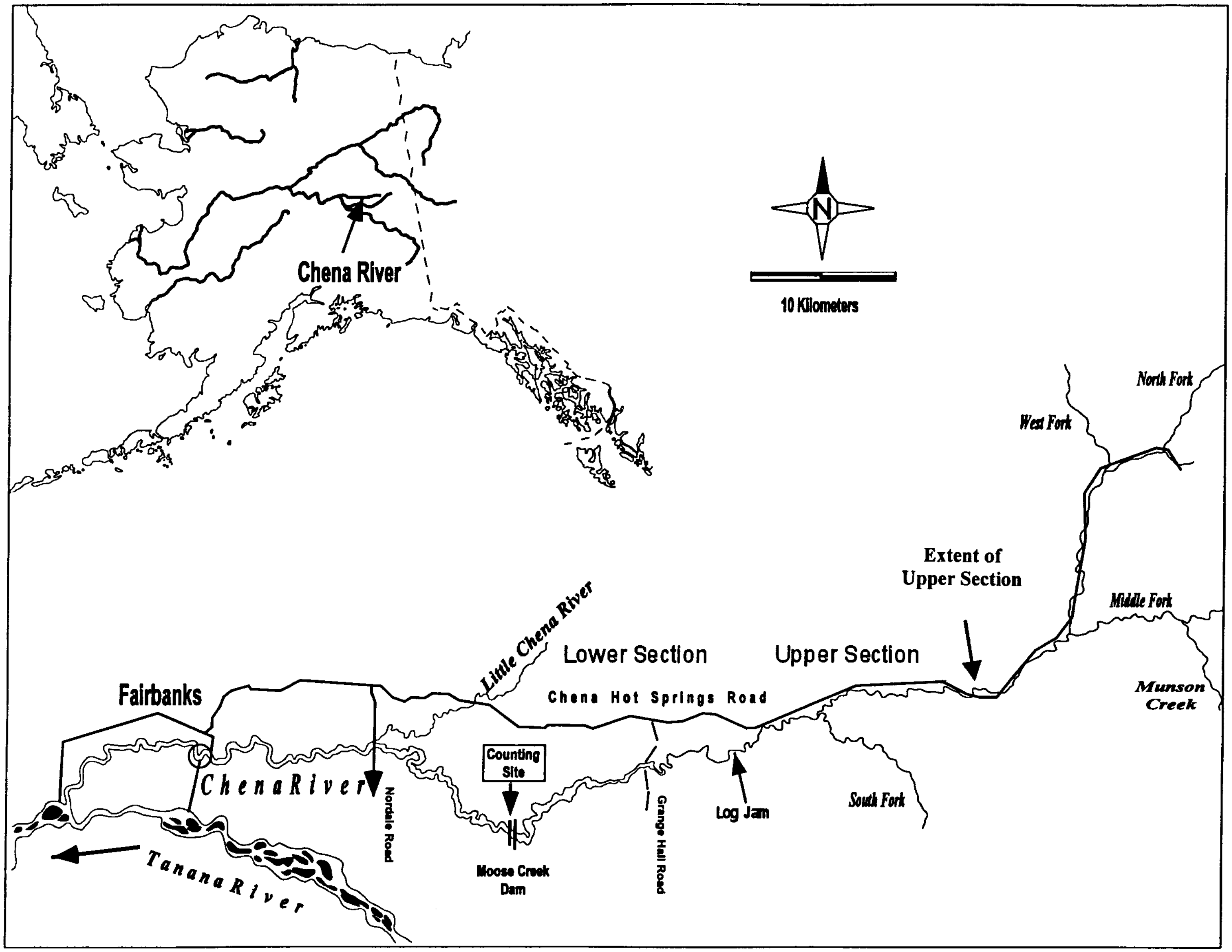


Figure 2.-Chena River study area.

Table 1.-Harvests of anadromous chinook salmon by sport, commercial, subsistence, and personal use fisheries, Tanana River drainage, 1978 - 1997.

	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	1,136	499	49	138	3,102	447	1392[d]	8,043
1997	None	None	NA[f]	NA[f]	NA[f]	NA[f]	NA[f]	NA[f]	2,728[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. 1995-1997.

[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.

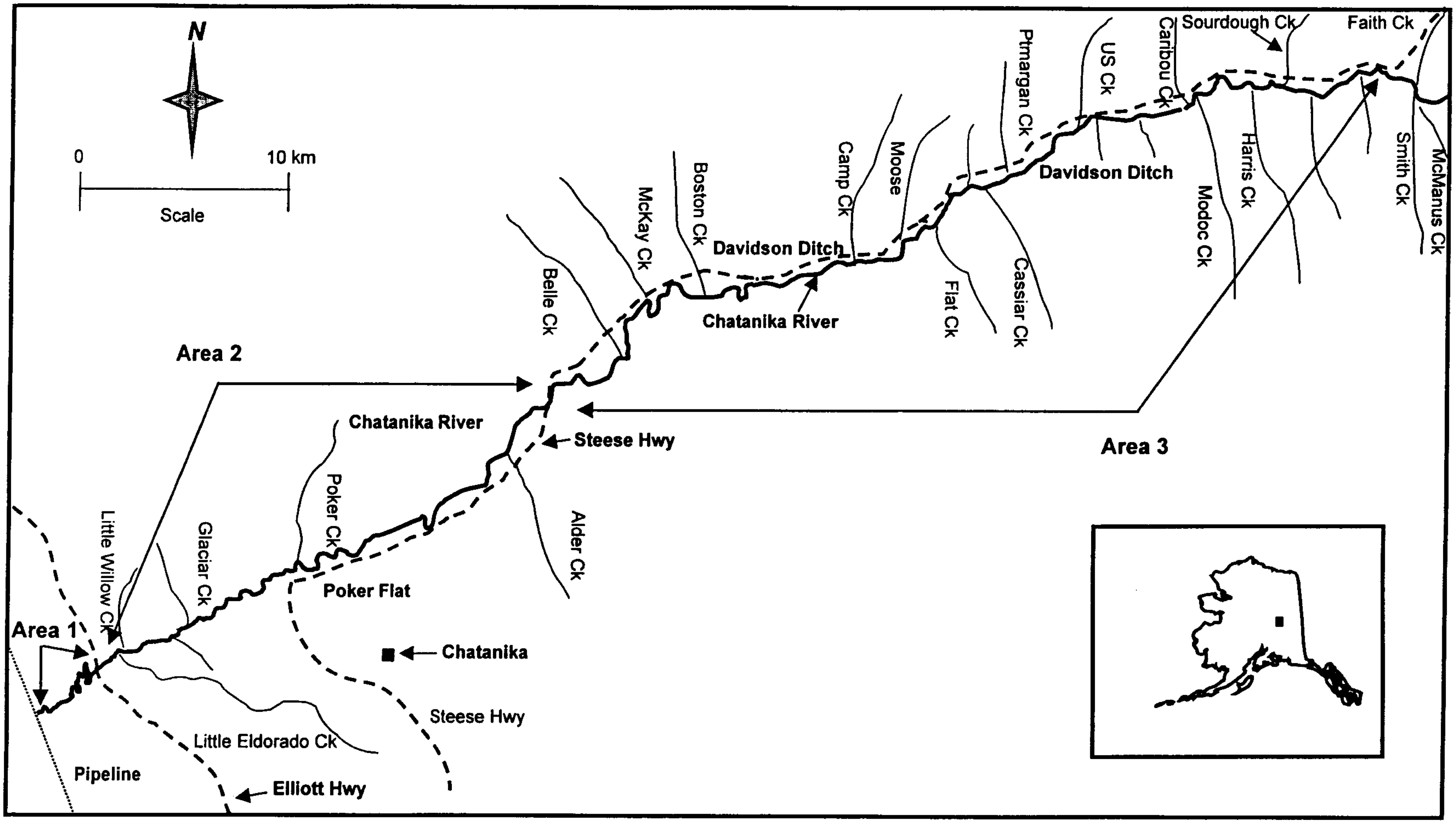


Figure 3.-Chatanika River study area.

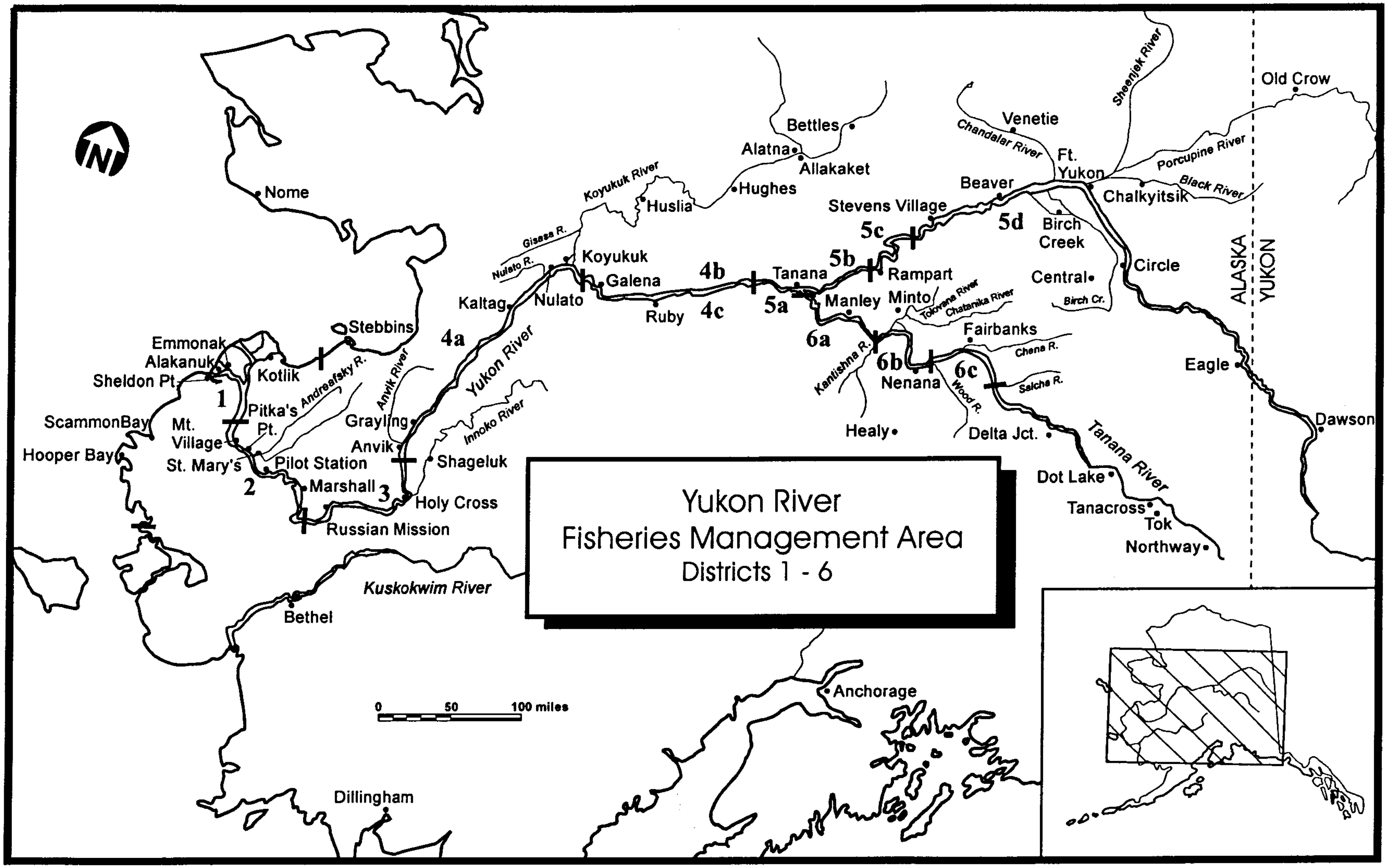


Figure 4.-Fishing districts in the Yukon River draiange.

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. Aerial surveys do not provide consistent indices of escapement. Thus, tower-counting methodology was initiated to provide the additional information on inseason escapement. 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 has been inadequate, as survey estimates from some years are less than harvest estimates for the same years.

The Alaska Department of Fish and Game (ADF&G) has established biological Escapement Goals for chinook salmon returning to the Salcha and Chena rivers. 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 (Evenson 1996). The minimum escapement guidelines using these expansions are 7,100 for the Salcha River and 6,300 for the Chena River. Escapement guidelines have not 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 Alaska 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 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 was 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 a biological escapement goal of 3,500 chum salmon from aerial surveys for the Salcha River, but none exist for the Chena River.

The research objectives of the chinook salmon projects in 1997 were to:

1. estimate the escapement of chinook salmon in the Salcha and Chena rivers using tower counting techniques;
2. estimate the total escapement of chinook salmon in the Chena and Chatanika rivers using mark-recapture techniques;
3. test the hypothesis that estimated abundance of chinook salmon from mark-recapture experiments is the same as that estimated from tower counts for the Chena River population; and,
4. estimate age, sex, and length compositions of the escapement of chinook salmon in the Salcha, Chena and Chatanika rivers.

In addition to these objectives, chum salmon were counted in the Salcha and Chena rivers during chinook salmon tower counting operations.

METHODS

Tower Counts

Daily escapements of chinook and chum salmon returning to the Salcha and Chena rivers were estimated by counting fish at fixed intervals as they passed beneath elevated counting sites. The Moose Creek Dam was used for the Chena River and the Richardson Highway Bridge was used for the Salcha River (Figures 1 and 2). Little or no spawning takes place downstream from these sites. A sport fishery occurs 2.5 miles upstream from the Richardson Highway Bridge but does not occur upstream of the Moose Creek Dam. Counting was initiated on 26 June for both rivers and ended on 3 August for the Chena River, and 7 August for the Salcha River. For the Salcha River, high water due to rainfall prevented counts on 16, 21-23 July. No days were missed for the Chena River.

Light-colored fabric panels were placed on the bottom of the rivers just downstream from the counting structures in order to improve visibility of fish moving over the panels. Lights were suspended over the panels to provide illumination during low light periods. Because salmon will often try to avoid areas with artificial substrate or illumination, the panels and overhanging lights formed a continuous band across the rivers. Once the light strings were turned on, they were 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 technicians were assigned to each river to conduct counts. Personnel were assigned 8-hour shifts and counted salmon 20 minutes of each hour. Counts were limited to 20 minutes to alleviate eyestrain and fatigue. The width of the Salcha and Chena rivers made it possible for fish to escape the counters watch. Thus, each river was divided in half by placing a red fabric strip across the panels near the center of the channel, allowing for ten-minute counts of each side. Seibel (1967) evaluated the use of hourly 10-minute counts as the basis for estimating hourly migration and thus total seasonal migration and found relative errors to be less than 10%. Start times for the first count were chosen randomly within the first ten minutes of the hour. Counts began on the left side of the river facing upstream. The second count immediately followed the first. A week consisted of 21 possible, eight hour shifts (three shifts per day). Shift I started at 24:00 h 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. During the period 26 June-6 July, only 2 persons were used on each tower to conduct counts. Counting was scheduled during two, randomly selected eight hour shifts each day during this period. During the period 7 July through the end of the counting period, four persons were used for each tower to conduct counts. During this period counts were conducted during 20 of the 21 possible shifts each week. High, murky water in the Salcha River prevented conducting some of the scheduled counts (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 are 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:

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

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

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

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

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

d = day;

i = 8 h shift;

j = 10 min counting period;

s = side of river counted;

$\boldsymbol{Y}$ = number of chinook or chum salmon counted;

$\boldsymbol{m}$ = number of 10 min counting periods sampled;

$\boldsymbol{M}$ = total number of possible 10 min counting periods;

$\boldsymbol{h}$ = number of 8 h shifts sampled;

$\boldsymbol{H}$ = total number of possible 8 h shifts;

$\boldsymbol{D}$ = total number of possible days;

$\boldsymbol{f_1}$ = fraction of 8 h shifts sampled;

$\boldsymbol{f_2}$ = fraction of 10 min counting periods sampled;

$\boldsymbol{s_2^2}$ = estimated variance of total across counting periods; and,

$\boldsymbol{s_1^2}$ = 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 the associated variance were calculated similarly by summing the estimates from each side.

The above equations worked well when two or three 8-hour shifts were worked in a day. For a few days, due to high water, technicians could only conduct one 8-hour count per day for the Salcha River. The equation for total estimated variance across shifts (4) assumes greater than one 8 hour shift, or the denominator becomes a zero. For days with only one shift, the SE was estimated from the total average daily coefficient of variation (CV) for each river and species for those days with greater than one counting period. The coefficient of variation was used because it is independent of the magnitude of the estimate and is relatively constant throughout the run (Evenson 1995). Eighty percent of Salcha River counts and 100% of Chena River counts fit the variance equation.

When k consecutive days were not sampled, the moving average estimate for the missing day i was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\,j\ was\,sampled)\hat{N}_j}{\sum_{j=i+k}^{i+k} I(day\ j\,was\,sampled)} \tag{10}$$

where:

$$I(\cdot) = \begin{cases} 1 & when\,the\,condition\,is\,true \\ 0 & otherwise \end{cases} \tag{11}$$

is an indicator function.

The estimate of the daily variation for missed days was the maximum variance of the *k* days before and the *k* days after the missed day *i*.

MARK-RECAPTURE EXPERIMENTS

Two sample mark-recapture experiments were conducted for the Chena and Chatanika rivers as a means of estimating total escapement of chinook salmon. The Chena River mark-recapture experiment also tested the hypothesis that the estimated escapement from the tower counts ($\hat{N}_t$) is equal to the estimate from mark-recapture experiments ($\hat{N}_{mr}$). The hypothesis was tested using a z-test (Seber 1982):

$$z = \frac{\hat{N}_t - \hat{N}_{mr}}{\sqrt{\left(\hat{V}(\hat{N}_t) + \hat{V}(\hat{N}_{mr})\right)}} \qquad (12)$$

This method assumes that the two estimates are independent.

Marking Event: Chena River

A river boat equipped with electrofishing gear (Clark 1985) and long-handled dip nets were used to capture adult chinook salmon on the spawning grounds. Sex was determined for all captured fish by appearance and by partially extruding gametes. All fish were measured to the nearest 5 mm from mid-eye to fork of the tail and tagged with an individually numbered jaw tag. In addition to the jaw tag, a secondary fin clip was made which varied according to the week and river section of tagging. Fish were marked during two complete passes through the study section. Each pass required four days to complete. The first pass occurred 22-25 July, and the second occurred from 29 July-1 August. The study section was 90 km in length and corresponds to the same area that is assessed during aerial surveys (Figure 2). For analysis of mixing, the section was delineated into two approximately equal areas with the boundary being a substantial logjam located between Grange Hall Road and the South Fork (Figure 2). The timing of the marking events were centered around the short period after completion of immigration and spawning and before the fish began to die.

Marking Event: Chatanika River

Chinook salmon were captured by means of a gillnet and electrofishing gear. A single gillnet was fished from 30 June-15 July at a fixed location approximately 5 km below the Elliott Highway Bridge (Figure 3). The net was 36.56 m long and 3.66 m deep and was constructed of four 9.14 m long panels. Panels alternated mesh sizes of 14.9 cm and 20.7 cm (stretch-measure). The net was fished daily during this period for varying lengths of time during the evening hours (16:00-06:00). Due to low catches with the gillnet, electrofishing gear, similar to that described for the Chena River marking event, was used on 16-18 and 21 July. During each of these days, a single pass was made through a section extending from the Elliott Highway Bridge downstream to the Trans Alaska Pipeline crossing (Area 1 on Figure 3). All marking occurred downstream from most of the spawning grounds. Measurements and tagging were conducted similar to procedures described above for the Chena River. Three scales were taken from each fish for aging.

Recapture Event
The recapture events for the Chena and Chatanika rivers were conducted similarly and entailed examination of chinook carcasses on the spawning grounds. Long handled spears were used to collect the carcasses. The fish were measured, three scales were taken for aging, and sex was determined by appearance and, in questionable cases, by examining the gonads. Area of recapture was noted for later examination of movement from the tagging areas. For the Chena River, one pass was made through the same sections where marking occurred from 31 July-7 August. For the Chatanika River, sampling was conducted from 28 July-8 August in a much larger section than during the marking event (Areas 1-3 on Figure 3). After examination, all carcasses were sliced on their left sides in order to prevent resampling. Desired sample numbers for both the mark and recapture events were determined from an *a priori* estimate of abundance and the desired precision and accuracy (95% ± 25%) according to Robson and Reiger (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 the marking event;
2. every fish has an equal probability of being collected during the recapture event; or,
3. marked fish mix completely with unmarked fish between mark and recapture 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:

$$\hat{N}^* = \left[\frac{(n_1+1)(n_2+1)}{(m_2+1)}\right] - 1 \qquad (13)$$

$$V(\hat{N}^*) = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \qquad (14)$$

where:

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

n_1 = the number of fish marked during the first event;

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

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

Age-Sex-Length Compositions

Age, sex and length composition data were collected from Chena and Chatanika River chinook salmon as part of the mark-recapture experiments. For the Salcha River, these data were collected during a single carcass survey conducted from 12-14 August. All length measurements were made from mid-eye to fork-of-tail. Three scales were removed from the left side of the fish 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 viewed at 100X magnification using equipment similar to that described by Ryan and Christie (1976). 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). For the Salcha and Chatanika rivers, proportions of chinook salmon in a carcass sample by ocean-age and the associated variances for each river were calculated separately for each sex using:

$$\hat{p}_{sg} = \frac{n_{sg}}{n_s} \tag{15}$$

$$\hat{V}(\hat{p}_{sg}) = \frac{\hat{p}_{sg}\left(1 - \hat{p}_{sg}\right)}{n_s - 1} \tag{16}$$

where:

$\hat{p}_{sg}$ = estimated proportion of chinook salmon of sex *s* in age group *g*; and,

n_s = number of chinook salmon of sex *s*.

The 1997 Chena River data required stratification by sex and the females required stratification by size. Total abundance, $\hat{N}^*$, was estimated using equation 13 for i = males (m), small females (f1) and large females (f2);

$$\hat{N}^*_{tot} = \hat{N}^*_m + \hat{N}^*_{f1} + \hat{N}^*_{f2} \tag{17}$$

$$V(\hat{N}^*_{tot}) = \sum_i V(\hat{N}^*_i) \tag{18}$$

The age distribution was corrected as described by Bernard and Hansen (1992). The conditional fraction of the sample is:

$$\hat{p}_{j/i} = {n_{ij}}/{n_i} \tag{19}$$

$$V(p_{j/i}) = \frac{p_{j/i}(1 - p_{j/i})}{n_i - 1} \tag{20}$$

where:

n_i = the number sampled from stratum i for i = male, small female, and large female;

n_{ij} = the number sampled from stratum I that belong to the jth age; and,

$p_{j/i}$ = the conditional fraction of fish that belong to the jth age, given that they are in stratum i.

The estimated abundance of males at age j is:

$$\hat{N}^*_{male\ j} = \hat{p}_{j/male}\hat{N}^*_{male} \tag{21}$$

with variance from Goodman's exact variance (1960);

$$V(\hat{N}^*_{male\ j}) = V(\hat{p}_{j/male})\hat{N}^{*\ 2}_{male} + V(\hat{N}^*_{male})\hat{p}_{j/male}{}^2 - V(\hat{p}_{j/male})V(\hat{N}^*_{male}) \tag{22}$$

the estimated abundance of females at age j is:

$$\hat{N}^*_{female\ j} = \hat{p}_{j/f1}\hat{N}^*_{f1} + \hat{p}_{j/f2}\hat{N}^*_{f2} \tag{23}$$

with variance estimated as:

$$V(\hat{N}^*_{female\ j}) = \sum_i \left[V(\hat{p}_{j/i})\hat{N}^{*2}_i + V(\hat{N}^*_i)\hat{p}_{j/i}{}^2 - V(\hat{p}_{j/i})V(\hat{N}^*_i) \right] \tag{24}$$

for i = f1, f2.

Sex composition proportions and their associated variance were estimated using:

$$\hat{p}_s = \frac{N_s^*}{N^*} \tag{25}$$

$$\hat{V}(\hat{p}_s) = \left[\left(\frac{1}{\hat{N}_m^* + \hat{N}_f^*}\right) - \left(\frac{\hat{N}_m^*}{(\hat{N}_m^* + \hat{N}_f^*)^2}\right)\right]^2 \hat{V}(\hat{N}_m^*) + \left[\frac{-\hat{N}_m^*}{\left(\hat{N}_m^* + \hat{N}_f^*\right)}\right]^2 \hat{V}(\hat{N}_f^*) \tag{26}$$

Aerial Counts

Commercial Fisheries Management and Development Division personnel conducted aerial survey counts at peak escapement in the Salcha and Chena rivers. The surveys were conducted on 18 July for the Chena River and 1 August for the Salcha River. 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

Tower counts were initiated for the Salcha and Chena rivers before the major runs of chinook salmon arrived. Total escapement was estimated at 18,514 (SE=1,043) for the Salcha River and 13,390 (SE=699) for the Chena River. The largest expanded daily count of chinook salmon for the Salcha River were 1,782 (SE=386) on 9 July and 1,992 (SE=208) on 16 July for the Chena River (Tables 2 and 3). Daily passage of chinook was minimal for both rivers when counts were terminated on 7 August for the Salcha River and 3 August for the Chena River. The largest number of chinook salmon to pass during one 10 minute count was 77 on 9 July for the Salcha River and 52 on 7 July for the Chena River. Typically, counts were larger for the right side of the Salcha River and were larger for the left side of 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 in the early morning and afternoon (Figures 5 and 6).

Chum salmon were first counted on 7 July on the Chena River and 2 July on the Salcha River. The Chum salmon migration was still underway when tower project operations ended. Estimated escapement through 7 August for the Salcha River was 35,948 (SE=819) and 9,439 (SE=589) through 3 August for the Chena River. The largest expanded daily count of chum salmon for the Salcha River was 3,828 (SE=294) on 30 July and 1,062 (SE=291) for the Chena River on 29 July (Tables 4 and 5). The largest number of chum salmon passing during any one 10 minute count was 41 for the right side of the Salcha River on 30 July and 34 for the left side of the Chena River on 29 July. Overall, counts tended to be much higher for the right side of the Salcha River

Table 2.-Daily counts and estimates of the number of chinook salmon passing by the counting site in the Salcha River, 1997.

Date	Count Periods	Left Side Count	Left Side Expanded Count[a]	Left Side SE[a]	Right Side Count	Right Side Expanded Count[a]	Right Side SE[a]	Total Count	Total Expanded Count[a]	Total SE[a]
26-Jun-97	16	0	0	0	2	18	14	2	18	14
27-Jun-97	16	0	0	0	0	0	0	0	0	0
28-Jun-97	16	2	18	10	5	45	16	7	63	19
29-Jun-97	16	0	0	0	3	27	12	3	27	12
30-Jun-97	16	0	0	0	0	0	0	0	0	0
1-Jul-97	16	0	0	0	3	27	12	3	27	12
2-Jul-97	16	6	54	22	30	270	136	36	324	138
3-Jul-97	16	2	18	7	8	72	33	10	90	34
4-Jul-97	16	0	0	0	5	45	21	5	45	21
5-Jul-97	16	1	9	7	6	54	33	7	63	34
6-Jul-97	16	0	0	0	20	180	70	20	180	70
7-Jul-97	23	13	81	38	70	438	101	83	520	108
8-Jul-97	24	11	66	31	91	546	185	102	612	188
9-Jul-97	24	18	108	48	279	1,674	383	297	1,782	386
10-Jul-97	24	7	42	30	114	684	144	121	726	147
11-Jul-97	24	9	54	34	163	978	223	172	1,032	225
12-Jul-97	16	10	90	30	96	864	249	106	954	251
13-Jul-97	15	14	134	60	99	950	245	113	1,085	252
14-Jul-97	24	18	108	35	123	738	135	141	846	139
15-Jul-97	8	28	504	192	59	1,062	403	87	1,566	446
16-Jul-97	0	0	407	192	0	922	403	0	1,328	446
17-Jul-97	7	15	309	117	38	782	297	53	1,090	319
18-Jul-97	24	20	120	32	123	738	86	143	858	92
19-Jul-97	24	37	222	28	147	882	153	184	1,104	155
20-Jul-97	12	7	84	32	14	403	153	21	487	156
21-Jul-97	0	0	154	32	0	536	153	0	690	156
22-Jul-97	0	0	142	32	0	415	153	0	619	156
23-Jul-97	0	0	113	32	0	281	153	0	481	156
24-Jul-97	13	17	188	28	11	122	50	28	310	57
25-Jul-97	23	10	63	19	21	131	39	31	194	43
26-Jul-97	16	5	45	15	9	81	15	14	126	22
27-Jul-97	24	11	66	23	19	114	31	30	180	39
28-Jul-97	24	11	66	20	25	150	35	36	216	41
29-Jul-97	24	9	54	24	21	126	26	30	180	35
30-Jul-97	24	7	42	13	21	126	24	28	168	27
31-Jul-97	24	11	66	14	18	108	31	29	174	34
1-Aug-97	24	3	18	10	3	18	12	6	36	15
2-Aug-97	8	2	36	16	-1	-18	26	1	18	31
3-Aug-97	23	3	19	16	9	56	26	12	75	31
4-Aug-97	23	0	0	0	1	6	9	1	6	9
5-Aug-97	15	3	29	34	1	10	9	4	38	35
6-Aug-97	23	4	25	11	2	13	15	6	38	18
7-Aug-97	22	4	26	20	-1	-7	10	3	20	22
Totals	728	318	3,698	335	1,657	14,668	988	1,975	**18,514**	**1,043**

[a] Shaded cells are estimates for days with no counts and for SE, days with only one counting period or less. See Methods section for a description of how estimates for expanded count's and SE's are calculated for these days.

Table 3.-Daily counts and estimates of the number of chinook salmon passing by the counting site in the Chena River, 1997.

		Left Side			Right Side			Total		
Date	Count Periods	Count	Expanded Count	SE	Count	Expanded Count	SE	Count	Expanded Count	SE
26-Jun-97	16	0	0	0	0	0	0	0	0	0
27-Jun-97	16	4	36	10	0	0	0	4	36	10
28-Jun-97	16	0	0	0	0	0	0	0	0	0
29-Jun-97	16	0	0	0	0	0	0	0	0	0
30-Jun-97	16	1	9	5	0	0	0	1	9	5
1-Jul-97	16	4	36	17	1	9	7	5	45	17
2-Jul-97	16	4	36	23	0	0	0	4	36	23
3-Jul-97	16	6	54	26	8	72	36	14	126	27
4-Jul-97	16	3	27	10	3	27	12	6	54	11
5-Jul-97	16	1	9	7	0	0	0	1	9	7
6-Jul-97	16	8	72	34	0	0	0	8	72	34
7-Jul-97	24	84	504	218	0	0	0	84	504	218
8-Jul-97	24	92	552	211	11	66	64	103	618	211
9-Jul-97	24	37	222	145	7	42	22	44	264	145
10-Jul-97	24	57	342	73	1	6	6	58	348	73
11-Jul-97	24	53	318	130	6	36	15	59	354	130
12-Jul-97	16	93	837	189	13	117	28	106	954	189
13-Jul-97	24	144	864	195	8	48	14	152	912	195
14-Jul-97	24	195	1,170	328	19	114	43	214	1,284	328
15-Jul-97	16	72	648	98	12	108	32	84	756	98
16-Jul-97	24	280	1,680	208	52	312	45	332	1,992	208
17-Jul-97	24	154	924	198	31	186	48	185	1,110	198
18-Jul-97	24	105	630	98	14	84	29	119	714	98
19-Jul-97	24	72	432	94	11	66	27	83	498	94
20-Jul-97	24	123	738	168	14	84	20	137	822	168
21-Jul-97	24	81	486	133	25	150	32	106	636	133
22-Jul-97	24	45	270	71	11	66	17	56	336	72
23-Jul-97	24	35	210	41	8	48	16	43	258	41
24-Jul-97	24	12	72	15	6	36	14	18	108	16
25-Jul-97	16	11	99	46	4	36	23	15	135	46
26-Jul-97	16	5	45	26	3	27	10	8	72	26
27-Jul-97	24	10	60	26	1	6	8	11	66	26
28-Jul-97	24	4	24	23	5	30	14	9	54	23
29-Jul-97	24	13	78	24	1	6	6	14	84	24
30-Jul-97	22	7	46	21	0	0	0	7	46	21
31-Jul-97	24	2	12	12	0	0	8	2	12	12
1-Aug-97	24	4	24	14	1	6	6	5	30	15
2-Aug-97	16	1	9	7	0	0	0	1	9	7
3-Aug-97	16	2	18	7	1	9	9	3	27	8
Total	798	1,824	11,593	699	277	1,797	139	2,101	**13,390**	**699**

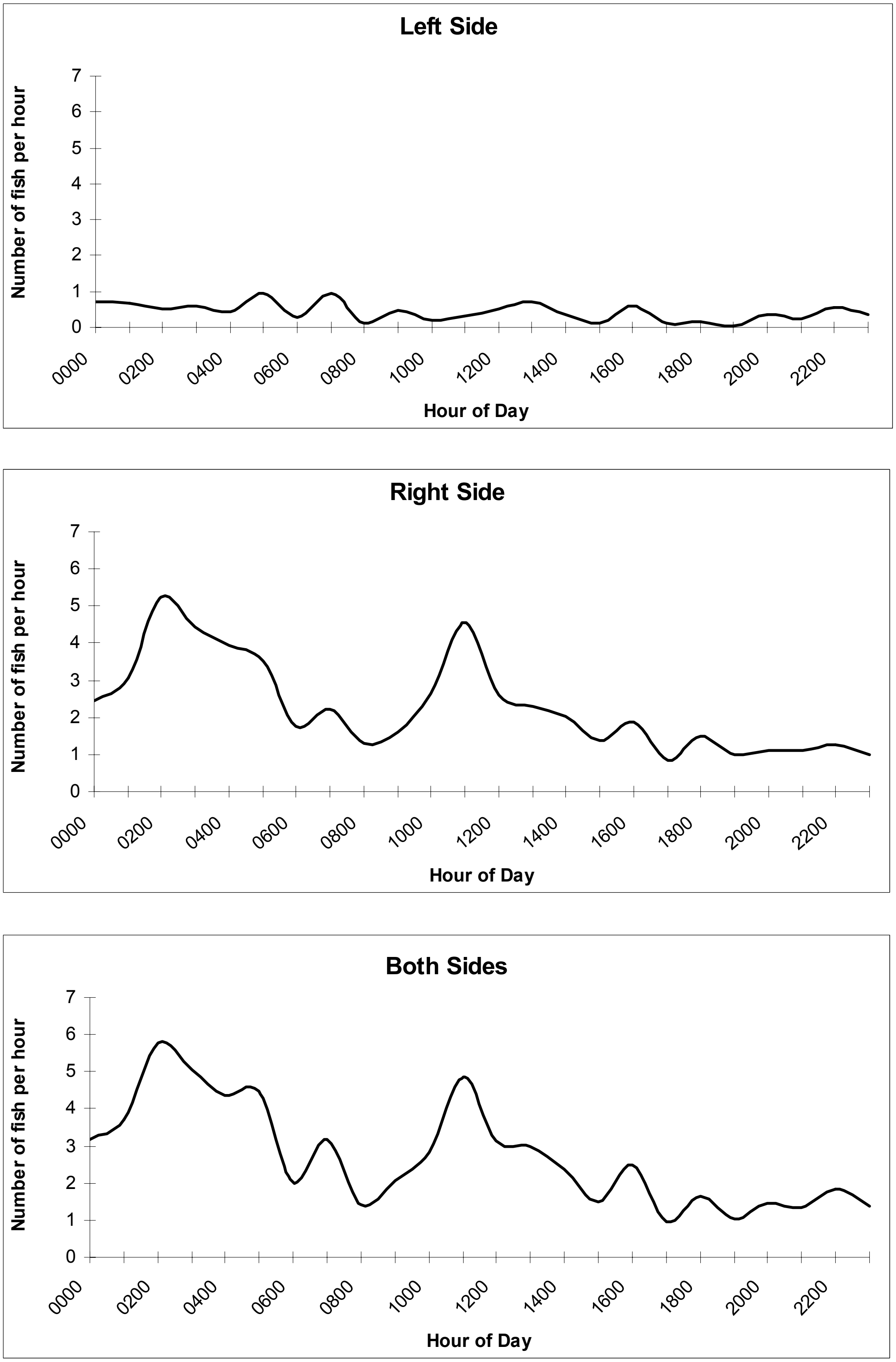


Figure 5.-Average hourly escapement of chinook salmon in the Salcha River, 1997.

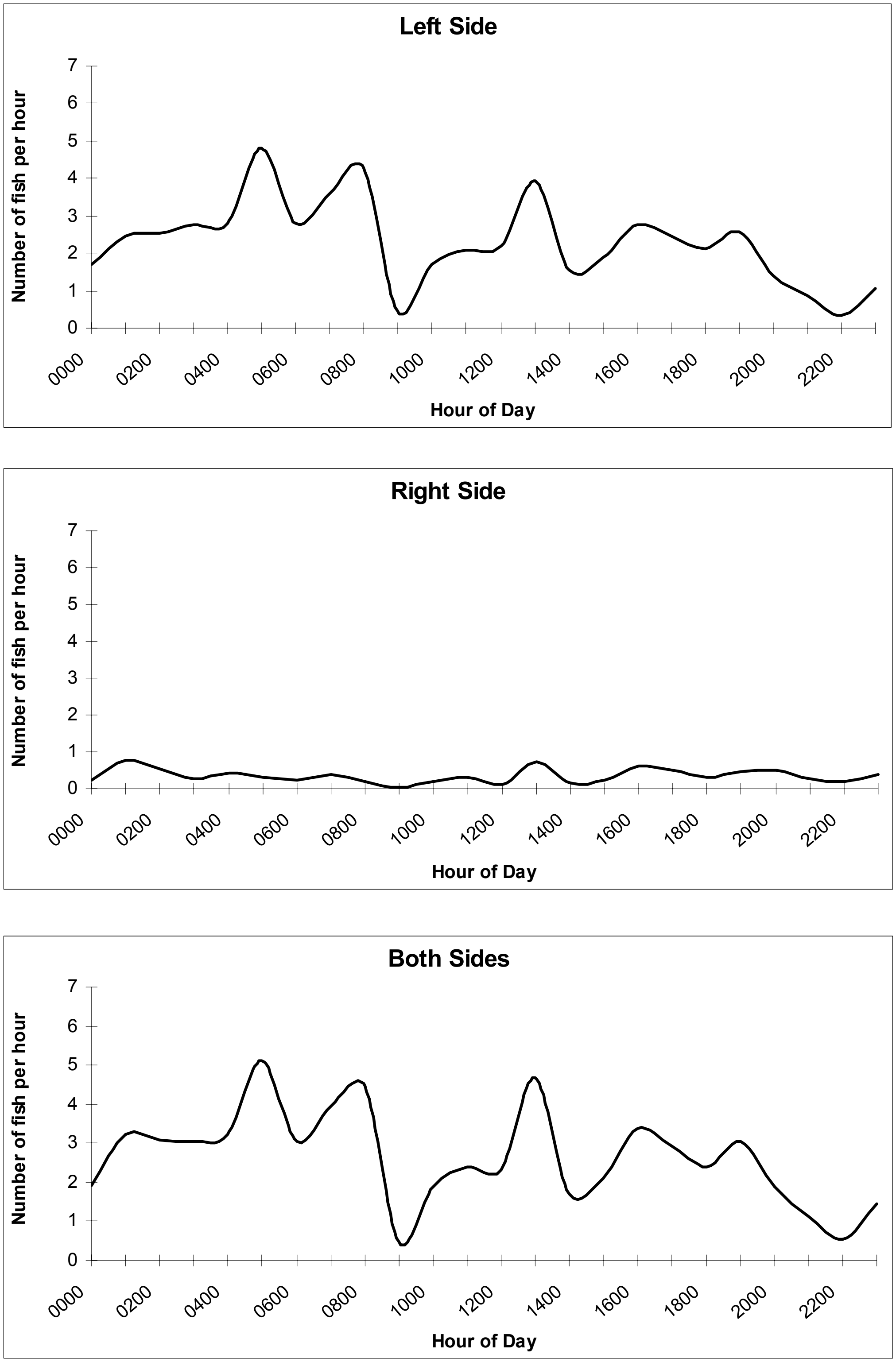


Figure 6.-Average hourly escapement of chinook salmon in the Chena River, 1997.

Table 4.-Daily counts and estimates of the number of chum salmon passing by the counting site in the Salcha River, 1997.

		Left Side			Right Side			Total		
Date	Count Periods	Count	Expanded Count[a]	SE[a]	Count	Expanded Count[a]	SE[a]	Count	Expanded Count[a]	SE[a]
26-Jun-97	16	0	0	0	0	0	0	0	0	0
27-Jun-97	16	0	0	0	0	0	0	0	0	0
28-Jun-97	16	0	0	0	0	0	0	0	0	0
29-Jun-97	16	0	0	0	1	9	7	1	9	7
30-Jun-97	16	0	0	0	0	0	0	0	0	0
1-Jul-97	16	0	0	0	0	0	0	0	0	0
2-Jul-97	16	3	27	15	2	18	14	5	45	21
3-Jul-97	16	0	0	0	0	0	0	0	0	0
4-Jul-97	16	0	0	0	0	0	0	0	0	0
5-Jul-97	16	0	0	0	0	0	0	0	0	0
6-Jul-97	16	0	0	0	1	9	7	1	9	7
7-Jul-97	23	0	0	0	0	0	0	0	0	0
8-Jul-97	24	3	18	8	1	6	6	4	24	10
9-Jul-97	24	0	0	0	8	48	14	8	48	14
10-Jul-97	24	1	6	6	5	30	14	6	36	16
11-Jul-97	24	0	0	0	1	6	6	1	6	6
12-Jul-97	16	1	9	7	4	36	29	5	45	30
13-Jul-97	15	3	29	11	8	77	36	11	106	38
14-Jul-97	24	18	108	57	13	78	21	31	186	60
15-Jul-97	8	9	162	44	11	198	53	20	360	69
16-Jul-97	0	0	133	44	0	264	89	0	396	99
17-Jul-97	7	5	103	28	16	329	89	21	432	93
18-Jul-97	24	59	354	67	95	570	88	154	924	111
19-Jul-97	24	62	372	69	91	546	76	153	918	103
20-Jul-97	12	14	168	101	14	403	109	28	571	149
21-Jul-97	0	0	509	101	0	604	109	0	1,113	162
22-Jul-97	0	0	556	176	0	625	127	0	967	217
23-Jul-97	0	0	534	176	0	606	127	0	979	207
24-Jul-97	13	103	1,141	176	81	897	127	184	2,038	217
25-Jul-97	23	94	589	91	108	676	74	202	1,265	117
26-Jul-97	16	27	243	43	48	432	71	75	675	83
27-Jul-97	24	62	372	93	60	360	77	122	732	120
28-Jul-97	24	99	594	97	258	1,548	147	357	2,142	176
29-Jul-97	24	177	1,062	187	412	2,472	234	589	3,534	299
30-Jul-97	24	203	1,218	141	435	2,610	258	638	3,828	294
31-Jul-97	24	113	678	81	326	1,956	82	439	2,634	115
1-Aug-97	24	70	420	64	247	1,482	104	317	1,902	122
2-Aug-97	8	27	486	64	75	1,350	112	102	1,836	129
3-Aug-97	23	58	363	63	206	1,290	112	264	1,653	129
4-Aug-97	23	84	526	102	224	1,402	198	308	1,928	223
5-Aug-97	15	74	710	109	121	1,162	133	195	1,872	172
6-Aug-97	23	105	657	113	165	1,033	161	270	1,690	197
7-Aug-97	22	30	196	80	98	641	64	128	838	102
Total	728	1,503	12,550	524	3,135	23,774	630	4,638	**35,948**	**819**

[a] Shaded cells are estimates for days with no counts and for SE, days with only one counting period or less. See Methods section for a description of how estimates for expanded count's and SE's are calculated for these days.

Table 5.-Daily counts and estimates of the number of chum salmon passing by the counting site in the Chena River, 1997.

		Left Side			Right Side			Total		
Date	Count Periods	Count	Expanded Count	SE	Count	Expanded Count	SE	Count	Expanded Count	SE
26-Jun-97	16	0	0	0	0	0	0	0	0	0
27-Jun-97	16	0	0	0	0	0	0	0	0	0
28-Jun-97	16	0	0	0	0	0	0	0	0	0
29-Jun-97	16	0	0	0	0	0	0	0	0	0
30-Jun-97	16	0	0	0	0	0	0	0	0	0
1-Jul-97	16	0	0	0	0	0	0	0	0	0
2-Jul-97	16	0	0	0	0	0	0	0	0	0
3-Jul-97	16	0	0	0	0	0	0	0	0	0
4-Jul-97	16	0	0	0	0	0	0	0	0	0
5-Jul-97	16	0	0	0	0	0	0	0	0	0
6-Jul-97	16	0	0	0	0	0	0	0	0	0
7-Jul-97	24	1	6	4	0	0	0	1	6	4
8-Jul-97	24	3	18	13	0	0	0	3	18	13
9-Jul-97	24	0	0	0	0	0	0	0	0	0
10-Jul-97	24	4	24	11	0	0	0	4	24	11
11-Jul-97	24	12	72	45	-1	-6	6	11	66	45
12-Jul-97	16	0	0	0	0	0	0	0	0	0
13-Jul-97	24	8	48	13	1	6	6	9	54	14
14-Jul-97	24	1	6	6	0	0	0	1	6	6
15-Jul-97	16	3	27	10	2	18	14	5	45	18
16-Jul-97	24	29	174	49	21	126	44	50	300	66
17-Jul-97	24	51	306	61	2	12	8	53	318	61
18-Jul-97	24	18	108	35	6	36	20	24	144	41
19-Jul-97	24	22	132	31	1	6	6	23	138	32
20-Jul-97	24	37	222	88	4	24	23	41	246	91
21-Jul-97	24	37	222	43	28	168	64	65	390	77
22-Jul-97	24	55	330	79	14	84	27	69	414	83
23-Jul-97	24	92	552	139	20	120	39	112	672	144
24-Jul-97	24	67	402	87	47	282	73	114	684	113
25-Jul-97	16	24	216	60	18	162	45	42	378	75
26-Jul-97	16	23	207	42	12	108	46	35	315	63
27-Jul-97	24	73	438	103	14	84	33	87	522	108
28-Jul-97	24	49	294	78	41	246	121	90	540	144
29-Jul-97	24	143	858	282	34	204	70	177	1,062	291
30-Jul-97	22	115	753	211	25	164	55	140	916	218
31-Jul-97	24	58	348	179	52	312	138	110	660	226
1-Aug-97	24	42	252	95	24	144	112	66	396	147
2-Aug-97	16	21	189	93	31	279	86	52	468	127
3-Aug-97	16	62	558	113	11	99	55	73	657	126
Total	798	1,050	6,762	512	407	2,678	291	1,457	**9,439**	**589**

and larger for the left side of the Chena River (Appendices D5-D8). Similar to chinook salmon, no distinct diurnal pattern could be seen for either river, although the highest passage tended to be during the very early and late hours (Figures 7 and 8).

Salcha River Chinook Salmon Studies

Total escapement was estimated solely by tower counts. Two hundred eighteen carcasses were collected and examined. The sex composition for this sample was 0.52 (SE=0.03) males and 0.48 (SE=0.03) females. Ages were determined for 0.83 of the sample. The dominant age class for males and especially for females was 1.4 at proportions of 0.49 and 0.90, respectively (Table 6). Males were also represented by ages 1.2 (26%), 1.3 (24%), and 1.5 (1%). Lengths of males varied from 510 to 1,065 mm (Figure 9). Lengths of females varied from 775 to 995 mm.

Chena River Chinook Salmon Studies

A total of 1,032 chinook were captured, tagged, measured and released during the marking event. During the recapture event, 878 carcasses were collected and measured with scales collected for later aging. All carcasses were examined for tags and secondary marks (Table 7). Ninety-two tags were recovered. No marked fish had lost jaw tags.

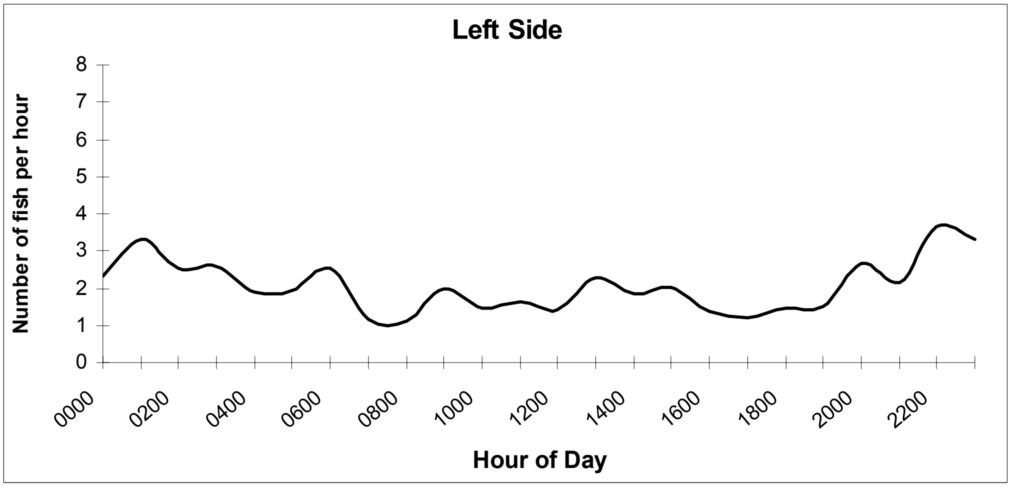
The following results were based on data from the mark-recapture experiment to test the hypotheses of equal probability of capture by sex, length, and river area during at least one sampling event (described in Appendix B).

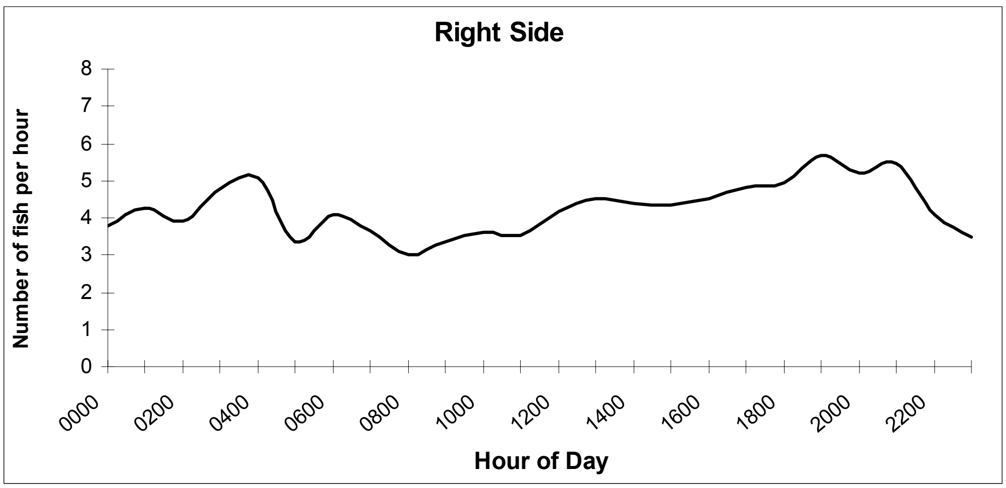
Equal Probability of Capture by Sex

Recapture rates for males (0.06) and females (0.15) differed significantly (χ^2=19.91, 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 (χ^2=3.15, df=1, P=0.08; Table 9) for both males and females.

Equal Probability of Capture by Length

Length distributions of all marked releases and all recaptures obtained during the carcass survey were dissimilar (DN=0.17; P=0.02), as were the length distributions of all marked fish and the length distribution of all fish captured during the carcass survey (DN=0.14; P<0.01; Figure 10). Due to the differences in recapture rates between males and females, Kolmogorov-Smirnov (KS) two sample tests were performed on males and females separately. The length distribution of marked fish were similar to those captured during the carcass survey for both males and females (DN=0.07, P=0.11 for males; DN=0.08, P=0.21 for females). However, length distributions of marked releases and all recaptures obtained during the carcass survey were similar for males (DN=0.11; P=0.68) but dissimilar for females (DN=0.31; P<0.01; Figure 11). These tests indicated size-selective sampling for females during the recapture event. The length categories of 675-875 mm and greater than 875 mm were chosen for further stratification in order to reduce bias. These categories were selected based on results from a battery of contingency table tests of marked to recaptured ratios with varying break points.





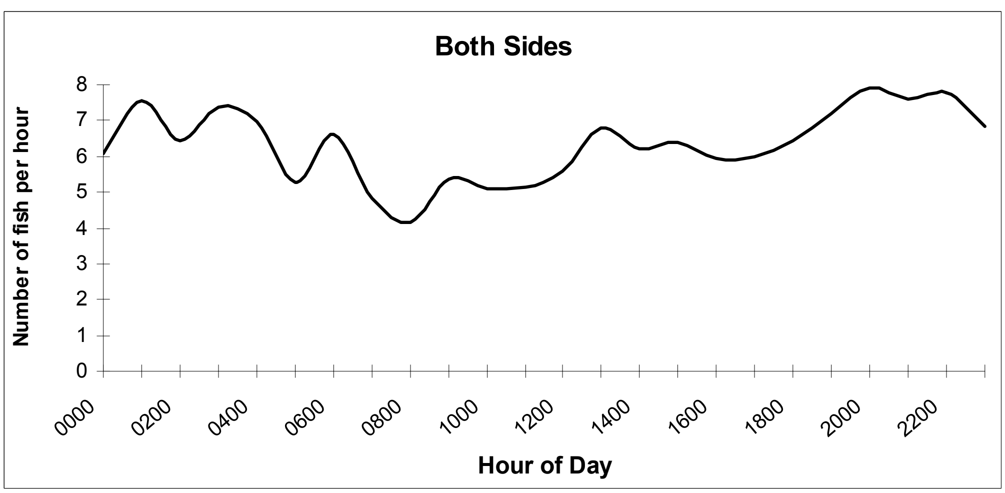
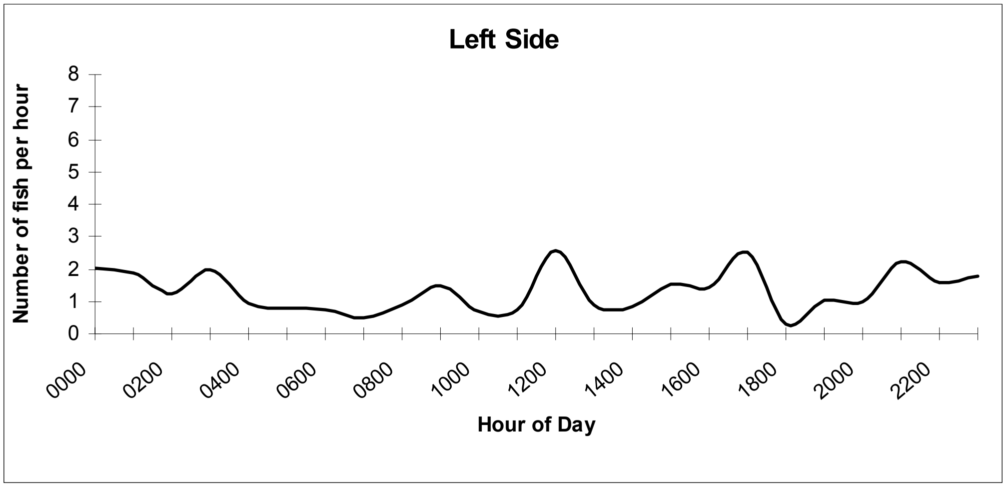
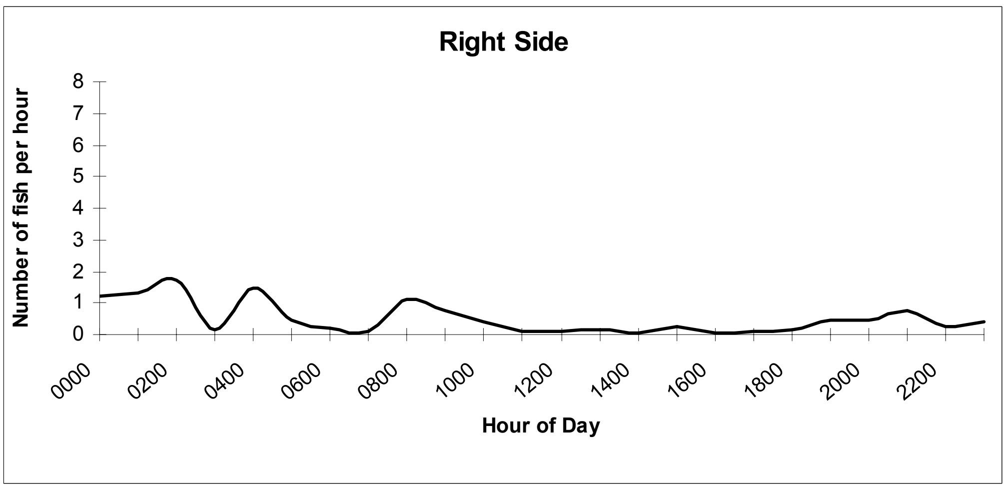


Figure 7.-Average hourly escapement of chum salmon in the Salcha River, 1997.





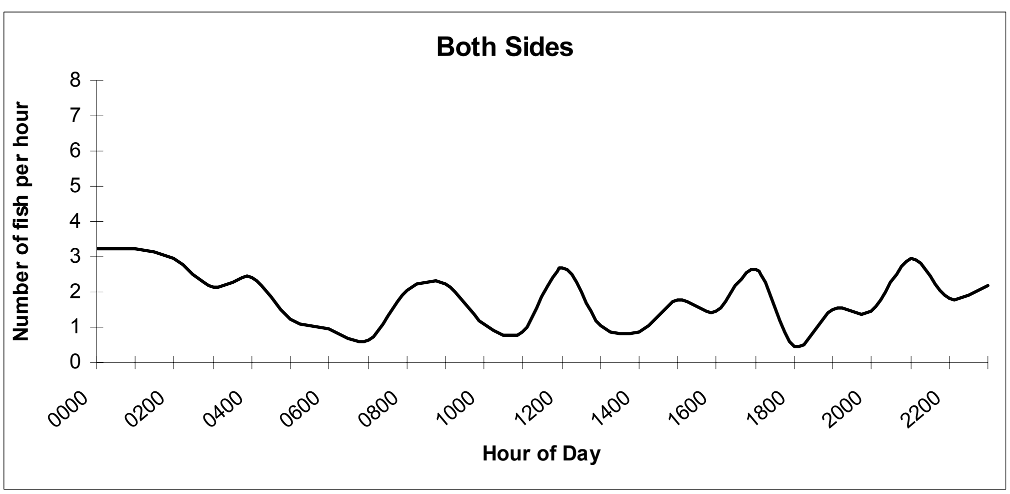


Figure 8.-Average hourly escapement of chum salmon in the Chena River, 1997.

Table 6.-Estimated proportions and mean length by age class of male and female chinook salmon in the Salcha River, 1997.

	Age[a]	Sample Size	Proportion	SE	Length Mean	Length SE	Length Min	Length Max
Male	1.2	23	0.26	0.05	590	13	510	770
	1.3	22	0.24	0.05	724	20	580	930
	1.4	44	0.49	0.05	876	13	685	1,065
	1.5	1	0.01	0.01	915		915	915
	Total	90	1.00					
Total[b]		113	0.52[c]	0.03[c]	762	13	510	1,065
Female								
	1.2	3	0.03	0.02	858	6	850	870
	1.3	4	0.04	0.02	860	22	815	905
	1.4	81	0.90	0.03	880	5	775	995
	1.5	2	0.02	0.02	833	23	810	855
	Total	90	1.00					
Total[b]		105	0.48[c]	0.03[c]	875	4	755	995

[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

[b] Totals include those chinook salmon which could not be aged.

[c] Proportion and corresponding SE are based on total number (218) of carcasses sampled.

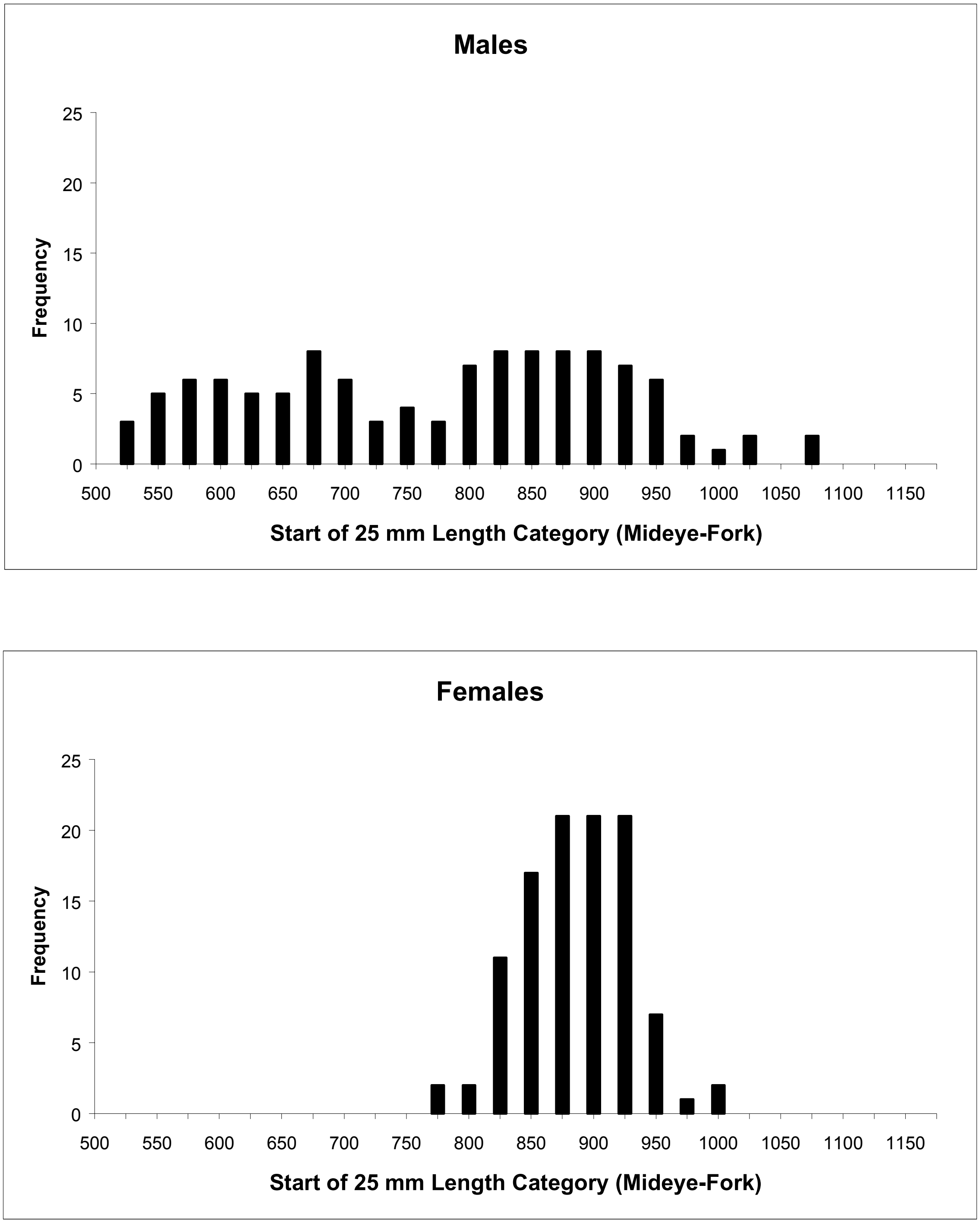


Figure 9.-Length frequency distributions of male and female chinook salmon carcasses sampled on the Salcha River, 1997.

Table 7.-Summary of capture histories of chinook salmon caught during the mark-recapture experiment in the Chena River, 1997.

	Section Tagged	Section Recaptured		Total Recaptured	Number not Recaptured	Total Marked
		Upper	Lower			
	Upper	75	1	76	707	783
Total	Lower	1	15	16	233	249
Fish[a]	Total	76	16	92	940	1,032
	Unmarked Carcasses	664	122	786	Total Number of Unique Fish Examined	
					1,818	
	Total Carcasses	740	138	878		

	Section Tagged	Section Recaptured		Total Recaptured	Number not Recaptured	Total Marked
		Upper	Lower			
	Upper	41	0	41	534	575
	Lower	0	6	6	153	159
Males	Total	41	6	47	687	734
	Unmarked Carcasses	416	61	477	Total Number of Unique Fish Examined	
					1,211	
	Total Carcasses	457	67	524		

	Section Tagged	Section Recaptured		Total Recaptured	Number not Recaptured	Total Marked
		Upper	Lower			
	Upper	34	1	35	172	207
	Lower	3	7	10	80	90
Females	Total	37	8	45	252	297
	Unmarked Carcasses	246	63	309	Total Number of Unique Fish Examined	
					606	
	Total Carcasses	283	71	354		

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

Table 8.-Contingency table analysis of recapture rates of male and female chinook salmon caught during the mark-recapture experiment in the Chena River, 1997.

	Male	Female	Total
Recaptured	47	45	92
Not Recaptured	687	252	939
Total	734	297	1031
Recapture Rate	0.06	0.15	0.09

$\chi^2 = 19.91$; 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 Chena River, 1997.

	Male	Female	Total
Marked	47	45	92
Unmarked	477	309	786
Total	524	354	878
Marked:Unmarked	0.09	0.13	0.10

$\chi^2 = 3.15$, df = 1; $P = 0.08$

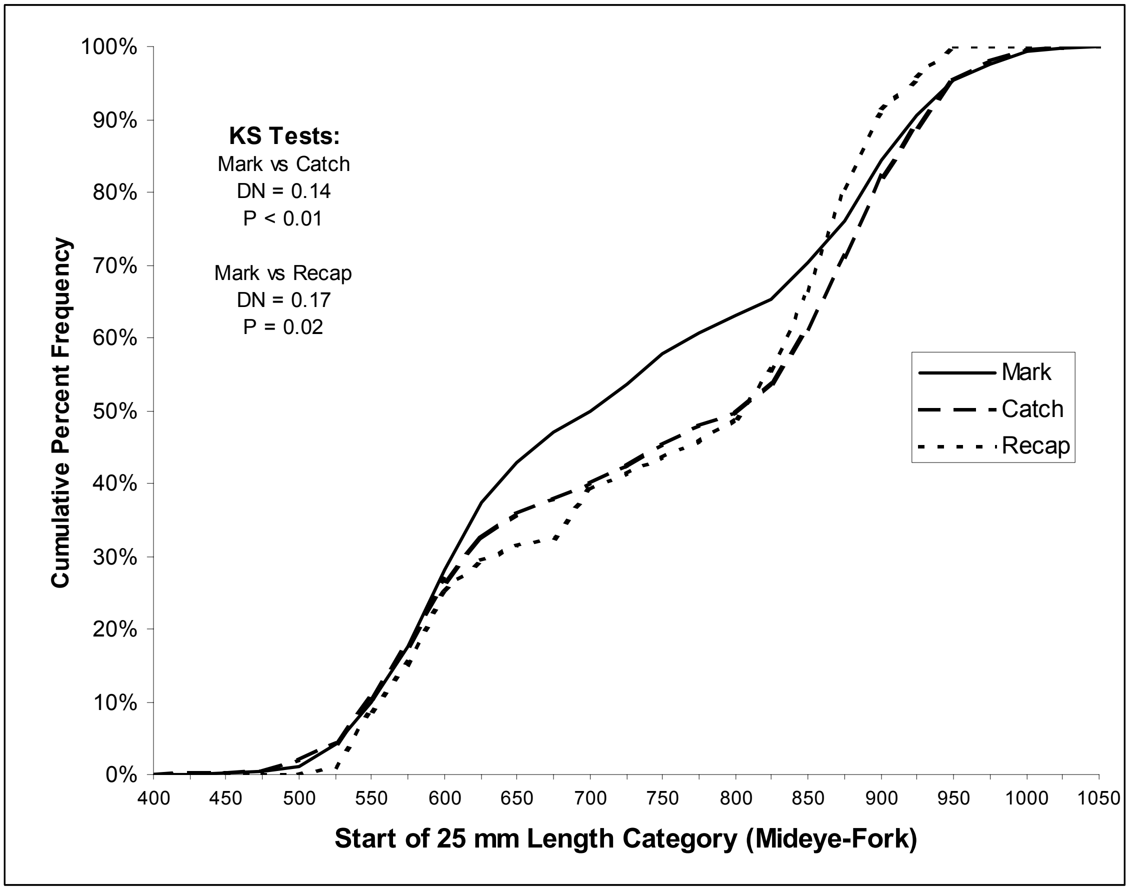
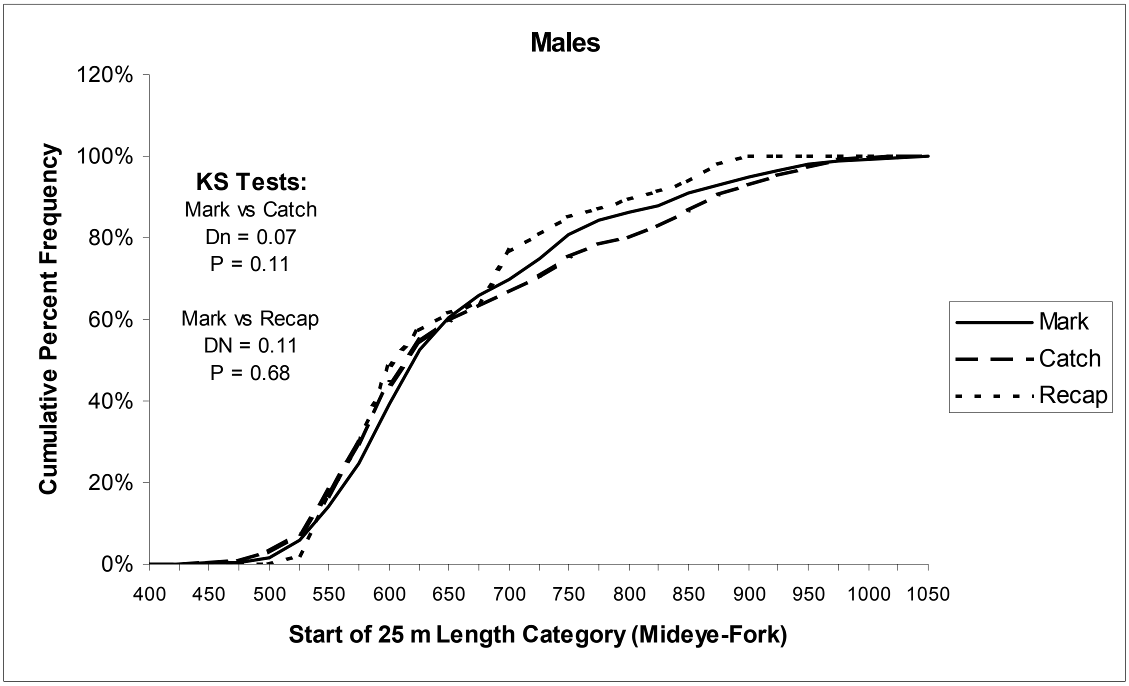


Figure 10.-Cumulative length frequency distributions comparing all chinook salmon caught during the first (Mark) and second (Catch) events, and all recaptured (Recap) fish caught during the second event from the mark-recapture experiment in the Chena River, 1997.



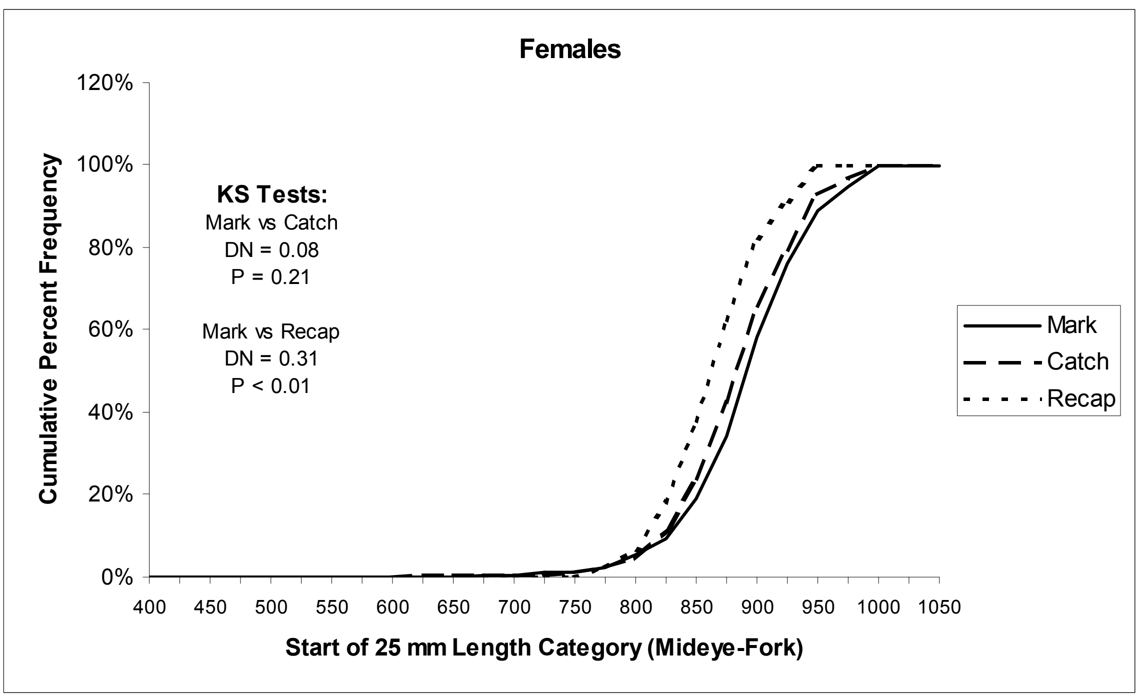


Figure 11.-Cumulative length frequency distributions comparing male and female chinook salmon sampled during the first event (Mark) to those sampled during the second event (Catch) and recaptured fish (Recap) from the mark-recapture experiment in the Chena River, 1997.

Equal Probability of Capture by River Area

The results of the chi-square tests of consistency validated the use of the Petersen estimator and ruled out the need for geographic stratification. The recaptured to not recaptured (χ^2=2.52, df=1, P=0.11) and marked to unmarked (χ^2=0.22, df=1, P=0.64; Table 10) ratios of chinook salmon were similar for the upper and lower portions of the Chena River. Movement probabilities were dissimilar between the two sections (χ^2=64.19, df=2, P<0.01). Geographic stratification is only necessary when all three test statistics are significant (Appendix B).

Abundance Estimate

Based on the results of the preceding tests, the Petersen estimator (Chapman 1951) stratified into three categories, all males, small (675-875 mm) females, and large (>875 mm) females, was used to estimate abundance. Estimated abundance for male chinook salmon was 8,038 (SE=1,058) for small females was 530 (SE=74), and for large females was 2,242 (SE=469). Estimated abundance of all females was 2,772 (SE=543). Total abundance was estimated to be 10,811 (SE=1,160).

Tower vs. Mark-Recapture Estimates

For the Chena River chinook salmon, a z-test was used to test the hypothesis that the abundance estimated from the tower count is similar to that estimated by the mark-recapture experiment. The test failed to reject the hypothesis (z=1.904; P=0.06).

Age-Sex-Length Compositions

Due to the differences in length distributions between the two sampling events, the adjusted length and age distributions from the carcass survey were considered unbiased and used for composition estimates. Sex composition from the marking event was 0.71 males and 0.29 females, while sex composition from the recapture event was 0.60 males and 0.40 females (Table 11). The adjusted sex composition based on mark-recapture abundance estimates was 0.74 males and 0.26 females (SE=0.04 for both estimates). Approximately 0.80 of the recapture sample were aged. The mark-recapture experiment showed unequal probabilities of capture between males and females and varying probabilities of capture by length within females. These biases were taken into account in calculating abundance and mean length by age for various age classes (Table 11). Males were most represented by age 1.2 (61%) and to a much lesser degree by ages 1.3 (18%) and 1.4 (20%). One male chinook salmon was aged at 2.4. The primary age class for females of all size classes was 1.4 (93%). Lengths were obtained from all sampled carcasses. Males ranged from 410-1,030 mm and females from 625-1,005 mm.

Aerial Surveys for Salcha and Chena Rivers

The 1 August peak aerial survey counted 3,458 chinook salmon for the Salcha River. Visibility was poor. This count represented about 0.19 of the abundance estimated by the tower counts. The peak Chena River aerial survey was conducted on 18 July and counted 3,495 chinook salmon. Visibility for the Chena River was good to fair. The Chena River count represented 0.32 of the mark-recapture estimate and 0.26 of the tower counts. Since 1986, the proportion of the population observed during aerial surveys has ranged from 0.19 to 0.71 of tower/mark-

Table 10.-Chi-square tests of consistency[a] for the Petersen estimator of chinook salmon sampled in the Chena River, 1997.

	First Event	Second Event: River Section Upper	Lower	Not Recaptured	
TEST I[b]	Upper	75	1	707	
	Lower	1	15	233	
					$\chi^2 = 64.19$; df = 2; $P < 0.01$

		River Section Where Marked: Upper	Lower	
TEST II[c]	Recaptured	76	16	
	Not Recaptured	706	233	
				$\chi^2 = 2.52$; df = 1; $P = 0.11$

		River Section During Recapture Event: Upper	Lower	
TEST III[d]	Marked	76	16	
	Unmarked	664	122	
				$\chi^2 = 0.22$; df = 1; $P = 0.64$

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 two 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 applies to unmarked salmon only.

Table 11.-Estimated proportions and mean length by age class of male and female chinook salmon in the Chena River, 1997.

	Age[a]	Sample Size	Proportion	SE	Abundance	SE	Length Mean	Length SE	Length Min	Length Max
	1.1	2	<0.01	<0.01	38	27	475	25	450	500
Male	1.2	259	0.61	0.02	4,910	674	579	3	460	770
	1.3	78	0.18	0.02	1,479	247	754	9	565	980
	1.4	83	0.20	0.02	1,573	259	849	11	490	1,030
	1.5	1	<0.01	<0.01	19	19	965		965	965
	2.4	1	<0.01	<0.01	19	19	885		885	885
	Total	424	1.00							
Total[b]		524	0.60[f]	0.04[f]	8,038[c]	1,058[c]	410	6	410	1,030

	Age[a]	Sample Size (mm) (625-875)	Sample Size (mm) (> 875)	Proportion (625-875)	Proportion (> 875)	SE (625-875)	SE (> 875)	Abundance[d]	SE[d]	Length Mean[e]	Length SE[e]	Length Min	Length Max
	1.2	1	1	0.01	0.01	0.01	0.01	19	14	765	.	625	905
Female[d]	1.3	11	5	0.10	0.03	0.03	0.01	119	37	857	42	765	985
	1.4	100	154	0.88	0.94	0.03	0.02	2,570	447	888	28	725	1,005
	1.5	2	4	0.02	0.02	0.01	0.01	64	30	901	26	855	950
	Total	114	164	1.00	1.00								
Total[b]		150	204	0.40[f]	0.04[f]			2,772[c]	543[c]	885	50	625	1,005

[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).

[b] The totals represent all chinook salmon for which gender was determined including those which could not be aged.

[c] The total abundance and its associated SE are Chapman estimates from the stratified sample.

[d] Female chinook salmon are stratified by size class. The abundance and SE represent all female size classes and were calculated from the stratified sample according to Bernard and Hansen (1992).

[e] Mean and SE estimates were weighted by sample sizes in each length strata.

[f] Proportion and corresponding SE are based on total number (878) of carcasses sampled. Values pertain to all size classes.

recapture estimates and averaged 0.43 for the Salcha River. For the Chena River, aerial surveys have ranged from 0.13 to 0.59 of tower/mark-recapture estimates and averaged 0.30 (Table 12).

Chatanika River Chinook Salmon Studies

From 1980-1994, chinook salmon abundance was assessed with aerial or boat counts (Table 13). This summer a mark-recapture estimate was performed in order to acquire a more accurate estimate of total escapement. A total of 149 fish were captured, tagged, and released. During the recapture event, 159 fish were examined for tags and secondary marks. Only 6 recaptures were recorded. No marked fish had lost jaw tags.

All tests to validate use of the Petersen estimator were performed similar to that used for Chena River chinook salmon (Appendix B). Due to the low number of recaptures, the tests for consistency were considered invalid (Table 14).

Equal probability of capture by sex

Recapture rates for males and females differed significantly (χ^2=4.28, df=1, *P*=0.04; Table 15). However, the marked-unmarked ratios of males to females sampled during the second event did not significantly differ (χ^2=1.25, df=1, *P*=0.26; Table 16). Only three males and three females were recaptured during the second event.

Equal probability of capture by length

Length distributions between the mark and recapture events were similar (DN=0.11, *P*=0.27; Figure 12). A reliable comparison could not be made between marked and recaptured fish due to the low numbers of recaptured fish. Length distributions between the two sampling events with respect to sex were dissimilar (DN=0.19, *P*=0.03 for males and DN=0.36, *P*=0.03 for females; Figure 13).

Abundance Estimate

Based on the above tests, the Petersen estimator (Chapman 1951) stratified by sex was used to estimate abundance. No further stratification was attempted despite apparent differences in length distributions between the two events with respect to sex. Estimated abundance of male chinook salmon was 3,474 (SE=1,501) and was 335 (SE=133) for females. Total abundance was 3,809 (SE=1,507).

Age-Sex-Length Compositions

A total of 302 chinook salmon were captured, measured, sex determined and a scale taken for later aging during both events. Eight nine percent were aged and gender determined for all fish (Table 17). Of the fish examined, 0.76 were male and 0.24 were female. The adjusted sex compositions based on mark-recapture experiments were 0.91 males and 0.09 females (SE=0.05 for both estimates). The majority of males examined were age 1.2 (75%) and to a much lesser degree, 1.3 (16%). Females were typically older with the majority at age 1.4 (80%) and to a lesser degree, 1.3 (15%). Male lengths varied from 485-940 mm. Female lengths showed less of a spread and varied from 590-995 mm.

DISCUSSION

Tower count methodology has been used for five consecutive years as a means of estimating abundance for the Salcha and Chena rivers. Tower counts offer a few advantages over mark-recapture techniques and aerial surveys. For one, tower counts are an on-going process

Table 12.-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	 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
1997	18,514[f]	1,043	3,458	Poor	0.19
					Avg=0.43
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
1997	10,811[c]	1,160	3,495	Fair-Good	0.32
1997	13,390[f]	699	3,495	Fair-Good	0.26
					Avg=0.30

[a] Details of estimates can be found in Barton (1987a and 1988); Barton and Conrad (1989); Burkholder (1991); Evenson (1991-1993; 1995-1996); Evenson and Stuby (1997); 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.

Table 13.-Aerial survey counts, boat counts, abundance estimates, and sport harvest and catch estimates of chinook salmon in the Chatanika River, 1980-1997.

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
1997	M-R[i]	NE	NE	NE	3,809		NE	NE

[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. (1995-1997).

[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.

[i] Estimate was obtained from a mark-recapture experiment.

Table 14.-Summary of capture histories of chinook salmon caught during the mark-recapture experiment in the Chatanika River, 1997.

	Section Tagged	Section Recaptured Area 1	Area 2	Area 3	Total Recaptured	Number not Recaptured	Total Marked
	Area 1	0	4	2	6	143	149
	Area 2	0	0	0	0	0	0
Total	Area 3	0	0	0	0	0	0
Fish	Total	0	4	2	6	143	149
	Unmarked	5	100	48	153	Total Number of unique fish Examined	
	Total	5	104	50	159	302	

	Section Tagged	Section Recaptured Area 1	Area 2	Area 3	Total Recaptured	Number not Recaptured	Total Marked
	Area 1	0	1	2	3	119	122
	Area 2	0	0	0	0	0	0
Male	Area 3	0	0	0	0	0	0
Fish	Total	0	1	2	3	119	122
	Unmarked	5	69	35	109	Total Number of Unique Fish Examined	
	Total	5	70	37	112	231	

	Section Tagged	Section Recaptured Area 1	Area 2	Area 3	Total Recaptured	Number not Recaptured	Total Marked
	Area 1	0	3	0	3	24	27
	Area 2	0	0	0	0	0	0
Female	Area 3	0	0	0	0	0	0
Fish	Total	0	3	0	3	24	27
	Unmarked	0	31	13	44	Total Number of Unique Fish Examined	
	Total	0	34	13	47	71	

Table 15.-Contingency table analysis of recapture rates of male and female chinook salmon caught during the mark-recapture experiment in the Chatanika River, 1997.

	Male	Female	Total
Recaptured	3	3	6
Not Recaptured	119	24	143
Total	122	27	149
Recapture Rate	0.02	0.11	0.04

$\chi^2 = 4.28$, df = 1; $P = 0.04$

Table 16.-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 Chatanika River, 1997.

	Male	Female	Total
Marked	3	3	6
Unmarked	109	44	153
Total	112	47	159
Marked:Unmarked	0.03	0.06	0.04

$\chi^2 = 1.25$, df = 1; $P = 0.26$

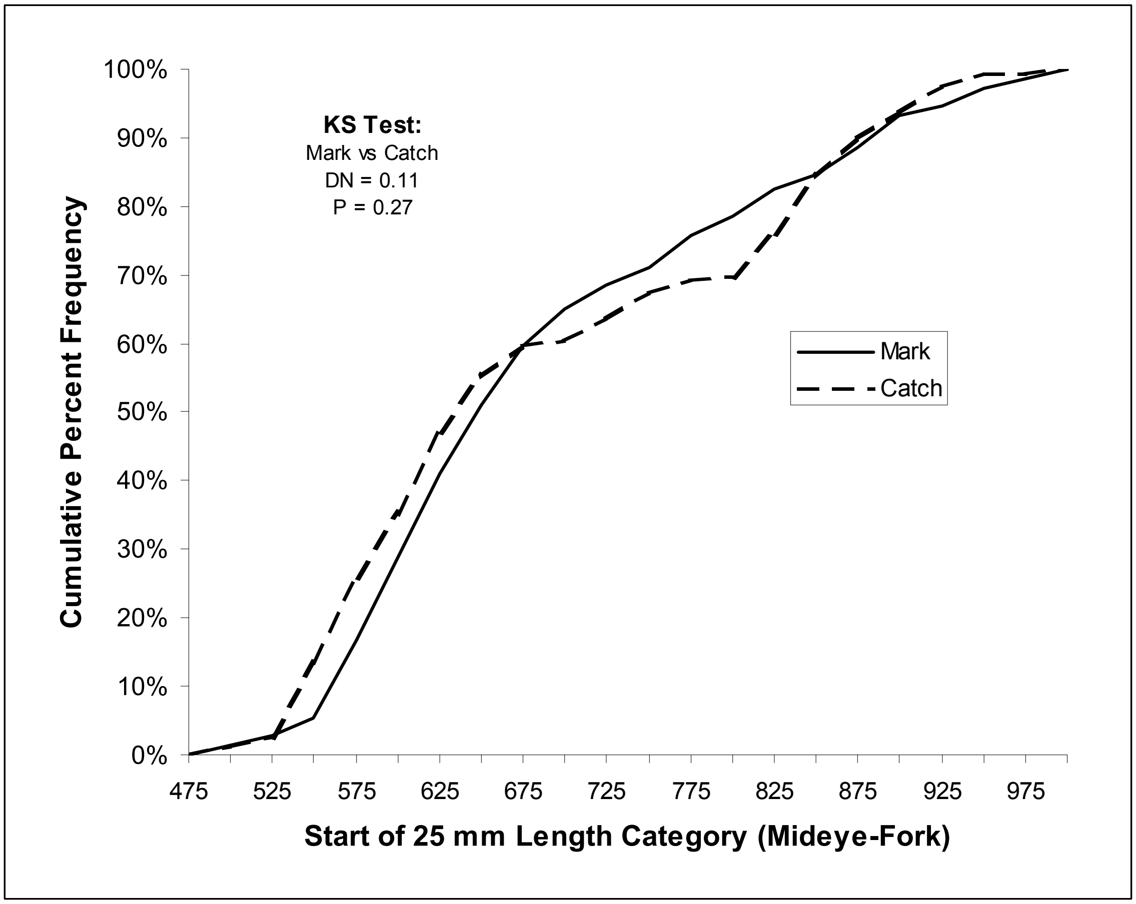
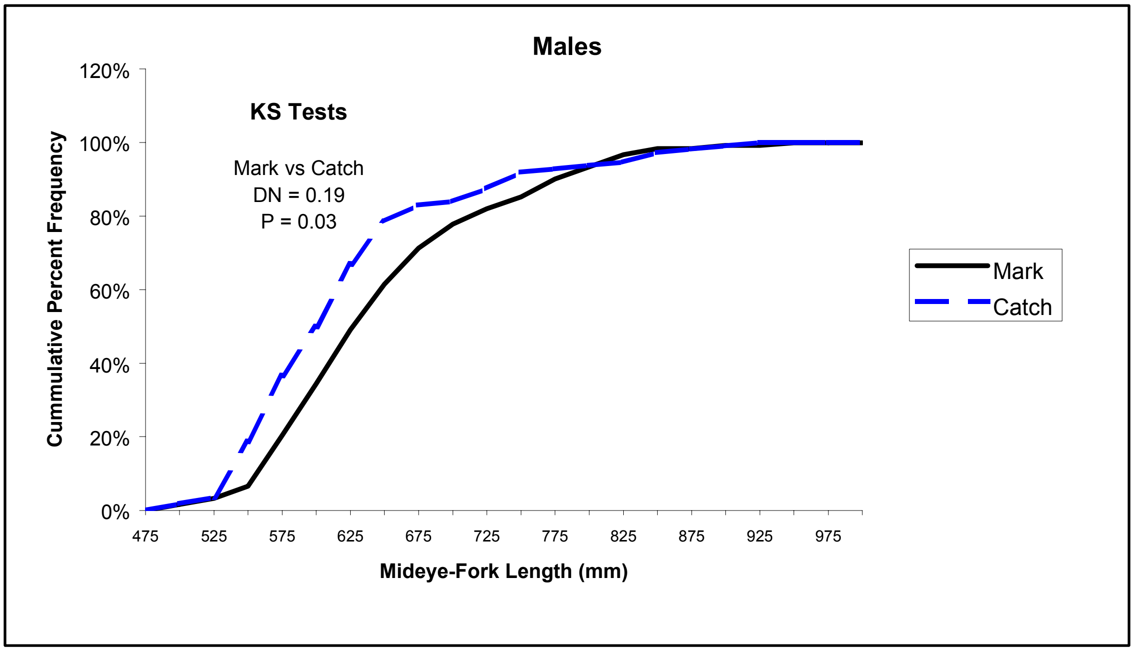


Figure 12.-Cumulative length frequency distributions comparing all chinook salmon caught during the first event (Mark) to all caught during the second event (Catch) from the mark-recapture experiment in the Chatanika River, 1997.



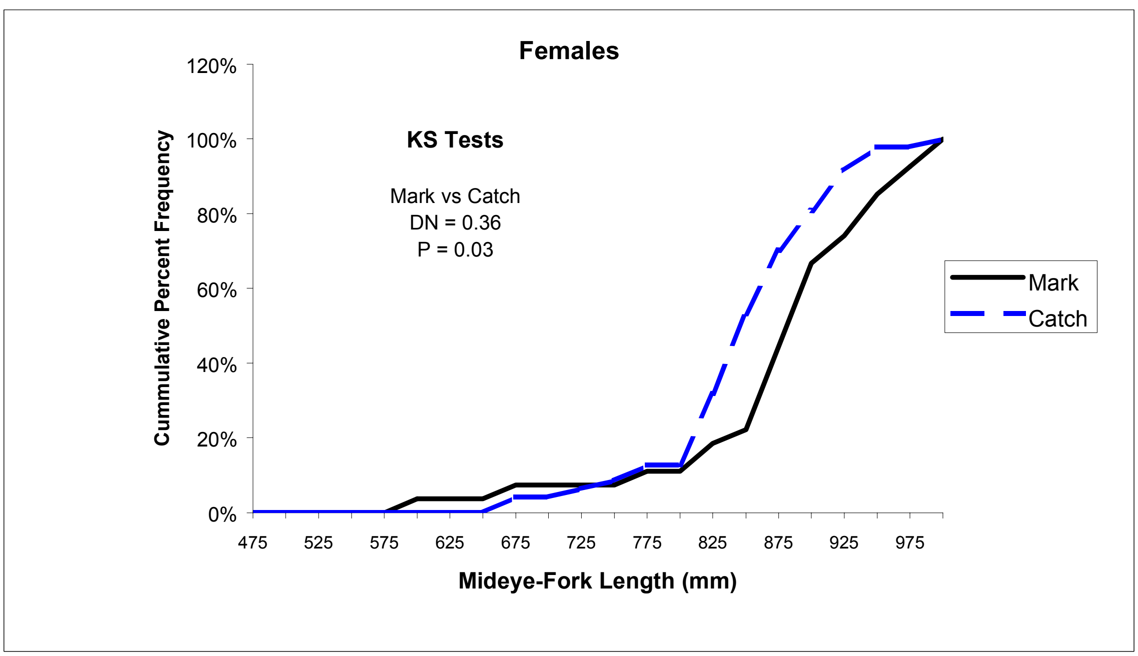


Figure 13.-Cumulative length frequency distributions comparing male and female chinook sampled during the first event (Mark) to those sampled during the second event (Catch) from the mark-recapture event on the Chatanika River, 1997.

Table 17-Estimated proportions and mean length by age class of male and female chinook salmon in the Chatanika River, 1997.

	Age[a]	Sample Size	Proportion	SE	Abundance	SE	Length Mean	Length SE	Length Min	Length Max
Male	1.2	153	0.75	0.03	2,606	1,131	596	3	485	690
	1.3	32	0.16	0.03	545	252	712	10	575	810
	1.4	19	0.09	0.02	324	157	826	13	735	940
	Total	204	1.00							
Total[b]		231	0.76[d]	0.03[d]	3,474[c]	1,501[c]	635	6	485	940

	Age[a]	Sample Size	Proportion	SE	Abundance	SE	Length Mean	Length SE	Length Min	Length Max
Female	1.2	1	0.02	0.02	5	5	590		590	590
	1.3	10	0.15	0.04	51	25	793	28	665	965
	1.4	53	0.80	0.05	269	108	862	8	675	980
	1.5	2	0.03	0.02	10	8	988	8	855	950
	Total	66	1.00							
Total[b]		71	0.24[d]	0.03[d]	335[c]	133[c]	855	9	590	995

[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).

[b] The totals represent all chinook salmon for which gender was determined including those which could not be aged.

[c] The total abundance and its associated SE are Chapman estimates from the stratified sample.

[d] Proportion and corresponding SE are based on total number (302) of carcasses sampled.

throughout the salmon run. Thus, they provide in-season information that can be used by fishery managers to help regulate harvest on the fishery. Based on tower counts, the sport fishing bag limit was increased by emergency order regulation from one to two chinook salmon per day in 1993 and 1994 as a result of large, early escapements. Aerial surveys do offer managers the ability to manage in-season and are usually less expensive than tower counts. Aerial counts are conducted during peak escapements. However aerial surveys are dependent on weather and water visibility, and do not appear to provide a consistent index of abundance. Also, aerial survey estimates tend to be much lower than both tower and mark-recapture estimates, even with good visibility.

The precision of the estimates obtained from the tower counts has been substantially better than the precision of mark-recapture estimates obtained from prior years. However, this precision may be misleading. The variance estimator assumes that during a count all salmon that pass over the panels are correctly identified and counted. Counting errors have been apparent during past tower count estimates. During the 1996 season, duplicate counts with two counters showed small discrepancies between counters (Evenson and Stuby 1997). Although these discrepancies appear to be slight in magnitude, the cumulative effect on the overall estimates of abundance and variance may be significant over time. Some of the errors may result from poor visibility as a result of adverse weather and/or water conditions, fish passing through a poorly illuminated portion of the panels, more than one group passing at a time, counter fatigue during the late evening/early morning shifts, and different experience levels of the counters in differentiating chum from chinook salmon. The bias resulting from fish not seen passing over the panels is negative and therefore makes the estimates conservative. The extent of the counting errors is unknown and could potentially over or under-bias the estimate. Another drawback to 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 the detection and possible correction of these biases. The past 13 mark-recapture experiments in the Salcha and Chena rivers have shown that size and sex composition estimates were biased during four experiments. For example, during 1992, size composition was biased, however this 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. High water events persisting for more than two days add a great deal of uncertainty to the estimate, especially during peak portions of the runs. Four days of counting were missed on the Salcha River due to high, murky water. In addition, for three days only one counting shift was conducted due to poor visibility. However, water conditions were good for the Chena River throughout the run. Over the years, of the ten total attempted tower count estimates performed for the Chena and Salcha rivers, seven have been successful. Yet, in years when a total estimate of escapement cannot be estimated from tower counts, the daily 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. The marking event occurs late into the run at the end of the chinook fishery.

Without the tower counts, managers would have to rely on aerial survey estimates to provide in-season escapement information. Also, in order for the experiment to be successful, a large sample relative to population size needs to be examined. For the Chatanika River study, insufficient sample size and the need to stratify by sex led to a fairly high coefficient of variation.

Mark-recapture experiments likely do not provide a total estimate of escapement for the Chena and Salcha rivers because spawning occurs in areas upstream from the upper boundaries of the study areas, whereas tower estimates are considered total estimates. Although the Chena River tower count estimate for total escapement of chinook salmon was 24% higher than the mark-recapture estimate, the difference was not significant given the precision for each estimate. At these levels of precision, we could have detected a difference of 34% or higher (α=0.05). Without a dramatic increase in sampling intensity of one or both experiments it is unlikely that a significant difference between the two estimates can be detected.

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 14). 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 -1997; Table 18). 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 riverboat. In recent years aerial surveys have been conducted to estimate escapement into non-boatable portions of the river (Table 18). 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 biological 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. The objectives of the coho salmon escapement project for the Delta Clearwater River in 1997 were:

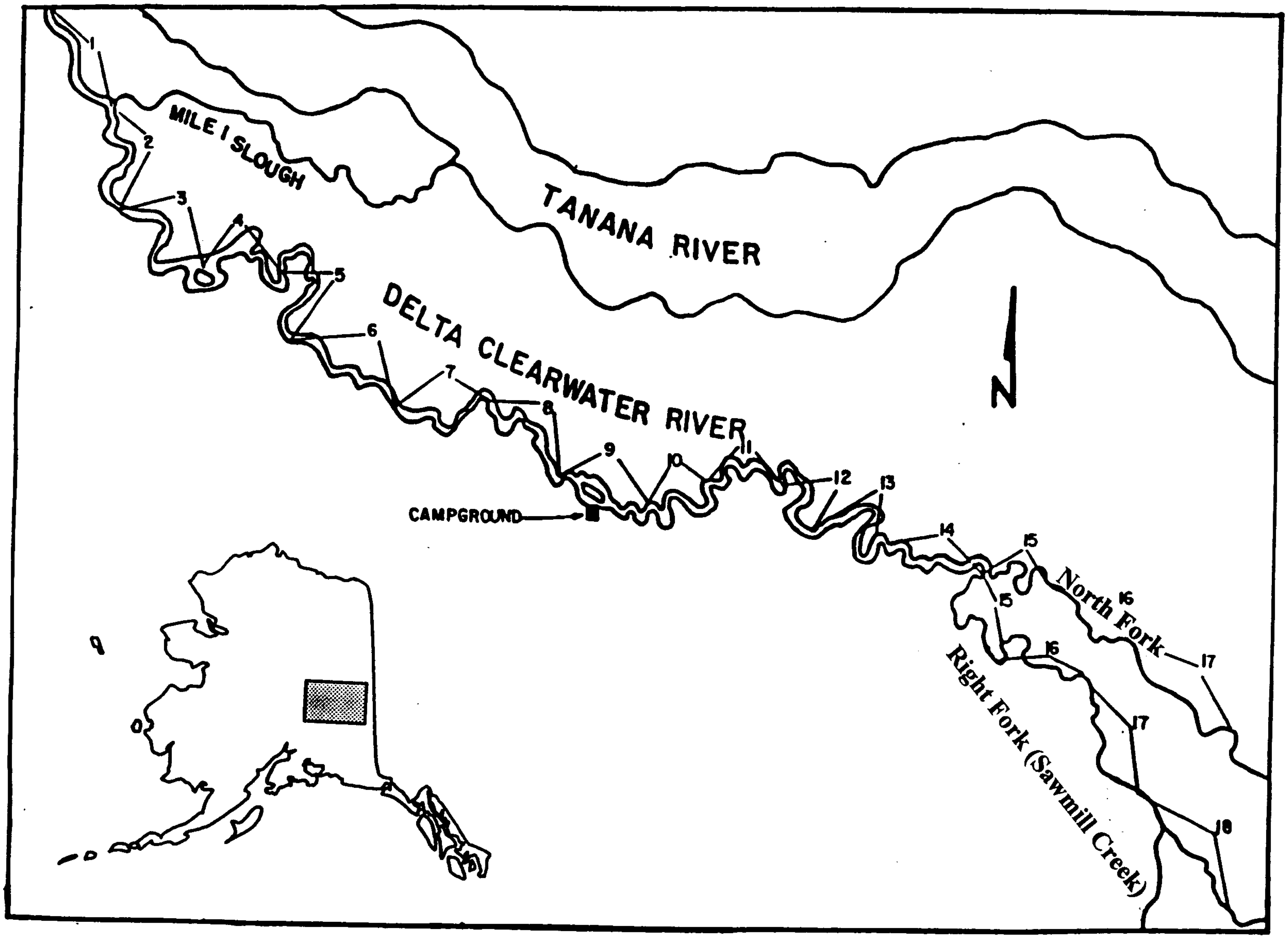


Figure 14.-Delta Clearwater River study area.

Table 18.-Peak escapements, harvests, and catch of coho salmon in the Delta Clearwater River, 1972-1997.

	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
1997	24 Oct	4,975	6,550	2,375[h]	13,900[i]	27,767	NA[e]	NA[e]

[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. (1995-1997).

[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.

1. count coho salmon from a drifting riverboat at approximately weekly intervals throughout the run, and estimate total escapement through a combination of boat counts and aerial surveys; and,
2. estimate age, sex, and length compositions of the escapement.

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 14). 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 were not included in the surveys. To determine the proportion of fish that 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 were collected from river kilometer 24 (mile 15) to 14 (mile 9) on 6 October and again on 12 November. For the first sample, live coho salmon were collected using electrofishing gear (Clark 1985). For the second sample, carcasses were collected from a drifting riverboat 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, by extruding gametes from live fish, or by cutting into the body cavity of carcasses 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).

Scale impressions were later made on acetate cards and viewed at 100X magnification using equipment similar to that described by Ryan and Christie (1976). 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 13 and 14. 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 Delta Clearwater River was conducted on 22 October from river mile 0 to 17.5, including tributaries. A total of 9,950 fish were counted in the mainstem river and 2,375 were counted in the tributaries (Table 19). A boat survey of the mainstem river was conducted on 24 October. A total of 11,525 fish were counted during this survey. Coho salmon were distributed throughout the entire stretch in densities varying from 50 to 1,550 fish per mile during the boat survey (Table 19). Counts for individual spring areas ranged from 0 to 700 (Table 20). Visibility for the aerial survey was considered to be excellent. Yet, visibility for the boat survey was thought to be better because overhanging vegetation blocked the near-bank areas from the air. Thus, the boat count was used as the estimate for the mainstem river and the aerial survey of the tributaries was added to this count to determine total escapement. The total

Table 19.-Counts of adult coho salmon in the Delta Clearwater River, 1997.

	Mainstem River (Boat Survey)	Mainstem River (Aerial Survey)
River Mile	Count (24 Oct)	Count (22 Oct)
17.5-16	600	(River Mile 17.5-14) 2,700
16-15	1,150	
15-14	1,225	
14-13	1,000	(River Mile 14-9) 3,000
13-12	525	
12-11	650	
11-10	675	
10-9	400	
9-8	325	300
8-7	325	300
7-6	50	125
6-5	525	350
5-4	825	550
4-3	1,025	1,000
3-2	275	200
2-1	1,550	1,050
1-0	400	375
Summary		
17.5-8	6,550	6,000
8-0	4,975	3,950
14-0	8,550	7,250
17.5-0	**11,525**	**9,950**
Tributaries	N/A	**2,375**
Clearwater Lake Inlet	N/A	350
Clearwater Lake Outlet	2,775	2,000
	Total Count (i.e. boat count of mainstream and aerial survey of tributaties)	**13,900**

Table 20.-Aerial survey counts of adult coho salmon in spring areas of the Delta Clearwater River, 1997

Nonboatable Portion (Aerial Survey)		
Name of Spring	Count (22 Oct)	Description of Location
Sawmill Creek	350	Headwaters to Richard Lake
Andersen	0	South Spring into Sawmill
Granite	25	Headwaters to Sawmill
South Clearwater	125	Headwaters to Reed Lake
Middle Clearwater	300	Headwaters to Reed Lake
Peckham	0	Spring on north side of Clearwater Creek.
Clearwater-Section 1	300	Including Reed Lake, to Peckham
Clearwater-Section 2	700	Peckham to confluence of Sawmill Creek.
Fronty	25	First spring below Granite-South Side
Jan	0	Between Fronty and Jesse
Jesse	0	South side of Sawmill Creek
Jennie	0	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	25	North side of Delta Clearwater River
Dubois	0	South side of Delta Clearwater River
Christie	25	North side of Delta Clearwater River
Caleb	125	North side of DCR across from camp
Isaac's Slough	25	Between Caleb and Parker-north side
Parker	25	North side of Delta Clearwater River
Kenna	0	North side of Delta Clearwater River
Dos Gris	0	South side of DCR (Gartz)
Remmington	125	South side of DCR (lodge)
Barb	0	North side of Delta Clearwater River
Backy	0	South side of DCR (Forck)
Ridder	25	North side of Delta Clearwater River
Pearse	125	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

escapement index was estimated to be 13,900 coho salmon. The tributaries comprised 0.17 (SE<0.01) of this count.

Age-Sex-Length Compositions

Three hundred ninety-one coho carcasses were collected, measured and scales were taken for later aging. In past years it has been shown that size, age and sex can significantly vary with respect to sampling date (Evenson 1996). Thus, two separate sampling events were conducted in order to help reduce sampling bias. A Kolmogorov-Smirnov two-sample test was used to compare length distributions for each sampling event. The results showed no bias with respect to length (DN=0.12, P=0.20). Contingency table analyses were used to compare sex and age compositions of each sample. For the two sampling dates, the number of males and females differed significantly between events (χ^2=5.02, df=1, P=0.03). Age composition did not differ significantly (χ^2=2.72, df=2, P=0.26).

Males comprised 0.54 and females 0.46 of the collected coho salmon carcasses. Ages were determined for 0.85 of the sample. Most of the males and females were age 2.1 (85% and 92% respectively). To a much lesser degree, 14% of males and 6% of females were age 1.1 (Table 21). Males varied over a larger length range (390-670 mm) than females (490-630 mm) for all coho salmon sampled (Figure 15).

DISCUSSION

Escapement survey counts were lower than the previous five-year average, but still well in excess of the minimum escapement goal of 9,000 salmon. The reasons for this moderate escapement are not known. The 1993 parent year, from which most of this escapement originated, was among the lowest on record (Table 18). For those years such as 1992 when the escapement goal is not met, the sport fishery can be closed. For large abundance years which is often the case, modifying sport fishing bag limits would likely be of little consequence. Most of the coho salmon are caught and then released. Thus, few fish are actually harvested and increasing the bag and possession limit would probably have little effect.

This year (1997) was the fourth year that aerial surveys were conducted to count the number of coho salmon in the non-boatable waters adjacent to the mainstream river. The proportion of fish spawning in tributaries was similar for all years (0.22, 0.24, 0.19, and 0.17, respectively). Thus, even though boat counts have been primarily used in the past to enumerate coho salmon escapement in the main river channel, aerial counts of the tributaries make a significant contribution to the overall estimate. However, boat counts appear to provide a consistent index and are less costly than aerial estimates.

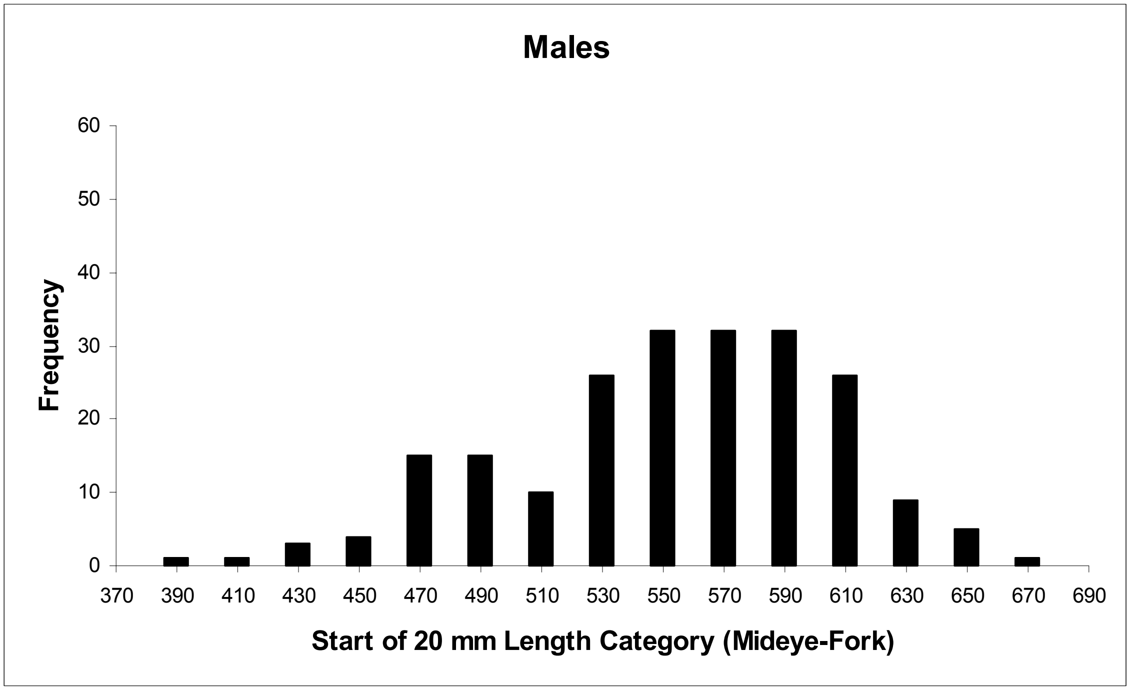
Table 21.-Statistics by age and sex for coho salmon carcasses collected from the Delta Clearwater River, 1997.

	Age[a]	Sample Size	Proportion	SE	Length Mean	Length SE	Length Min	Length Max
Male	1.1	25	0.14	0.02	523	11	430	610
	2.1	152	0.85	0.02	548	4	380	655
	2.2	1	0.01	0.01	510		510	510
	Total	178	1.00					
Total[b]		212	0.54[c]	0.03[c]	546	4	380	655
Female								
	1.1	9	0.06	0.02	565	13	485	605
	2.1	142	0.92	0.02	571	3	495	775
	3.1	3	0.02	0.01	570	20	530	595
	Total	154	1.00					
Total [b]		179	0.46[c]	0.03[c]	572	2	485	775

[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

[b] Totals include those coho salmon which could not be aged.

[c] Proportion and corresponding SE are based on total number (391) of carcasses sampled.



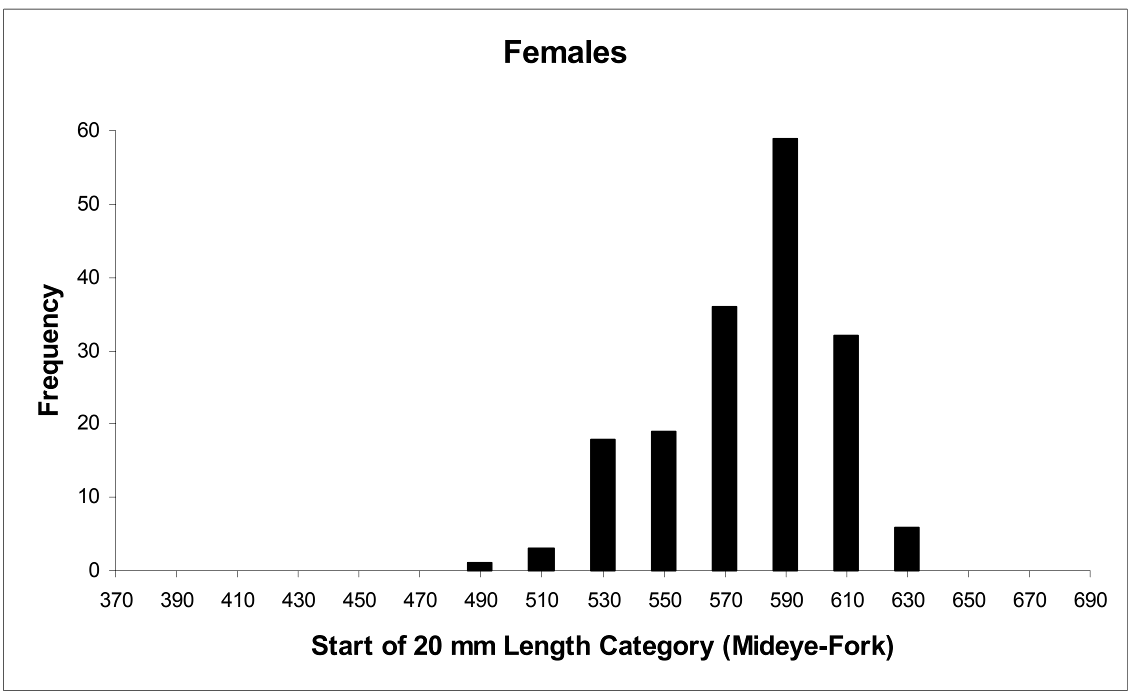


Figure 15.-Length frequency distributions of male and female coho salmon collected in the Delta Clearwater River, 1997.

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APPENDIX A

Appendix A1.-Schedule for counting salmon in the Salcha River, 1997. Shaded boxes indicate shifts when counts were scheduled, but were not conducted due to high water and poor visibility or schedule conflicts.

June 23 – June 29	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800				COUNT	COUNT	COUNT	
0800-1600				COUNT			COUNT
1600-0000					COUNT	COUNT	COUNT

June 30 – July 6	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800			COUNT	COUNT	COUNT	COUNT	
0800-1600	COUNT	COUNT		COUNT	COUNT	COUNT	COUNT
1600-0000	COUNT	COUNT	COUNT				COUNT

July 7 – July 13	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

July 14 – July 20	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

July 21 – July 27	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

July 28 – Aug 3	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

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

Appendix A2.-Schedule for counting salmon in the Chena River, 1997.

June 23 – June 29	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800				COUNT	COUNT	COUNT	
0800-1600						COUNT	COUNT
1600-0000				COUNT	COUNT		COUNT

June 30 – July 6	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0000-0800			COUNT	COUNT	COUNT	COUNT	
0800-1600	COUNT	COUNT			COUNT	COUNT	COUNT
1600-0000	COUNT	COUNT	COUNT	COUNT			COUNT

July 7 – July 13	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

July 14 – July 20	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

July 21 – July 27	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

July 28 – Aug 3	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

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 hypotheses are rejected, a geographically stratified estimator (Darroch 1961) will be used to estimate abundance by river section.

TEST I[a]

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

TEST II[b]

	Second Event: River Section		
	Upper	Middle	Lower
Recaptured			
Not Recaptured			

TEST III[c]

	Captured During Second Event River Section		
	Upper	Middle	Lower
Marked			
Unmarked			

[a] 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.

[b] 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.

[c] 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.

APPENDIX C

Appendix C.-Data files used to estimate parameters of chinook, chum, and coho salmon populations in the Salcha, Chena, Chatanika, and Delta Clearwater rivers, 1997.

Data File	Description
CRHPEK97.AWL[a]	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, 1997.
U00201AA.DTA[b]	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, 1997.
CRHPCK97.AWL[a]	Data file of length, sex, and age data for chinook salmon collected during the marking and recapture events of the mark-recapture experiment in the Chatanika River, 1997.
SRHPEK97.AWL[a]	Data file of length, sex, and age data for chinook salmon carcasses collected from the Salcha River, 1997.
DCRECS97.AWL[a]	Data file of length, sex, and age data for coho salmon carcasses collected from the Delta Clearwater River, 1997.
KINGTOW.XLS[c]	Excel spreadsheet of hourly counts of chinook salmon, daily expansions of escapement, and variance estimates for the Salcha and Chena rivers, 1996
CHUMTOW.XLS[c]	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, Commercial Fisheries Research and Development Division, 333 Raspberry Road, Anchorage, 99518-1599.

[b] 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.

[c] Data files are available from the authors.

APPENDIX D

Appendix D1.-Numbers of chinook salmon counted during 10 min periods for the left side of the Salcha River, 1997. 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
6/26									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	1	0	0	1	0	0	0									0	0	0	0	0	0	0	0	2
6/29									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2	2	0	3	1	0	0	0	0									0	0	0	0	0	0	0	0	6
7/3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0									2
7/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0									1
7/6									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7	0	2	0	0	0	3	0	0	0	0	0	0	0	4	0	0		0	0	0	0	0	0	4	13
7/8	0	3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	11
7/9	3	0	0	1	0	2	0	0	0	0	0	0	7	0	0	0	1	0	0	0	0	1	3	0	18
7/10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1	0	7
7/11	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	9
7/12	3	0	0	0	0	0	1	0	0	0	0	0	2	4	0	0									10
7/13										9	0	2	0	1	0	0	0	0	0	0	0	2	0	0	14
7/14	4	0	1	1	0	1	0	0	0	0	1	0	4	0	2	0	0	2	2	0	0	0	0	0	18
7/15	0	0	3	4	2	6	1	12																	28
7/16																									
7/17																	3		0	1	3	1	7	0	15
7/18	0	1	2	1	1	3	2	0	1	3	0	4	0	1	0	0	0	0	0	0	0	0	1	0	20
7/19	0	1	2	4	4	6	3	4	0	0	0	1	1	1	3	1	3	0	0	0	2	0	0	1	37
7/20							0	2	0	2	3														7
7/21																									
7/22																									
7/23																									
7/24												2	2	1	1	2	3	0	1	1	2	0	0	2	17
7/25		1	0	0	0	2	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	1	1	0	10
7/26									0	0	0	0	0	1	0	0	0	0	0	0	1	0	2	1	5
7/27	1	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	6
7/28	0	3	0	1	0	1	0	2	1	0	0	1	0	0	0	0	0	0	-1	0	0	1	0	0	9
7/29	0	1	0	2	0	1	1	1	1	0	0	1	0	2	0	0	0	0	0	0	1	0	0	0	11
7/30	2	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	7
7/31	1	2	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	1	2	11
8/1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	3
8/2	2	0	0	0	0	0	0	0																	2
8/3		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	1	0	0	1	3
8/4	0	0	0	0	-1	0	-1	0	0	0	0	-1	0	0	0	0		0	0	0	0	0	0	0	-3
8/5		1	0	-1	0	1	-2	0	0	0	0	0	0	3	0	1									3
8/6	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	0	0	0	0	4
8/7	0	0	2	1	1	0	0	-1	0	0	0	0	-1	2	0	0	0	0	0	0	0	0			4
Total	19	19	15	17	13	28	8	28	4	15	6	10	17	23	11	4	17	4	5	1	11	7	17	11	310

Appendix D2.-Numbers of chinook salmon counted during 10 min periods for the right side of the Salcha River, 1997. 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
6/26									0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	0	0	2	2	0	0	0									0	0	0	0	1	0	0	0	5
6/29									0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	3
7/2	0	0	18	1	0	7	0	3									0	0	0	0	0	0	0	1	30
7/3	0	0	4	0	0	1	1	0	0	0	0	0	2	0	0	0									8
7/4	0	0	2	0	0	0	0	3	0	0	0	0	0	0	0	0									5
7/5	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0									6
7/6									0	0	7	0	0	0	0	9	3	0	0	0	0	0	0	1	20
7/7	0	3	14	7	6	12	0	0	11	6	0	8	0	0	0	0		0	0	0	0	0	3	0	70
7/8	13	0	27	9	0	0	2	0	0	6	0	0	0	12	0	1	5	0	12	0	0	1	0	3	91
7/9	2	19	3	10	31	9	0	1	0	0	17	77	56	9	1	5	0	4	0	8	0	12	10	5	279
7/10	7	23	23	2	11	3	6	1	0	3	1	2	0	0	13	3	4	2	0	4	3	0	3	0	114
7/11	1	0	21	41	5	4	6	22	1	9	11	3	1	2	3	8	7	1	12	0	0	0	0	5	163
7/12	3	0	5	1	3	27	1	20	0	0	0	22	7	1	2	4									96
7/13										7	18	18	3	31	16	1	4	0	0	0	0	0	0	1	99
7/14	6	15	9	7	7	4	3	13	2	5	20	0	4	0	9	1	6	2	1	1	1	1	3	3	123
7/15	18	18	4	10	4	3	2	0																	59
7/16																									0
7/17																	5		7	5	2	3	13	3	38
7/18	3	0	6	13	4	8	11	1	10	4	6	4	7	7	6	4	7	1	5	3	5	2	4	2	123
7/19	4	6	9	12	33	19	11	1	4	3	0	3	4	1	7	2	4	8	-2	2	14	1	0	1	147
7/20							4	3	4	3	0														14
7/21																									0
7/22																									0
7/23																									0
7/24												0	0	4	1	1	1	1	2	1	0	0	0	0	11
7/25		0	3	0	0	0	1	0	4	0	1	1	0	3	0	0	1	2	1	1	0	3	0	0	21
7/26									0	0	0	0	0	0	0	1	0	1	3	2	1	1	0	0	9
7/27	1	0	0	0	1	0	0	1	1	0	1	0	0	0	2	2	0	0	0	1	1	0	1	2	14
7/28	1	2	0	1	1	1	0	0	0	1	0	3	1	0	2	1	2	1	1	1	1	-1	0	2	21
7/29	1	1	0	3	3	0	3	-1	1	0	0	1	-1	0	0	0	1	3	3	0	2	3	1	1	25
7/30	1	0	3	1	2	3	1	0	0	0	1	1	0	1	1	0	1	0	0	2	1	1	0	1	21
7/31	1	2	-1	2	0	1	0	0	1	1	0	0	2	2	1	2	3	-1	0	-1	1	1	1	0	18
8/1	0	0	1	1	0	0	1	0	0	0	1	0	-1	0	0	0	-1	0	0	0	-1	0	-1	-1	-1
8/2	0	0	0	0	0	0	0	-1																	-1
8/3		0	1	0	0	0	0	0	0	2	0	2	-1	1	1	0	0	0	1	0	0	2	0	0	9
8/4	2	0	-1	0	-1	0	0	0	1	0	1	0	0	0	-1	0		0	0	0	0	0	0	0	1
8/5		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0									1
8/6	0	0	0	0	2	0	0	0	0	0	0	0	-1	0	1	0		0	0	0	0	0	0	0	2
8/7	0	0	0	0	0	0	0	0	0	0	0	1	0	-1	0	-1	0	0	0	0	0	0			-1
Total	64	89	152	129	114	102	53	67	40	51	85	146	83	73	65	44	53	25	46	31	34	34	38	30	1.648

Appendix D3.-Numbers of chinook salmon counted during 10 min periods for the left side of the Chena River, 1997. 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
6/26	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									2	2	0	0	0	0	0	0	4
6/28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
6/29									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30									1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/1									0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	4
7/2	0	0	0	0	0	0	3	0									0	1	0	0	0	0	0	0	4
7/3	0	0	0	0	0	0	3	0									3	0	0	0	0	0	0	0	6
7/4	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0									3
7/5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0									1
7/6									0	0	0	0	0	3	0	0	0	0	3	0	0	2	0	0	8
7/7	16	0	0	0	0	0	0	1	52	2	0	0	1	4	4	1	0	0	0	1	1	0	1	0	84
7/8	0	0	0	0	1	0	1	0	0	0	2	0	2	28	2	28	23	0	0	3	0	-1	0	3	92
7/9	0	24	0	3	1	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	4	0	0	0	37
7/10	0	1	1	0	6	3	2	1	3	0	0	0	6	9	14	2	5	0	0	0	0	0	0	4	57
7/11	3	0	-1	23	8	0	0	8	5	0	0	0	2	0	0	0	0	0	2	0	0	0	0	3	53
7/12	5	9	2	0	1	21	23	4	24	1	0	0	0	0	3	0									93
7/13	2	1	0	3	5	17	14	44	7	0	14	3	0	0	0	0	27	0	0	1	0	5	0	1	144
7/14	4	4	21	17	11	20	4	3	5	0	5	27	2	44	1	7	0	20	0	0	-1	0	0	1	195
7/15	0	1	7	15	17	6	6	0									0	7	8	2	0	3	0	0	72
7/16	0	6	20	13	19	6	9	23	24	0	18	12	20	9	6	7	8	10	21	31	11	3	2	2	280
7/17	0	10	11	2	1	28	2	0	0	1	3	3	23	15	8	4	7	6	3	9	10	2	0	6	154
7/18	2	1	6	1	5	10	5	19	1	0	1	9	6	3	2	0	1	7	11	3	7	3	2	0	105
7/19	9	4	3	0	6	1	0	8	6	0	3	0	0	1	0	0	3	1	13	3	5	1	0	5	72
7/20	8	5	8	6	7	32	7	3	2	0	3	6	1	3	1	0	3	12	0	6	2	0	3	5	123
7/21	1	6	1	2	1	6	2	0	4	1	4	4	0	4	3	3	4	7	0	21	2	0	0	5	81
7/22	4	3	1	0	1	2	4	1	1	1	1	2	0	7	1	3	1	10	0	0	0	1	1	0	45
7/23	0	2	2	1	2	2	2	2	0	0	2	1	2	0	2	3	3	0	0	6	1	2	0	0	35
7/24	1	1	0	1	2	3	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	12
7/25									2	-1	0	0	1	0	2	0	1	-1	4	0	3	0	0	0	11
7/26									0	3	0	-1	1	0	0	0	0	0	1	1	0	0	0	0	5
7/27	-1	1	0	1	0	0	0	0	0	3	0	1	1	-1	1	1	0	0	0	0	0	2	1	0	10
7/28	0	0	0	1	-1	0	1	0	0	0	0	0	0	0	0	0	1	-1	1	-1	2	1	0	0	4
7/29	0	0	1	0	0	1	1	0	0	2	0	0	2	0	0	3	1	2	0	0	0	0	0	0	13
7/30	1	0	0	2	0	0	0	1			0	1	0	0	0	0	0	0	0	0	0	2	1	-1	7
7/31	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3
8/1	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	4
8/2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0									1
8/3	1	0	0	0	0	0	0	0									0	0	0	0	0	0	0	1	2
Total	56	81	84	91	93	159	92	118	137	14	56	69	73	130	51	62	94	83	72	87	47	29	11	36	1,825

Appendix D4.-Numbers of chinook salmon counted during 10 min periods for the right side of the Chena River, 1997. 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
6/26	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
6/29									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
7/2	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
7/3	0	0	0	0	0	0	0	0									7	0	0	0	0	1	0	0	8
7/4	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0									3
7/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/6									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7	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
7/8	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	11
7/9	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	7
7/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/11	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	6
7/12	2	0	0	0	4	2	1	3	0	1	0	0	0	0	0	0									13
7/13	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	2	1	0	0	1	0	0	0	8
7/14	0	5	2	0	0	0	0	0	0	0	0	5	0	2	0	0	2	3	0	0	0	0	0	0	19
7/15	0	0	1	4	0	0	2	0									0	0	0	2	1	1	1	0	12
7/16	0	2	4	2	2	1	0	4	3	0	0	0	0	1	2	0	2	4	1	8	6	5	3	2	52
7/17	2	6	0	2	0	3	2	0	0	0	1	0	0	4	0	1	1	1	0	3	1	1	0	3	31
7/18	0	4	1	0	3	1	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	-1	0	2	14
7/19	0	0	0	0	1	0	0	0	-1	0	1	0	0	0	0	0	2	1	1	0	4	0	0	2	11
7/20	0	0	2	1	1	3	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	2	2	14
7/21	0	4	4	0	0	0	0	0	0	0	1	0	1	3	1	3	0	2	3	2	0	0	1	0	25
7/22	0	0	1	0	0	0	1	1	0	0	1	1	2	2	0	0	0	2	0	0	0	0	0	0	11
7/23	0	0	0	0	2	0	0	1	0	0	0	1	1	0	0	1	1	0	0	1	0	0	0	0	8
7/24	1	0	1	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	6
7/25									0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	4
7/26									1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	3
7/27	1	0	0	0	0	0	0	0	-1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
7/28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	1	1	0	5
7/29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
7/30	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8/1	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
8/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
8/3	1	1	0	0	0	0	0	0									0	0	0	0	0	0	-1	0	1
Total	7	25	18	9	14	10	8	13	6	1	6	10	4	24	5	7	21	17	10	16	17	9	7	13	277

Appendix D5.-Numbers of chum salmon counted during 10 min periods for the left side of the Salcha River, 1997. 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
6/26									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/29									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	3	3
7/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/6									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
7/8	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	3
7/9	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
7/10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/11	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
7/12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0									1
7/13										0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	3
7/14	1	0	0	0	0	0	0	0	0	0	0	0	3	1	1	0	0	1	0	0	2	0	9	0	18
7/15	0	0	3	2	2	0	2	0																	9
7/16																									
7/17																	0		0	0	2	0	3	0	5
7/18	5	0	1	1	3	2	0	1	0	3	1	2	0	3	1	0	0	0	3	4	5	9	2	13	59
7/19	3	2	6	1	4	2	3	0	2	0	1	2	1	1	2	3	4	1	1	2	10	1	7	3	62
7/20							3	0	2	6	2														13
7/21																									
7/22																									
7/23																									
7/24												10	3	16	9	7	13	4	4	8	8	3	9	9	103
7/25		3	1	4	1	0	0	1	2	11	4	1	1	5	8	5	3	4	10	0	0	6	14	10	94
7/26									0	1	2	4	4	0	4	1	2	2	0	2	1	0	0	4	27
7/27	11	0	4	4	0	1	6	1	0	8	2	0	0	0	2	1	3	0	0	0	0	4	4	3	54
7/28	3	23	13	8	6	0	27	8	9	4	7	1	0	7	0	8	4	1	7	3	10	13	9	6	177
7/29	1	6	2	1	2	1	9	0	5	2	4	3	3	0	0	7	3	1	9	1	8	9	6	16	99
7/30	7	9	12	20	12	22	4	4	5	8	19	16	10	4	6	9	1	3	0	6	2	1	16	7	203
7/31	1	10	9	2	4	0	1	1	5	4	2	7	5	10	7	9	2	3	3	6	0	7	11	4	113
8/1	7	10	9	11	1	4	0	3	0	0	2	0	0	4	0	2	1	3	0	3	6	3	1	0	70
8/2	6	1	4	1	5	3	2	5																	27
8/3		8	3	0	2	4	2	0	0	2	-1	1	3	1	3	1	0	0	2	5	5	0	9	8	58
8/4	7	3	2	8	2	4	5	4	4	9	0	0	3	0	0	0		4	0	0	6	9	1	13	84
8/5		10	2	2	4	9	9	1	0	1	0	0	2	12	16	6									74
8/6	2	12	3	10	5	3	6	3	0	2	1	8	6	3	0	3		5	4	7	12	1	8	1	105
8/7	6	-1	0	0	1	1	-3	3	0	2	1	-3	1	4	0	3	2	4	3	0	6	0			30
Total	60	96	74	75	55	56	76	35	35	63	47	52	46	73	59	65	39	36	46	47	83	67	110	100	1.495

Appendix D6.-Numbers of chum salmon counted during 10 min periods for the right side of the Salcha River, 1997. 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
6/26									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/29									0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2	0	0	2	0	0	0	0	0									0	0	0	0	0	0	0	0	2
7/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/6									0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
7/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
7/8	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
7/9	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	2	1	0	8
7/10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	5
7/11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/12	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0									4
7/13										0	0	4	1	0	2	0	1	0	0	0	0	0	0	0	8
7/14	1	1	2	0	1	0	0	0	1	0	1	0	2	2	0	0	0	2	0	0	0	0	0	0	13
7/15	0	7	1	0	3	0	0	0																	11
7/16																									0
7/17																	2		8	3	0	1	1	1	16
7/18	2	3	4	11	2	4	0	2	3	0	2	0	2	3	2	3	10	0	9	2	7	8	10	6	95
7/19	2	0	3	7	4	3	0	4	6	2	0	3	10	4	7	6	3	5	2	1	10	4	1	4	91
7/20							1	4	2	7	0														14
7/21																									0
7/22																									0
7/23																									0
7/24												8	5	8	6	6	11	2	3	6	3	0	6	7	71
7/25		3	6	1	4	10	4	3	7	3	5	8	6	5	1	4	6	1	2	5	10	5	5	4	108
7/26									0	0	1	1	5	4	4	2	7	0	4	9	5	0	5	1	48
7/27	0	0	0	1	0	0	9	1	9	0	3	0	0	0	1	4	3	0	1	5	1	7	1	1	47
7/28	27	11	16	23	26	8	19	11	10	17	15	12	19	20	3	24	30	16	18	16	17	21	8	7	394
7/29	1	1	3	2	8	3	5	9	3	3	20	7	14	2	12	8	6	13	20	32	28	27	15	16	258
7/30	15	23	11	41	16	12	15	14	16	25	11	11	19	21	18	20	10	30	9	31	18	12	11	26	435
7/31	5	10	13	10	8	9	10	4	16	13	20	14	17	19	14	13	18	16	18	22	17	12	18	10	326
8/1	13	6	5	9	13	15	12	8	3	5	7	2	4	3	11	12	11	27	22	14	18	12	8	7	247
8/2	5	6	17	3	5	4	13	22																	75
8/3		11	10	3	8	5	6	2	2	3	2	4	8	11	21	19	5	11	13	14	10	22	7	9	206
8/4	11	4	7	4	9	3	15	9	6	12	6	8	6	20	12	5		8	15	10	2	27	21	4	224
8/5		14	5	15	4	8	5	4	3	5	9	16	8	7	12	6									121
8/6	6	15	7	7	29	5	8	10	4	8	9	5	3	11	7	2		3	2	2	9	6	5	2	165
8/7	8	8	1	2	6	8	1	3	3	5	4	6	3	3	7	5	4	7	7	3	3	1			98
Total	98	123	113	139	147	97	123	110	94	108	116	113	133	144	140	139	127	144	153	176	162	169	123	105	3.096

Appendix D7.-Numbers of chum salmon counted during 10 min periods for the left side of the Chena River, 1997. 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
6/26	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
6/29									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
7/3	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
7/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/6									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/8	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	3
7/9	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
7/10	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	4
7/11	2	0	8	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
7/12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/13	2	1	0	0	0	2	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8
7/14	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/15	0	0	0	0	0	0	0	0									0	1	1	0	0	1	0	0	3
7/16	0	1	2	3	1	0	0	2	0	0	1	0	6	0	2	1	0	0	1	3	1	5	0	0	29
7/17	2	3	1	1	0	2	0	0	0	0	0	0	1	7	11	3	0	0	0	1	5	0	5	9	51
7/18	0	3	0	5	1	1	0	1	0	0	0	0	2	2	0	0	1	0	0	1	1	0	0	0	18
7/19	5	0	2	0	1	0	0	0	0	0	1	0	0	1	0	0	0	2	1	3	3	1	2	0	22
7/20	0	0	1	0	2	0	3	0	5	0	0	2	0	0	0	0	0	8	0	0	0	1	13	2	37
7/21	8	5	1	1	1	1	0	0	0	2	0	0	1	4	1	7	0	0	0	0	1	0	0	4	37
7/22	4	13	1	0	1	2	4	1	1	1	1	2	0	7	1	3	1	10	0	0	0	1	1	0	55
7/23	14	1	1	3	7	6	0	4	0	1	6	5	22	0	0	1	10	3	0	3	0	1	1	3	92
7/24	7	1	0	0	0	2	3	0	8	15	9	0	9	1	1	2	9	0	0	0	0	0	0	0	67
7/25									5	1	0	0	5	0	0	0	0	6	2	0	3	0	1	0	23
7/26									0	0	0	0	4	2	2	0	1	4	3	0	3	1	3	0	23
7/27	0	11	0	1	1	1	1	4	1	9	0	1	4	0	0	5	15	8	0	4	2	4	2	0	74
7/28	16	2	3	5	1	0	2	0	1	0	0	0	0	3	0	2	0	2	0	0	8	3	1	0	49
7/29	4	1	7	1	0	2	0	0	7	18	0	10	19	0	8	1	0	34	0	0	0	26	5	0	143
7/30	0	12	9	17	0	7	5	2			0	4	1	1	0	24	0	0	1	20	6	1	5	0	115
7/31	0	0	3	0	12	0	0	0	0	0	0	0	10	0	0	0	3	3	0	1	0	26	0	0	58
8/1	0	2	0	6	-1	0	0	2	0	1	3	0	0	0	0	0	2	4	0	0	0	4	0	19	42
8/2	1	2	1	13	0	0	3	0	0	0	0	0	0	0	1	0									21
8/3	2	4	0	9	1	0	2	0									5	0	0	0	1	0	14	24	62
Total	67	62	40	66	31	26	25	17	29	48	23	24	84	29	27	50	48	85	10	36	34	75	53	61	1,050

Appendix D8.-Numbers of chum salmon counted during 10 min periods for the right side of the Chena River, 1997. 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
6/26	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
6/29									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
7/3	0	0	0	0	0	0	0	0									0	0	0	0	0	0	0	0	0
7/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/6									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7	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
7/8	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
7/9	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
7/10	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
7/11	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
7/12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									0
7/13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
7/14	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
7/15	0	0	0	0	0	0	0	0									0	0	0	0	2	0	0	0	2
7/16	0	5	7	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	3	0	0	21
7/17	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
7/18	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6
7/19	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7/20	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
7/21	1	12	10	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	2	28
7/22	1	1	1	0	1	0	3	0	2	0	0	0	0	1	0	0	0	0	0	0	1	3	0	0	14
7/23	0	5	0	0	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	1	0	2	5	1	20
7/24	5	1	1	3	7	3	2	0	3	12	0	0	2	0	0	4	0	1	1	0	1	0	0	1	47
7/25									1	0	2	0	0	0	0	0	0	1	0	2	4	7	0	1	18
7/26									0	2	0	0	0	0	0	0	0	0	0	0	0	7	2	1	12
7/27	1	6	1	1	1	0	1	0	0	-1	0	0	0	1	0	0	0	0	0	1	0	0	0	2	14
7/28	1	2	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	4	0	1	0	41
7/29	2	2	3	0	1	7	0	3	0	9	0	1	0	0	0	3	0	1	0	0	1	0	0	1	34
7/30	13	2	0	0	1	0	0	0			0	0	0	1	0	0	0	0	0	0	2	4	0	2	25
7/31	10	0	7	0	0	0	0	0	30	0	1	0	2	0	0	0	2	0	0	0	0	0	0	0	52
8/1	3	2	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
8/2	3	5	1	0	7	2	0	0	0	1	10	0	0	2	0	0									31
8/3	0	0	2	1	8	0	0	0									0	0	0	0	0	0	0	0	11
Total	40	44	57	5	49	15	7	4	36	24	13	4	4	5	1	8	2	4	6	15	16	26	9	13	407