Fishery Data Series No. 04-01

Salmon Studies in the Chena, Chatanika, Delta Clearwater, and Salcha Rivers, 2001

by

Mike Doxey

January 2004

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour	h
minute	min
second	s

Physics and chemistry

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

General

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

Mathematics, statistics, fisheries

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

FISHERY DATA SERIES NO. 04-01

SALMON STUDIES IN THE CHENA, CHATANIKA, DELTA CLEARWATER, AND SALCHA RIVERS, 2001

by
Mike Doxey
Division of Sport Fish, Fairbanks

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

January 2004

Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-17, Job No. S-3-1(a).

The Fishery Data Series was established in 1987 for the publication of technically-oriented results for a single project or group of closely related projects. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

Mike Doxey
Alaska Department of Fish and Game, Division of Sport Fish, Region III,
1300 College Road, Fairbanks, AK 99701-1599,USA

This document should be cited as:
Doxey, Mike 2004. Salmon studies in the Chena, Chatanika, Delta Clearwater, and Salcha Rivers, 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-01, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Escapements of chinook salmon *Oncorhynchus tshawytscha* in the Chena and Chatanika rivers near Fairbanks, Alaska were estimated using tower-count methodology. Counts were conducted from 30 June to 29 August for the Chena River and 3 July to 29 August for the Chatanika River. Tower-count estimates were 9,696 (SE = 568) chinook salmon for the Chena River and 964 (SE = 112) chinook salmon for the Chatanika River. An aerial survey count during the period of maximum escapement was 1,487 chinook salmon for the Chena River, which was 0.15 of the tower estimate. Age and sex compositions of the Chena River chinook escapement were determined after carcass surveys. After correction for gender-selective sampling, females comprised an estimated 0.32 (SE = 0.04) of the escapement. The majority of males examined from the carcass population were age 1.3 (0.46) with the rest comprising ages 1.1 (0.01), 1.2 (0.15), 1.4 (0.36), and 1.5 (0.02). The majority of females were age 1.4 (0.72) with the rest comprising 1.2 (0.02), 1.3 (0.17), and 1.5 (0.02).

A portion of the chum salmon *Oncorhynchus keta* escapements for the Chena and Chatanika rivers were also estimated during the tower-counts. Estimated escapements from start of run through July 29 were 4,773 (SE = 380) chum salmon for the Chena River and 388 (SE = 69) chum salmon for the Chatanika River.

Staff from the Bering Sea Fishermen's Association conducted tower counts on the Salcha River from 5 July to 5 September and conducted a carcass survey. The counts were suspended for a long period beginning on 24 July due to flooding at, what appeared to be, the period of peak chinook salmon passage. Estimated escapement up to that time was 9,300 (SE = 322) chinook salmon. Total escapement was estimated to be 13,328 (SE = 2,163) chinook salmon and was calculated by summing the estimate from count data through 23 July with an estimate of escapement after 23 July based on historical run timing information. An estimated 14,900 chum salmon passed by the tower through 23 July.

Escapement of coho salmon *Oncorhynchus kisutch* was determined in the Delta Clearwater River by means of a boat count. The boat count of the mainstem river was 46,875 coho salmon on 19 October. An expansion of 12,672 fish, which was based on the average proportion observed during five consecutive years of aerial surveys in areas not accessible by boat, was added to the boat count for a total estimated escapement of 59,547 coho salmon.

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, counting towers, carcass survey, electroshock survey, aerial survey, boat survey, escapement.

CHINOOK AND CHUM SALMON STUDIES IN THE CHENA AND CHATANIKA RIVERS

INTRODUCTION

The Chena River (Figure 1) has some of the largest chinook salmon *Oncorhynchus tshawytscha* escapements in the Yukon River drainage (Schultz et al. 1994), and supports a popular sport fishery in the lower 72 km of the river. Annual harvest estimates from the Alaska Department of Fish and Game (ADF&G) Statewide Harvest Survey (SWHS) since 1978 have ranged from 0 to 1,270 chinook salmon (Mills 1979-1994; Howe et al. 1995-2001a-d, Walker et al. 2003; Jennings et al. *In prep*; Table 1). Chinook salmon harvests by anglers in the Chena River were monitored during 1988 - 1990 with creel surveys (Table 1; Evenson 1995). However, creel surveys have not been conducted recently due to their high cost and the difficulty of obtaining more meaningful estimates of harvest and effort than those estimated by the SWHS.

The Chatanika River (Figure 2) sustains a small stock of chinook salmon. Recent estimates of sport harvests (0-373 fish; Table 1) have indicated the possibility of large relative exploitation.

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

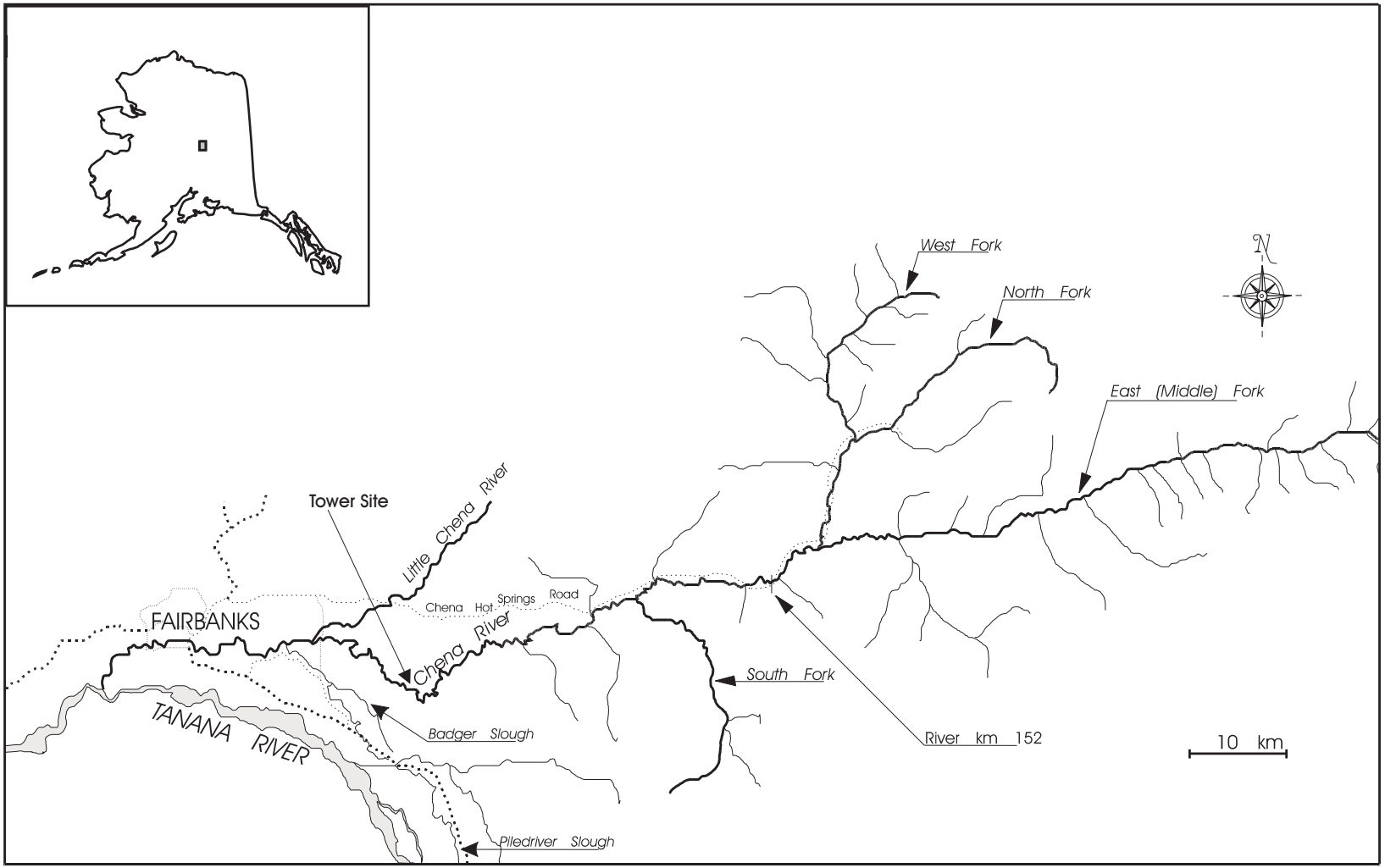

Figure 1.-Chena River study area.

Table 1.-Estimated sport, commercial, and subsistence harvests of anadromous chinook salmon in the Tanana River drainage, 1978 - 2001.

	Sport Harvest										
	Creel Survey[a]		Statewide Survey[b]						Commercial	Subsistence and Personal Use	Total Estimated
Year	Chena River	Salcha River	Chena River	Salcha River	Chatanika River	Nenana River	Other Streams	Tanana Drainage	Harvest[d]	Harvest [d,e]	Harvest
									Tanana Drainage		
1978	-	-	23	105	35	-	0	163	635	1,231	2,029
1979	-	-	10	476	29	-	0	515	772	1,333	2,620
1980	-	-	0	904	37	-	0	941	1,947	1,826	4,714
1981	-	-	39	719	5	-	0	763	987	2,085	3,835
1982	-	-	31	817	136	-	0	984	981	2,443	4,408
1983	-	-	31	808	147	-	10	1,048	911	2,706	4,665
1984	-	-	0	260	78	-	0	338	867	3,599	4,804
1985	-	-	37	871	373	-	75	1,356	1,142	7,375	9,873
1986	-	526	212	525	0	-	44	781	950	3,701	5,432
1987	-	111	195	244	21	7	7	474	3,338	4,096	7,908
1988	567	19	73	236	345	36	54	744	786	5,507	7,037
1989	685	123	375	231	231	39	87	963	2,181	2,999	6,143
1990	24	200	64	291	37	0	0	439	2,989	3,069	6,497
1991	-	362	110	373	82	11	54	630	1,163	2,515	4,308
1992	-	4	39	47	16	0	0	118	785	2,438	3,341
1993	-	54	733	601	192	0	19	1,573	1,445	2,098	5,116
1994	-	776	993	714	105	0	59	1,871	2,606	2,370	6,847
1995	-	811	662	1,448	58	0	320	2,488	2,747	2,178	7,413
1996	-	-	1,270c	1,136	348	53	118	2,925	447	1,392	4,764
1997	-	-	1,029c	719	155	10	0	1,913	2,728	3,025	7,666
1998	-	-	299	121	6	15	0	441	963	2,276	3,680
1999	-	-	442	445	36	11	0	934	690	1,955	3,579
2000	-	-	71	72	0	24	0	167	0	1,058	1,225
2001			425	108	23	0	0	556	0	2,571	N/A

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) Howe et al. (1995, 1996, 2001 a-d), Walker et al 2003, and Jennings et al. *In prep*.

c Commercial, subsistence, and personal use estimates (Schultz 1994; Borba and Hamner 1998, 1999; K. Schultz, Alaska Dept. of Fish and Game, Fairbanks, personal communication; B. Busher, Alaska Dept. of Fish and Game, Fairbanks, personal communication).

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.

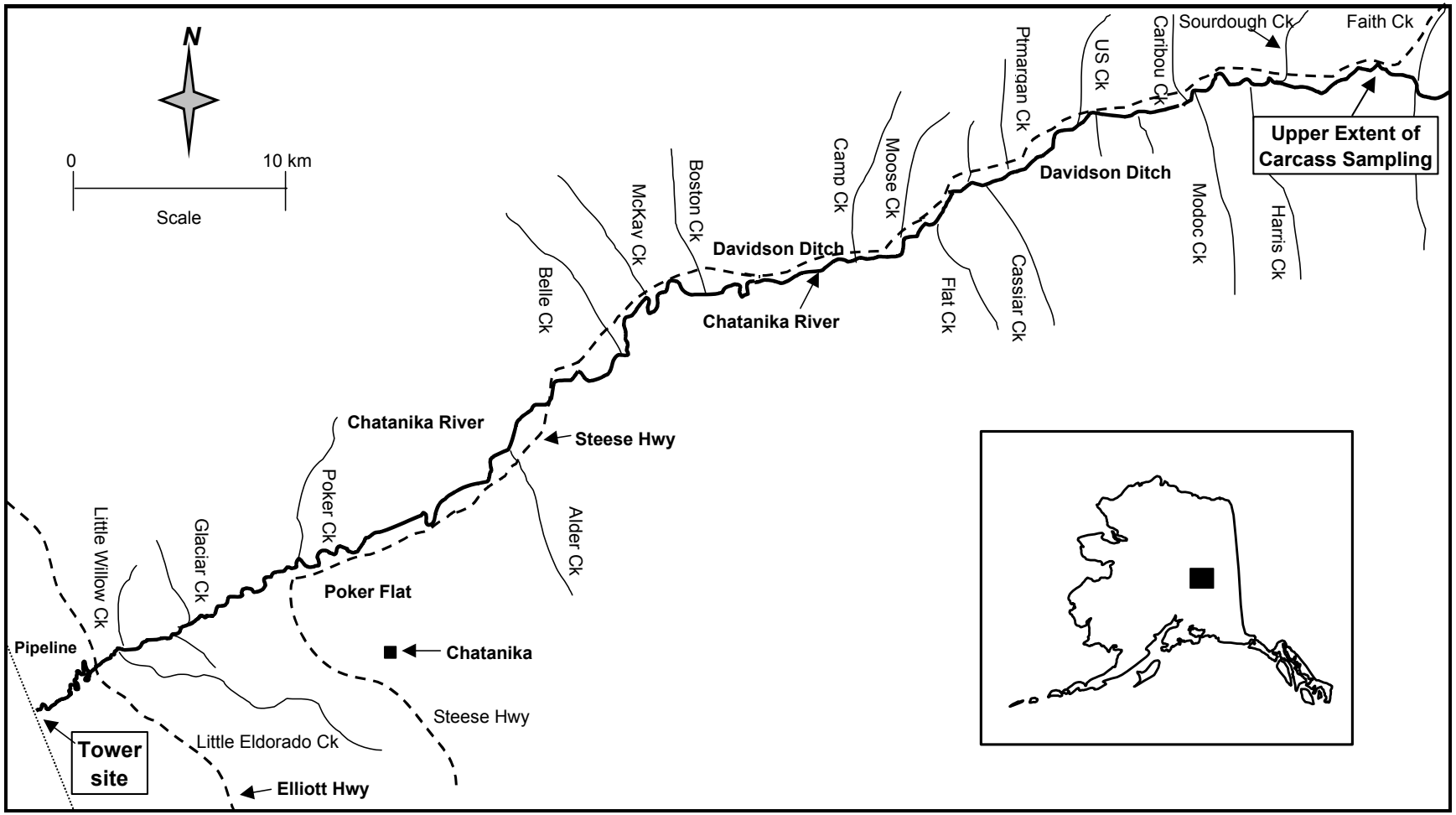

Figure 2.-Chatanika River study area.

fishing districts in the Yukon and Tanana rivers (Figure 3). Subsistence and/or personal use fishing also occur in each district.

From 1986 to 1993, chinook salmon escapements in the Chena River were estimated using mark-recapture experiments and monitored with aerial surveys. This information, along with similar information gathered from the Salcha River, was used to evaluate management of the commercial, subsistence, personal use, and sport fisheries on Tanana River stocks. However, these methods only provided fishery managers with limited inseason information. Mark-recapture experiments occurred after most of the escapement had passed through the various fisheries. Aerial surveys did not provide consistent indices of escapement. Consequently, tower-counts were initiated on the Chena and Salcha rivers in 1993 to provide additional inseason escapement information.

Escapements of chinook salmon in the Chatanika River prior to 1997 were assessed on a semi-annual basis with aerial surveys from fixed wing aircraft. This methodology was inadequate, as evidenced by harvest estimates that exceeded the escapement estimates in some years. A mark-recapture experiment was conducted in 1997, but difficulties in capturing adequate numbers of fish precipitated the switch to tower counting beginning in 1998.

In 1992, ADF&G established an aerial survey escapement goal of 1,700 chinook salmon for the Chena River. Using counts from aerial surveys and mark recapture abundance estimates, the escapement goal for aerial surveys was expanded into actual abundance (Evenson 1996), and a minimum escapement goal of 6,300 fish using this expansion was developed. In 1987 the Alaska Board of Fisheries (BOF) established a sport harvest guideline of 300 to 600 chinook salmon for the Chena River.

In January of 2001, the BOF adopted the ADF&G biological escapement goal (BEG) range of 2,800 to 5,700 chinook salmon for the Chena River. The BEG was calculated using a spawner-recruit model which incorporated past mark-recapture/tower escapement values, harvest estimates, and stock composition data from escapements and harvest (Evenson 2002). Also in January 2001, an escapement based management strategy replaced the interim management strategy of using a guideline sport harvest level (300 to 600 chinook salmon). The department was directed to manage the fisheries to achieve the BEG range (Doxey *In prep*). Neither escapement goals nor guideline harvest ranges have been established for the Chatanika River salmon stocks.

Summer chum salmon *Oncorhynchus keta* also return annually to the Chena and Chatanika rivers. The timing of chum salmon migration is later than that of chinook salmon, but there is overlap. Some chum salmon are taken incidentally in the sport fisheries, primarily by anglers targeting chinook salmon. Chum salmon escapements are monitored throughout the duration of the chinook salmon run, but counts are terminated prior to the end of the chum salmon run. The incomplete escapement counts are used by ADF&G Commercial Fisheries Division (CFD) for inseason management of commercial and subsistence chum salmon fisheries in the Tanana River. Currently there are no established sport or commercial harvest guidelines or escapement goals for chum salmon in the Chena and Chatanika rivers.

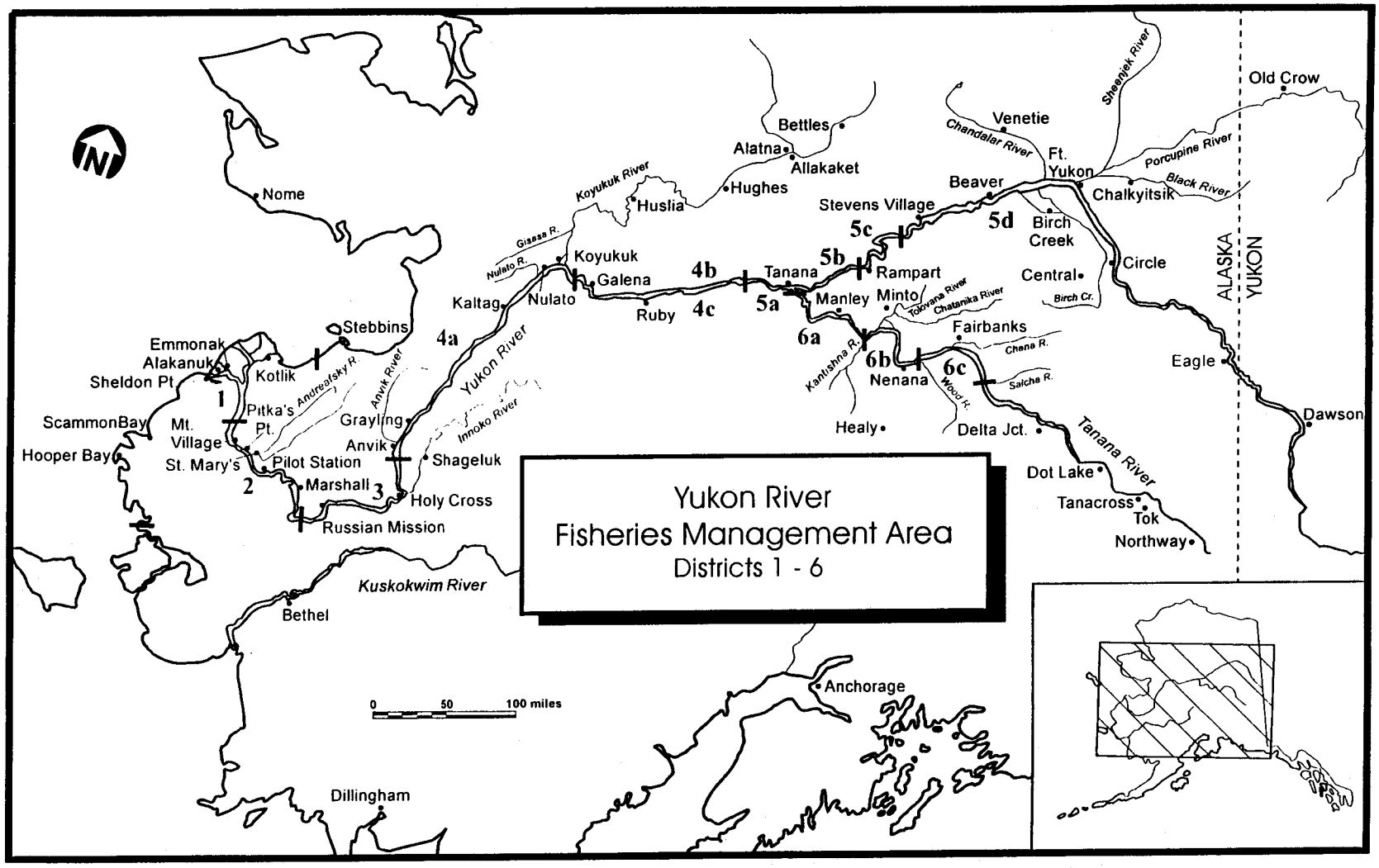

Figure 3.-Fishing districts in the Yukon River drainage.

The research objectives of the Interior chinook salmon projects in 2001 were to:

1. estimate the total escapement of chinook salmon in the Chena and Chatanika rivers using tower counting techniques;
2. estimate age and sex compositions of the escapement of chinook salmon in the Chena and Chatanika rivers by means of carcass samples; and,
3. estimate the total escapement of chinook salmon in the Chena River using mark-recapture techniques if the tower counts became unreliable due to poor viewing conditions.

Project tasks were to:

1. count chum salmon in the Chena and Chatanika rivers in conjunction with the chinook salmon tower counts; and,
2. count coho salmon in the Delta Clearwater River from a drifting river boat at weekly intervals during the run until peak escapement was reached.

METHODS

Tower-Counts

Daily escapements of chinook and chum salmon were estimated by visually counting them at fixed intervals as they passed through the Moose Creek Dam on the Chena River (Figure 1) and in front of a scaffold tower on the bank of the Chatanika River. The counting site for the Chatanika River was located immediately downstream from the Alyeska pipeline crossing (Figure 2). Counters stood on the deck of the dam looking down at the salmon in the Chena River, and sat on a platform atop the scaffold tower looking down and across the Chatanika River. The counts were conducted from 30 June to 29 July for the Chena River and 3 July to 29 July for the Chatanika River. Little or no spawning occurs downstream from these sites. No harvest of salmon is allowed upstream from the dam on the Chena River, so completed estimates from tower-counts represent total escapement. Most sport fishing for salmon in the Chatanika River occurs upstream from the tower, so complete tower-count estimates represent the total inriver return for the Chatanika River.

A string of light-colored fabric panels was placed across the bottom of the rivers from bank to bank adjacent to the counting platforms to backlight fish as they crossed. A string of lights was suspended over the panels to provide illumination during periods of low ambient light. When the lights were turned on, they were left on until salmon crossing the panels could be seen with ambient light, ensuring that salmon passed over the panels at the same rate during counting and non-counting periods.

Sampling Design

A stratified systematic sampling design was used to estimate daily passage of chinook and chum salmon. Personnel were assigned to 8-h shifts and counted salmon for the first 20 minutes of each hour. Counts were limited to 20 minutes to alleviate eyestrain and fatigue. The width of the Chena River made it possible for fish to pass unseen by a single observer, so the river was bisected by placing a red strip across the panels near the center of the channel, and 10 minute counts were conducted on each side. The count on the left side of the river (facing upstream) began within the first 10 minutes of the hour, and the count of the right side immediately followed. In contrast, the Chatanika River channel was sufficiently narrow to permit a single

20-min count over the entire width. A week consisted of 21 possible 8-h shifts (three shifts per day). Shift I started at 2400 hours and ended at 0759 hours; shift II started at 0800 hours and ended at 1559 hours; shift III started at 1600 hours and ended at 2359 hours.

Three fisheries technicians were assigned to count on each river. For both rivers, 15 out of 21 possible 8-h shifts were scheduled each week. High, murky water prevented some of the scheduled counts for both rivers.

The total number of fish passing over the panels during any single 10 or 20-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. If more fish were counted moving downstream than upstream, the resulting negative number was expanded and used as part of the daily estimate of passage.

Abundance Estimator

Estimates of abundance were stratified by day and by river half for the Chena River. The daily estimates of abundance were considered two-stage direct expansions where the first stage consisted of 8-h shifts within a day and the second stage consisted of 10-min counting periods within a shift. The second stage was considered systematic sampling because the 10-min counting periods were not randomly chosen. The formulas (1-10) in this section for parameter estimates and variances necessary to calculate escapement from counting tower data were taken directly or modified from those provided in Cochran (1977).

The expanded shift passage on day i and shift j was calculated by:

$$Y_{di} = \frac{M_{di}}{m_{di}} \sum_{j=1}^{m_{di}} y_{dij} . \quad (1)$$

The average shift passage for day d was:

$$\overline{Y}_d = \frac{\sum_{i=1}^{h_d} Y_{di}}{h_d} . \quad (2)$$

The expanded daily passage was:

$$\hat{N}_d = \overline{Y}_d H_d . \quad (3)$$

The period sampling was systematic, because a period was sampled every hour in a shift. The variance associated with periods was calculated as:

$$s_{2di}^2 = \frac{1}{2(m_{di} - 1)} \sum_{j=2}^{m_{di}} \left(y_{dij} - y_{dij-1} \right)^2 . \quad (4)$$

Shift sampling was random. The between shift variance was calculated as:

$$s_{1d}^2 = \frac{1}{h_d - 1} \sum_{i=1}^{hd} \left(Y_{di} - \overline{Y}_d \right)^2 . \quad (5)$$

The variance for the expanded daily passage was estimated by:

$$\hat{V}\left(\hat{N}_d\right)=\left[(1-f_{1d})H_d^2\frac{s_{1d}^2}{h_d}\right]+\left[\frac{1}{f_{1d}}\sum_{i=1}^{h_d}\left((1-f_{2di})M_{di}^2\frac{s_{2di}^2}{m_{di}}\right)\right] \quad (6)$$

where:

$$f_{1d}=\frac{h_d}{H_d}; \quad (7)$$

$$f_{2di}=\frac{m_{di}}{M_{di}}; \quad (8)$$

d = day;

i = 8-h shift;

j = 10-min counting period;

y = observed period count;

Y = expanded shift passage;

m = number of 10-min counting periods sampled;

M = total number of possible 10-min counting periods;

h = number of 8-h shifts sampled;

H = total number of possible 8-h shifts;

D = total number of possible days;

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

s_1^2 = estimated variance of total across shifts.

Passage for the entire run and it's variance were estimated by:

$$\hat{N}=\sum_{d=1}^{D}\hat{N}_d \text{, and} \quad (9)$$

$$\hat{V}\left(\hat{N}\right)=\sum_{d=1}^{D}\hat{V}(\hat{N}_d) \quad (10)$$

For the Chena River, the daily expanded shift passage and the associated variance were calculated for each side and then added. Total abundance and the associated variance were calculated similarly by summing the estimates from each side. For the Chatanika River, the same estimator and variance equations were used, except that j, m, M and f_2 represented 20-min counting periods and were adjusted accordingly.

The above equations worked well when two or three 8-h shifts were worked in a day. High water sometimes forced counts to be curtailed to one 8-h shift per day. The equation for total estimated variance across shifts (equation 5) assumes greater than one 8-h shift was counted each day, or the denominator becomes zero. For days when only one shift was counted, the SE was

estimated from the total average daily coefficient of variation (CV) for each river and species for those days when more than one shift was counted. 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).

When k consecutive days were not sampled due to adverse viewing conditions, a moving average estimate for the missing day i was calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\ j\ was\ sampled)\hat{N}_j}{\sum_{j=i-k}^{i+k} I(day\ j\ was\ sampled)} \tag{11}$$

where:

$$\mathrm{I}(\cdot) = \begin{cases} 1 & \text{when the condition is true} \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

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.

Age-Sex Composition

Sampling to estimate age and sex composition took place on the Chena River during 31 July-13 August and during 31 July-9 August on the Chatanika River. Salmon carcasses were collected with long handled spears. A boat powered by an outboard motor equipped with a jet unit was used on the Chena River, and samples were collected from the Moose Creek Dam to approximately 76 km upriver (Figure 1). A canoe was used during Chatanika River sample collection from the Alyeska Pipeline river crossing to approximately 85 km upriver (Figure 2).

This was the second season of a multi-year cooperative radiotelemetry program conducted by CFD and the National Marine Fisheries Service. Near Marshall and Russian Mission on the lower Yukon River, chinook salmon were marked with spaghetti tags and/or radio transmitters. Recovery of some of these tags was a secondary benefit of the carcass survey.

Scales were taken from each carcass for age determination, and sex was determined from external characteristics and, in questionable cases, by examining the gonads. An attempt was made to remove three scales 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). Due to the poor condition of some carcasses, scales were sometimes removed wherever they were available.

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). After examination, all carcasses were sliced through the left orbit in order to prevent resampling and returned to the river. Ages were assigned using the European notation x.x which represents the number of scale annuli formed during river residence and ocean residence.

Biased estimates of sex composition have been noted during previous carcass sampling events when sex ratios of chinook salmon collected during carcass surveys were compared with those

collected by electrofishing (Stuby 2000). Correcting the estimated proportion of females in an escapement from a carcass survey to the proportion we may have observed by electrofishing required analysis of data from previous years when both sampling procedures were conducted. Carcass survey procedures are described above and electrofishing procedures conducted for mark-recapture experiments are described in Stuby (2001). Both electrofishing and carcass survey data are available for eight years from the Chena River (1989-92, 1995-97, and 2000) and seven years from the Salcha River (1987-92, 1996).

The abundance estimate was apportioned by sex prior to apportioning by age categories within each sex. Estimates of the proportion of females and males in the Chena River escapement based on carcass surveys were adjusted to estimate what would have been observed from an electrofishing sample, had that occurred. The estimated proportions of males and females from carcass surveys was (Cochran 1977):

$$\hat{p}_{sc} = \frac{y_{sc}}{n_c}; \tag{13}$$

with variance:

$$\hat{V}[\hat{p}_{sc}] = \frac{\hat{p}_{sc}(1-\hat{p}_{sc})}{n_c - 1}; \tag{14}$$

where y_{sc} is the number of salmon of sex s observed during carcass surveys and n_c is the total number of salmon of either sex observed during carcass surveys for $s = m$ or f.

The correction factor necessary to adjust estimates of the proportion of females in the Chena River escapement from carcass surveys in years when no electrofishing is conducted is R_p = 0.76153 with $\hat{V}(R_p)$ = 0.00754092.

The estimate and variance (Goodman 1960) of the proportion of females observable during electrofishing, $\tilde{p}_{fe}$, is:

$$\tilde{p}_{fe} = \hat{p}_{fc} R_p \text{ with } \hat{V}(\tilde{p}_{fe}) = \hat{p}_{fc}^2 \hat{V}(R_p) + R_p^2 \hat{V}(\hat{p}_{fc}) - \hat{V}(R_p)\hat{V}(\hat{p}_{fc}). \tag{15}$$

The estimate and variance of the proportion of males observable during electrofishing are $\tilde{p}_{me} = 1. - \tilde{p}_{fe}$ and $\hat{V}(\tilde{p}_{me}) = \hat{V}(\tilde{p}_{fe})$.

Abundance of each sex is then estimated by:

$$\hat{N}_s = \tilde{p}_{se}\hat{N} \tag{16}$$

The variance for $\hat{N}_s$ in this case is (Goodman 1960):

$$Var(\hat{N}_s) = Var(\tilde{p}_{se})\hat{N}_s^{\,2} + Var(\hat{N}_s)\tilde{p}_{se}^2 - Var(\tilde{p}_{se})Var(\hat{N}_s). \tag{17}$$

The proportion of fish at age by sex s was calculated as:

$$\hat{p}_{sk} = \frac{y_{sk}}{n_s} \tag{18}$$

where: $\hat{p}_{sk}$ = the estimated proportion of chinook salmon that are age k; y_{sk} = the number of chinook salmon sampled that are age k; and, n_s = the total number of chinook salmon sampled.

The variance of this proportion was estimated as:

$$\hat{V}[\hat{p}_{sk}] = \frac{\hat{p}_{sk}(1-\hat{p}_{sk})}{n_s - 1}. \quad (19)$$

Abundance of age or size class k for each sex was then estimated by:

$$\hat{N}_{sk} = \hat{p}_{sk}\hat{N}_s \quad (20)$$

The variance for $\hat{N}_{sk}$ in this case was (Goodman 1960):

$$Var(\hat{N}_{sk}) = Var(\hat{p}_{sk})\hat{N}_s^2 + Var(\hat{N}_s)\hat{p}_{sk}^2 - Var(\hat{p}_{sk})Var(\hat{N}_s). \quad (21)$$

Aerial Counts

An aerial survey count of chinook salmon in the Chena River was conducted by CFD staff after peak escapement had passed the dam. The daily tower counts of chinook salmon and weather conditions were considered when determining the optimum day for the survey. The survey was conducted on 31 July. The count was made from a low flying, fixed-wing aircraft. Barton (1987b) described the methods used for this survey. The proportion of the total estimated escapement counted by the aerial survey was calculated.

RESULTS

Chena River Chinook Salmon Studies

Chinook salmon were first counted (day 1 of the run) on 5 July 2001. Documented escapement (escapement during days when counting was conducted) was 9,244 (SE = 550) chinook salmon (Table 2). Poor counting conditions prevented counts from being conducted during 8-9 July and on 15 July. Total escapement for the period 30 June-29 July (including days of missed counting) was estimated to be 9,696 (SE = 568) chinook salmon. The largest expanded daily count of chinook salmon for the Chena River was 1,017 (SE = 97) on 18 July. Daily passage of chinook salmon was declining rapidly by 29 July when the count was terminated at the beginning of an extended period of high water. Typically during counts, more fish passed through the left side of the dam. Raw count data are available as electronic files described in Appendix A.

The calendar date where 50% of the season's escapement of chinook salmon had passed the Moose Creek Dam on the Chena River has varied from 14 July to 24 July for the five years during which total escapement was estimated using tower counts. However, the day of the run at which 50% of the escapement had migrated past the dam has been relatively consistent, with the long term average being day 15 of the run (Figure 4). The 2001 escapement conformed to that average. The average total escapement estimated from complete tower-counts for 1993, 1994, and 1997 - 1999 was 9,231. The tower-count escapement estimates were unreliable for 1995 and 1996 due to high water events. Mark-recapture experiments were required in order to develop estimates for those two years. Every year since the inception of tower-counts, escapement has exceeded the minimum of the BEG range (2,800 chinook salmon; Table 3). Cumulative passage by day of runs in 2001 tracked well with the average for the five years of complete tower counts (Figure 5).

Table 2.-Daily chinook salmon passage at the Chena River counting site, 2001. Shaded cells indicate days with missing counts due to high water.

Date	Day Of Run	Number of 10 min Counts/Side	Left Side			Right Side			Total		
			Number Counted	Estimated Passage	SE	Number Counted	Estimated Passage	SE	Number Counted	Estimated Passage	SE
30-Jun-01		8	0	0	0	0	0	0	0	0	0
1-Jul-01		8	0	0	0	0	0	0	0	0	0
2 Jul-01		16	0	0	0	0	0	0	0	0	0
3-Jul-01		16	0	0	0	0	0	0	0	0	0
4-Jul-01		8	0	0	0	0	0	0	0	0	0
5-Jul-01	1	13	1	11	9	0	0	0	1	9	9
6-Jul-01	2	14	1	9	9	0	0	0	1	9	9
7-Jul-01	3	8	0	0	23	0	0	0	0	0	0
8-Jul-01	4	0	0	15	23	0	17	26	0	32	35
9-Jul-01	5	0	0	25	136	0	30	26	0	55	35
10-Jul-01	6	14	4	36	23	5	51	26	9	87	35
11-Jul-01	7	20	6	39	12	5	38	16	11	77	20
12-Jul-01	8	16	46	414	136	33	297	143	79	711	198
13-Jul-01	9	16	35	315	72	16	144	46	51	459	85
14-Jul-01	10	16	43	387	107	16	144	38	59	531	114
15-Jul-01	11	0	0	252	107	0	113	44	0		
16-Jul-01	12	12	8	117	48	5	81	44	13	198	65
17-Jul-01	13	16	31	279	130	24	216	86	55	495	156
18-Jul-01	14	16	86	774	74	27	243	63	113	1,017	97
19-Jul-01	15	16	31	279	59	10	90	19	41	369	62
20-Jul-01	16	15	66	661	254	25	249	97	91	910	272
21-Jul-01	17	16	26	234	52	7	63	15	33	297	54
22-Jul-01	18	16	55	495	87	16	144	53	71	639	101
23-Jul-01	19	16	63	567	173	14	126	28	77	693	175
24-Jul-01	20	16	75	675	223	35	315	71	110	990	234
25-Jul-01	21	16	36	324	86	12	108	51	48	432	100
26-Jul-01	22	16	51	459	96	12	108	33	63	567	102
27-Jul-01	23	24	46	276	40	24	144	26	70	420	48
28-Jul-01	24	16	19	171	59	10	90	31	29	261	67
29-Jul-01	25	8	4	72	0	0	0	0	4	72	22
Total		392	733	6,886	506	296	2,810	250	1,029	9,696	568

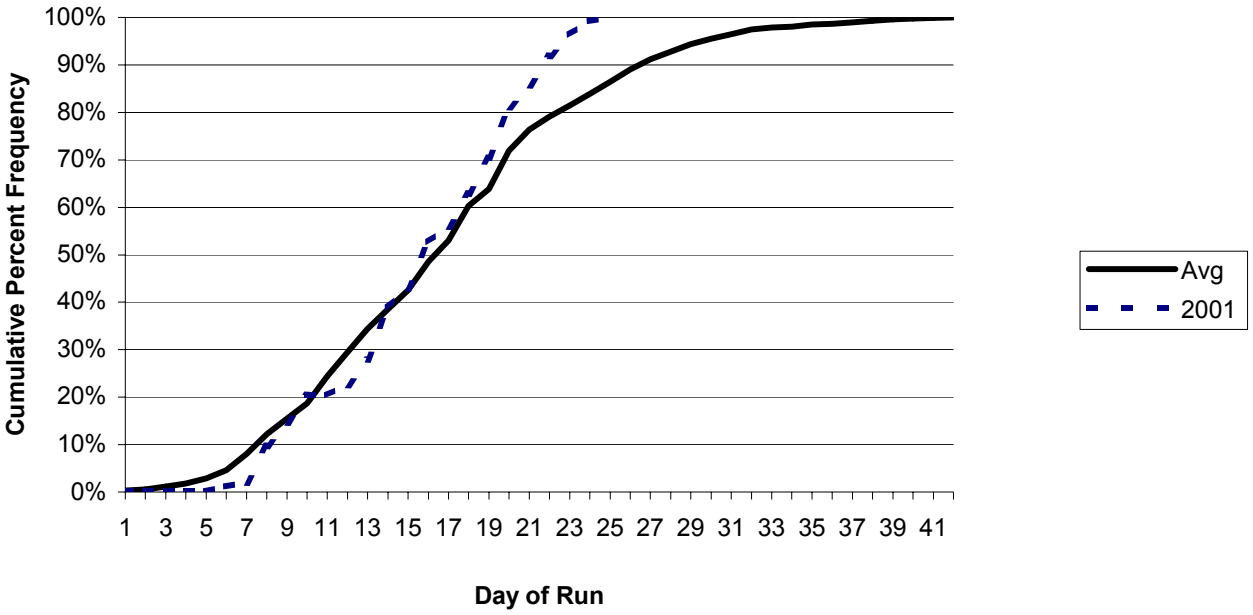

Figure 4.-Cumulative passage by day of run of Chena River chinook salmon comparing average of 1993, 1994, 1997, 1998, and 1999 with 2001. Day 1 of the 2001 run was 5 July.

Table 3.-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 Chena River, 1986 - 2001.

Year	Estimated Abundance[a]	SE	Enumeration Method[c]	Aerial Survey Count	Aerial Survey Condition[b]	Proportion of Total Escapement
1986	9,065	1,080	M-R	2,031	Fair	0.22
1987	6,404	557	M-R	1,312	Fair	0.20
1988	3,346[d]	556	M-R	1,966	Fair-Poor	0.59
1989	2,666	249	M-R	1,180	Fair-Good	0.44
1990	5,603	1,164	M-R	1,436	Fair-Poor	0.26
1991	3,025	282	M-R	1,276	Poor	0.42
1992	5,230	478	M-R	825	Fair-Poor	0.16
1993	12,241	387	Tower	2,943	Fair	0.24
1994	11,877	479	Tower	1,570	Fair-Poor	0.13
1995	9,680	958	M-R	3,567	Fair	0.37
1996	7,153	913	M-R	2,233	Poor-Good	0.31
1997	10,811	1,160	M-R	3,495	Fair-Good	0.32
1997	13,390	699	Tower	3,495	Fair-Good	0.26
1998	4,745	503	Tower	386	Incomplete	0.08
1999	6,485	427	Tower	2,412	Fair	0.37
2000	4,694	1,184	M-R	906	Poor-Incomplete	0.19
2001	9,696	565	Tower	1,487	Good	0.15
						Average = 0.26

[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), Skaugstad (1988, 1989, 1990a, 1990b, 1992, 1993, and 1994), Stuby and Evenson (1998), Stuby (1999-2001).

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

[c] Estimate was obtained from either mark-recapture (M-R) or Tower-counting (Tower) techniques.

[d] 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.

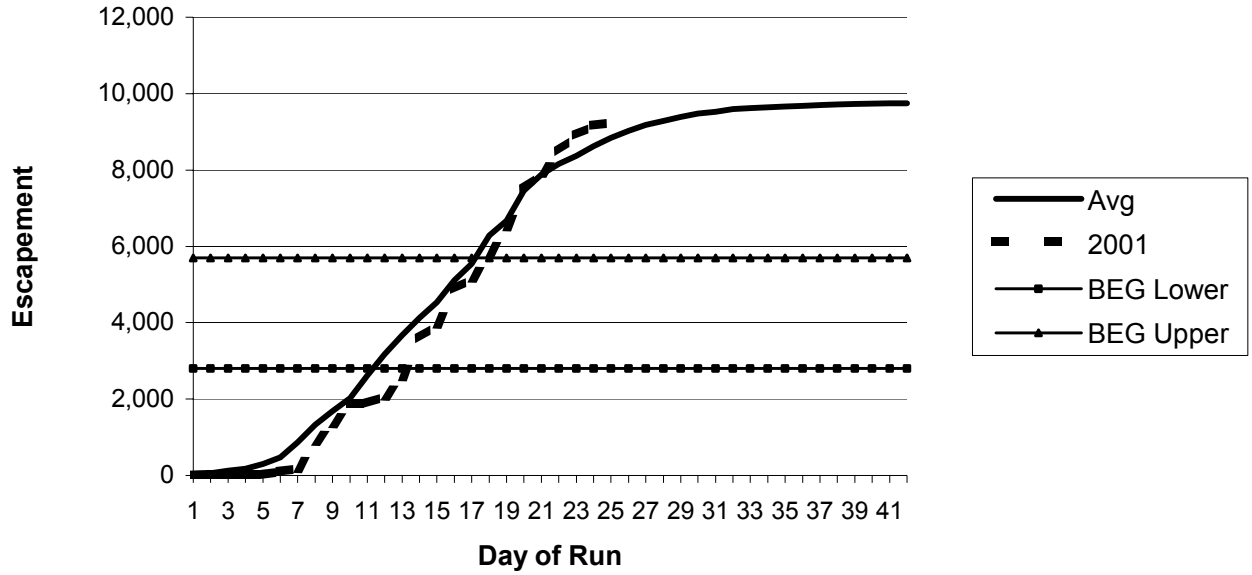

Figure 5.-Average expanded cumulative passage by day of run of Chena River chinook salmon comparing average of 1993, 1994, 1997, 1998, and 1999 with 2001. Day 1 of the 2001 run was 5 July.

Chena River Age-Sex Compositions

A total of 595 chinook salmon carcasses were collected and examined from the Chena River during 31 June-8 August. The uncorrected sex composition for this sample, including those fish not aged, was 0.57 males and 0.43 females. The average (uncorrected for gender bias) male:female ratio of all sampled fish during 1989-2000 was 0.54:0.46 (Table 4). The estimated proportion of females in the 2001 escapement based on carcass survey data corrected to the electrofishing standard was 0.32 (SE = 0.04; 95% CI = 0.23-0.42).

Ages were determined for 88% of the sample collected in 2001. The dominant age classes for males were 1.3, with a corrected abundance of 3,031 (SE = 316) and 1.4 with an abundance of 2,313 (SE = 265) chinook salmon (Table 5). Ages 1.1 (abundance = 67, SE = 39), 1.2 (abundance = 1,010, SE = 162), and 1.5 (abundance = 135, SE = 55) were also present. The dominant age class for females was 1.4 with an abundance of 2,249 (SE = 320) chinook salmon. Females at ages 1.2 (abundance = 69, SE = 32), 1.3 (abundance = 548, SE = 108), and 1.5 (abundance = 274, SE = 69) were also present.

Chena River Aerial Survey

A total of 1,487 chinook salmon were counted on 31 July during the Chena River aerial survey. Visibility into the Chena River from the aircraft was rated as good. The aerial count represented 0.15 of the tower-count estimate. Since 1986, the proportion of the population observed during aerial surveys has ranged from 0.08 to 0.59 of tower/mark-recapture estimates and averaged 0.29 (Table 5).

Chena River Chum Salmon Studies

Chum salmon were first counted on 17 July. The chum salmon migration was still underway when counting ended. Documented escapement (not including expansions for days when counts were missed due to high, turbid water) through 29 July was 4,773 (SE = 380) chum salmon (Table 6). The largest daily-expanded count was 1,242 chum salmon on 26 July. The run appeared to be tapering off when the ADF&G crew terminated the counts. A research contractor funded by Bering Sea Fishermen's Association (BSFA) provided technicians to continue the counts after ADF&G ended counting efforts. However, their efforts to enumerate chum salmon passage were thwarted by high, turbid water.

Chatanika River Chinook and Chum Salmon Studies

During 1980-1996, abundance of chinook salmon in the Chatanika River was assessed with aerial or boat-counts (Table 7). In 1997, a mark-recapture experiment was performed. After 1997, escapement was estimated from tower counts. During 2001, chinook salmon were first counted (going downstream) at the tower on 4 July. Total 2001 estimated escapement, including one day when counts were missed due to high, turbid water, was 964 (SE = 112) chinook salmon. The largest daily expanded counts for the Chatanika River were 108 (SE = 64) chinook salmon on 19 July and 22 July (Table 8). Counts were terminated on 29 July at the beginning of what became an extended period of high water and turbidity. Catches of chinook salmon in subsistence fishery fish wheels in the Tanana River downstream from the Chatanika River were declining at the time, which indicated the peak of the run had passed.

Estimated escapement of chum salmon for 3 July to 29 July was 388 (SE = 69) fish. As with the Chena River, the project concluded while chum salmon were still migrating past the tower. The

Table 4.-Proportions of male and female chinook salmon sampled from the Chena and Chatanika rivers, 1989-2001.

Year	Sample Size			Proportion	
	Males	Females	Total	Males	Females
Chena River					
1989[a]	119	218	337	0.35	0.65
1990[a]	430	382	812	0.53	0.47
1991[a]	267	120	387	0.69	0.31
1992[a]	369	212	581	0.64	0.36
1993[a]	205	38	243	0.84	0.16
1994[a]	326	275	601	0.54	0.46
1995[a]	312	586	898	0.35	0.65
1996[a]	268	346	614	0.44	0.56
1997[a]	524	354	878	0.60	0.40
1998[a]	160	107	267	0.60	0.40
1999[a]	74	134	208	0.36	0.64
2000[b]	286	72	358	0.80	0.20
2001[a]	342	253	595	0.57	0.43
Average 1989-00	278	237	515	0.54	0.46
Chatanika River					
1995[a]	21	49	70	0.30	0.70
1996[a]	60	48	108	0.56	0.44
1997[c]	231	71	302	0.76	0.24
1998[a]	40	20	60	0.67	0.33
1999[a]	7	19	26	0.27	0.73
2000[a]	26	11	37	0.70	0.30
2001[a]	20	24	44	0.45	0.55
Average 1995-00	64	36	101	0.64	0.36

[a] Samples collected during carcass surveys.

[b] Samples collected during electroshock surveys.

[c] Combined carcass and electroshock samples.

Table 5.-Number and proportions by age and sex, and estimated abundance, of chinook salmon sampled during the Chena River carcass survey, 2001.

Age	Sample Size	Sample Proportion	Corrected Abundance	SE
		Male		
1.1	3	0.01	67	39
1.2	45	0.15	1,010	162
1.3	135	0.46	3,031	316
1.4	103	0.36	2,313	265
1.5	6	0.02	135	55
Total Aged	292	1.00		
Total Males[b]	342	0.57		
Corrected Total[c]		0.68	6,556	544
		Female		
1.2	5	0.02	69	32
1.3	40	0.17	548	108
1.4	164	0.72	2,249	320
1.5	20	0.09	274	69
Total Aged	229	1.00		
Total Females[b]	253	0.43		
Corrected Total[c]		0.32	3,140	428

[a] Age is represented by 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 for a total age of seven years).

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

[c] Estimated proportion of females was corrected by a factor of 0.7615 and total abundance of females was calculated using this corrected proportion. Abundance of females at age was calculated by multiplying the corrected total abundance by the sample proportion for each age class. Similar calculations were conducted for males where the corrected proportion of males was one minus the corrected proportion of females.

Table 6.-Daily chum salmon passage at the Chena River counting site, 2001. Shaded cells indicate days with missing or unreliable counts due to high water.

	Number of	Left Side			Right Side			Total		
Date	10 min Counts	Number Counted	Estimate Passage	SE	Number Counted	Estimate Passage	SE	Number Counte	Estimated Passage	SE
30-Jun-01	8	0	0	0	0	0	0	0	0	0
1-Jul-01	8	0	0	0	0	0	0	0	0	0
2-Jul-01	16	0	0	0	0	0	0	0	0	0
3-Jul-01	16	0	0	0	0	0	0	0	0	0
4-Jul-01	8	0	0	0	0	0	0	0	0	0
5-Jul-01	13	0	0	0	0	0	0	0	0	0
6-Jul-01	14	0	0	0	0	0	0	0	0	0
7-Jul-01	8	0	0	0		0	0		0	0
8-Jul-01	0	0	0	0		0	0		0	0
9-Jul-01	0	0	0	0		0	0		0	0
10-Jul-01	14	0	0	0	0	0	0	0	0	0
11-Jul-01	20	0	0	0	0	0	0	0	0	0
12-Jul-01	16	0	0	0	0	0	0	0	0	0
13-Jul-01	16	0	0	0	0	0	0	0	0	0
14-Jul-01	16	0	0	0	0	0	0	0	0	0
15-Jul-01	0	0	0	0	0	0	0	0	0	0
16-Jul-01	12	0	0	0	0	0	0	0	0	0
17-Jul-01	16	2	18	15	2	18	12	4	36	19
18-Jul-01	16	6	54	23	6	54	24	12	108	33
19-Jul-01	16	4	36	22	10	90	31	14	126	38
20-Jul-01	15	13	127	42	7	68	27	20	195	50
21-Jul-01	16	16	144	66	7	63	17	23	207	68
22-Jul-01	16	30	270	67	10	90	31	40	360	74
23-Jul-01	16	32	288	72	7	63	28	39	351	77
24-Jul-01	16	30	270	92	14	126	55	44	396	108
25-Jul-01	16	22	198	54	31	279	53	53	477	76
26-Jul-01	16	60	540	147	78	702	186	138	1,242	237
27-Jul-01	24	54	324	67	76	456	83	130	780	107
28-Jul-01	16	32	288	179	13	117	82	45	405	197
29-Jul-01	8	4	72		1	18		5	90	
Total	400	305	2,629	294	262	2,144	241	567	4,773	380

Table 7.-Aerial survey, boat and tower counts, and a mark-recapture abundance estimate of chinook salmon in the Chatanika River, 1980-2001.

Year	Method	Lower[a]	Middle[b]	Upper[c]	Total	Survey Condition
1980	Aerial	NA[d]	NA	NA	37	Fair
1981				No Survey		
1982	Aerial	NA	NA	NA	159	Fair-Good
1983				No Survey		
1984	Aerial	NA	NA	NA	9	Poor
1985				No Survey		
1986	Aerial	NA	NA	NA	79	Fair
1987				No Survey		
1988				No Survey		
1989	Aerial	NA	NA	NA	75	Fair
1990	Aerial	10	46	5	61	Fair-Poor
1991	Aerial	2	84	18	104	Fair
1992	Aerial	NC[e]	78	NC	78[f]	Fair
1993	Aerial	6	46	23	75	Fair
1993	Boat	NC	253	NC	253[f]	Good
1994	Aerial	49	NC	NC	372	Fair
1995	Boat	NC	326	118	444[f]	Fair-Good
1996	Boat	NC	147	51	198[f]	Fair-Good
1997	M-R				3,809	
1998	Tower				864	
1999	Tower				503	
2000	Tower				398[g]	
2001	Tower				964	

[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 4).

[d] NA = section subtotals are not available.

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

[f] Incomplete survey.

[g] Incomplete tower estimate.

Table 8.-Daily chinook and chum salmon passage at the Chatanika River counting site, 2001. Shaded cells indicate days with missing or unreliable counts due to high water.

	Number	Chinook			Chum		
Date	Of Counts	Number Counted	Estimated Passage	SE	Number Counted	Estimated Passage	SE
3-Jul-01	24	0	0	0	0	0	0
4-Jul-01	16	-1	-5	3	0	0	0
5-Jul-01	16	0	0	0	0	0	0
6-Jul-01	16	0	0	0	0	0	0
7-Jul-01	13	0	0	0	0	0	0
8-Jul-01	16	0	0	0	0	0	0
9-Jul-01	16	0	0	0	0	0	0
10-Jul-01	15	0	0	0	0	0	0
11-Jul-01	16	0	0	0	0	0	0
12-Jul-01	16	11	50	43	10	45	41
13-Jul-01	15	3	15	10	0	0	0
14-Jul-01	16	6	27	11	0	0	0
15-Jul-01	0	0	45	19	0	5	5
16-Jul-01	8	7	63	19	1	9	5
17-Jul-01	16	13	59	13	13	59	13
18-Jul-01	16	6	27	24	0	0	0
19-Jul-01	16	24	108	64	0	0	0
20-Jul-01	16	17	77	17	1	5	3
21-Jul-01	16	14	63	39	1	5	3
22-Jul-01	24	36	108	26	13	39	13
23-Jul-01	14	4	23	13	2	11	5
24-Jul-01	16	15	68	18	13	59	16
25-Jul-01	16	18	81	25	0	0	0
26-Jul-01	16	5	23	14	13	59	42
27-Jul-01	16	11	50	12	11	50	17
28-Jul-01	16	16	72	29	8	36	18
29-Jul-01	12	3	14	8	2	9	8
Total	413	208	964	112	88	388	69

largest daily-expanded counts were 59 chum salmon on 17, 24 and 26 July (SE = 13, 16, and 42, respectively; Table 8).

Chatanika River Chinook Salmon Age-Sex Compositions

A total of 44 chinook salmon carcasses were sampled for sex and age from the Chatanika River. Ages were determined for 80% of the sample (Table 9). The sex ratio of the total sample was 0.45 male and 0.55 female. The average sampled male:female ratio during 1995-2000 was 0.55 males and 0.45 females (Table 4). The majority of males (0.44 of the sample) examined in 2001 were age 1.3. Males age 1.2 (0.17), 1.4 (0.33) and 1.5 (0.06) were also sampled. The majority (0.82) of females were age 1.4. Age 1.3 females comprised 0.24 of the sample and age 1.5 the remainder.

DISCUSSION

There are two primary goals driving the Chena River chinook salmon enumeration project. For management purposes, escapement status relative to the BEG (2,800 - 5,700 fish) must be tracked. Inseason documented and projected escapement estimates provide the foundation for in-season management of the chinook salmon sport fishery in the Chena River and add to the body of information used to manage the subsistence, personal use, and commercial fisheries for chinook salmon in the Tanana River downstream from the Chena River. For research purposes, the total abundance and age-sex composition information is used to build brood tables that, over time, will be used to refine the BEG.

During early July 2001, due to an extremely weak run of chinook salmon in the Yukon River drainage chinook salmon subsistence, personal use, sport, and commercial fisheries in the Tanana River drainage were closed by emergency order to conserve stocks. Subsequently, once escapement in the Chena River exceeded the lower end of the BEG range, restrictions on subsistence fishing in the Tanana River were relaxed. Ultimately sport fishing for chinook salmon was restored in the Chena River and on the Salcha River, where the escapement goal was also met (described below). Sport fishing for chinook salmon resumed on 20 July under the original regulations (daily bag and possession limit of one chinook salmon). Sport fishing for chum salmon remained closed. Chinook salmon fishing remained closed elsewhere in the Tanana River drainage due to a lack of verification that escapements were sufficient. Final estimated abundance of chinook salmon in the Chena River exceeded the upper boundary of the BEG by approximately 4,000 fish. Details of management actions are found in Doxey (*In prep*).

Estimates of total escapement from tower counts may not always be needed for management of the sport fishery. Even when periods of high, turbid water create breaks in the counts that are too lengthy (several days) to be bridged by interpolated estimates, the cumulative abundance from uninterrupted counts (documented escapement) may be sufficient to evaluate whether the BEG was achieved. If total documented escapement is within the BEG range there would be no reason to restrict fisheries.

The estimated escapement in 2001 was within the range of previous documented escapements for the Chena River (2,666-13,390; Table 3). However, the escapement estimate and age composition information provide a dataset that may prove useful as part of the long term database for the Chena River. It describes a run that showed unexpected strength in a season when the Yukon River chinook salmon run, as a whole, was generally considered to be a "disaster". This characterization was used to describe chinook salmon stocks in the Yukon River

Table 9.-Number and proportions of chinook salmon by age and sex sampled during the Chatanika River carcass survey, 2001.

Age[a]	Sample Size	Proportion
	Male	
1.2	3	0.17
1.3	8	0.44
1.4	6	0.33
1.5	1	0.06
Total Aged	18	
Total Fish[b]	20	0.45
	Female	
1.3	2	0.12
1.4	14	0.82
1.5	1	0.06
Total Aged	17	
Total Fish[b]	24	0.55

[a] Age is represented by 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.

Below the Tanana River, which included Tanana drainage stocks, and above the confluence of the Tanana and Yukon rivers which excluded the Tanana River stocks and most fish were of Canadian origin.

In this report, run timing, proportional escapement, and cumulative escapement on a given day are described by day-of-run instead of by calendar dates (i.e., day 1 is the day of first passage of a chinook salmon during a scheduled counting period). Anchoring escapement curves on day-1 of the run (rather than a range of calendar dates) and aligning cumulative escapement curves by day of run makes comparison of passage rates between years and comparisons of proportional passage compared to the long-term average (Figure 4) easier. It also facilitates escapement projections.

Over time, annual escapement and age composition estimates of the Chatanika River chinook salmon stock will allow for development of an escapement goal for the Chatanika River. The 2001 tower-count estimate of chinook salmon escapement for the Chatanika River is the third complete tower-count estimate and the highest tower count to date (Table 7). The substantially larger mark-recapture estimate of 1997 (3,809; SE = 1,507) occurred during a year of correspondingly strong chinook salmon escapements in the Chena River (Table 3) and Salcha River (Table 10). As with the Chena River, this apparent strength in 2001 was unexpected during a generally poor Yukon River chinook salmon run.

Sport fishing for chinook salmon in the Chatanika River was closed throughout 2001. In past years, sport harvests have been proportionally high relative to index measures of abundance. Since no escapement goals have been established for this river, continuation of enumeration projects to acquire precise estimates is important for managing this stock.

Sampling to accurately estimate age-sex compositions of chinook salmon on the Chatanika River continues to be problematic due to small sample sizes and gender bias associated with sampling carcasses. For these reasons, no estimates of age or sex-specific abundance are presented in this report. Because the chinook salmon run in this river is usually small, and spawning areas are relatively dispersed, it is unreasonable to expect that large samples of carcasses can be easily collected. Thus, for the purpose of developing brood tables, either different sampling strategies need to be developed, or an evaluation of whether surrogate stocks (such as the Chena River or Salcha River) can be used to estimate age-sex compositions. There was no attempt to correct for gender bias, nor to estimate age-class abundance for the small sample collected during the carcass survey.

SALCHA RIVER CHINOOK SALMON STUDIES

INTRODUCTION

Historically, the Salcha River has some of the largest chinook salmon escapements in the Yukon drainage (Schultz et al. 1994), and supports popular chinook salmon sport fishery. ADF&G Sport Fish Division conducted mark-recapture abundance estimates on the Salcha River between 1987 and 1992 (Table 9). Tower-count estimates began in 1993 and continued through 1998. After 1998, Sport Fish Division discontinued efforts to estimate chinook salmon abundance in the Salcha River. BSFA began contracting with a Fairbanks fisheries consultant to conduct tower counts, in 1999 which have continued up to the present. Their funding was from grant

Table 10.-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 River, 1987 - 2001.

Year	Estimated Abundance[a]	SE	Aerial Survey Count	Aerial Survey Condition[b]	Proportion of Total Escapement
1987	4,771[c]	504	1,898	Fair	0.40
1988	4,562[c]	556	2,761	Good	0.61
1989	3,924[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
1992	7,862[c]	975	1,484	Fair-Poor	0.19
1993	10,007[d]	360	3,636	Fair	0.36
1994	18,339[d]	549	11,823	Good	0.64
1995	13,643[d]	471	3,978	Fair-Good	0.29
1996	7,570[c]	1,238	4,866	Fair-Good	0.64
1997	18,514[d]	1,043	3,458	Poor	0.19
1998	5,027[d]	331	1,985	Poor	0.39
1999	9,198[d]	290	3,570	Fair	0.39
2000	4,595[d]	802	2,478	Poor	0.53
2001	13,328[e]	N/A	2,990	Good	N/A
				1987-2000 Avg. =	0.43

[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), Skaugstad (1988, 1989, 1990a, 1990b, 1992, 1993, and 1994), Stuby and Evenson (1998), Stuby (1999, 2000, and 2001).

[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] Estimate was obtained from tower-counts.

[e] Estimate was obtained from expansion of interrupted tower-count based on day-of-run average proportion (counts effectively ended on day 19 of run, when 6 year average proportional passage was 67.38%).

administered by the US Fish and Wildlife Service (USFWS). Escapement data for Tanana River chinook salmon stocks were given to ADF&G and are presented in this report.

METHODS

A pair of towers were erected on opposite sides of the Salcha River approximately 0.25 miles downstream from the Richardson Highway Bridge (Figure 6). Project mobilization, escapement enumeration, and data analysis procedures for Salcha River chinook and chum salmon were similar to those for the Chatanika River. Counts were conducted from 1 July to 19 September. A long period of high water caused suspension of counting beginning on 24 July, and by the time counts resumed intermittently on 7 August the chinook salmon run was virtually over.

RESULTS

Chinook salmon were first observed at the counting towers on 5 July (day 1). Counts were suspended during high water beginning on 24 July (day 20). Daily totals of 828, 1,425, and 1,191 chinook salmon were documented on 21-23 July, respectively, indicating that the run may have been at its peak (Table 11). The Chena River chinook salmon run was also showing considerable strength during that time (Table 2). Between 23 July and 7 August, counts were only conducted during two 8-hr shifts on 27 and 28 July. Documented passage was minimal. Counting at the Salcha River fully resumed on August 7 (day 34 of the run) however, few chinook salmon were seen passing. Based on the 6-year (1993-95 and 1997-1999) day-of-run average proportions, (Figure 7) cumulative passage is into the 99th percentile by day 34 of the Salcha River chinook salmon run. The highest expanded daily count of chinook salmon for the Salcha River was 1,425 (SE = 211) on 22 July (Table 11).

Documented escapement through July 23 (day 19) was estimated to be 9,300 (SE = 322) chinook salmon for the Salcha River (adjusted for three days of missing counts due to high, turbid water). After July 23, an additional 119 chinook salmon were counted. Total escapement, estimated to be 13,328 (SE = 2,163) chinook salmon, was calculated by summing the estimate from count data through 23 July with an estimate of escapement after 23 July based on historical run timing information. Raw count data are available as electronic files described in Appendix A.

The calendar dates at which 50% of the season's chinook salmon escapement has passed the Salcha River counting tower during 1993-95 and 1997-99 varied from 15 to 24 July, but the long-term average day by which 50% of the escapement passed the tower occurred on day 16 of the run (Figure 7). Termination of counting as the run was peaking precluded assessment of the 50% benchmark, but cumulative abundance at day-of-run was similar to the long term average (Figure 8) and indicative of a robust escapement. Average proportional escapement on day 19 of the run is 67.4%. The average total escapement estimated from tower-counts for 1993-1995 and 1997-1999 was 12,564. The estimated escapement for 2000 of 4,595 chinook salmon was not included in long-term average because there were about 6.5 days of consecutive missed counts due to high water during days 8-14 of the run (11-17 July). Escapement was estimated for those dates (Stuby 2000) but there is too much uncertainty with the estimate to include it in the long-term evaluations of passage patterns. Similarly, while the 2001 estimated escapement of 13,328 fish will be used for purposes of this report, this estimate should be reevaluated after future escapements are documented.

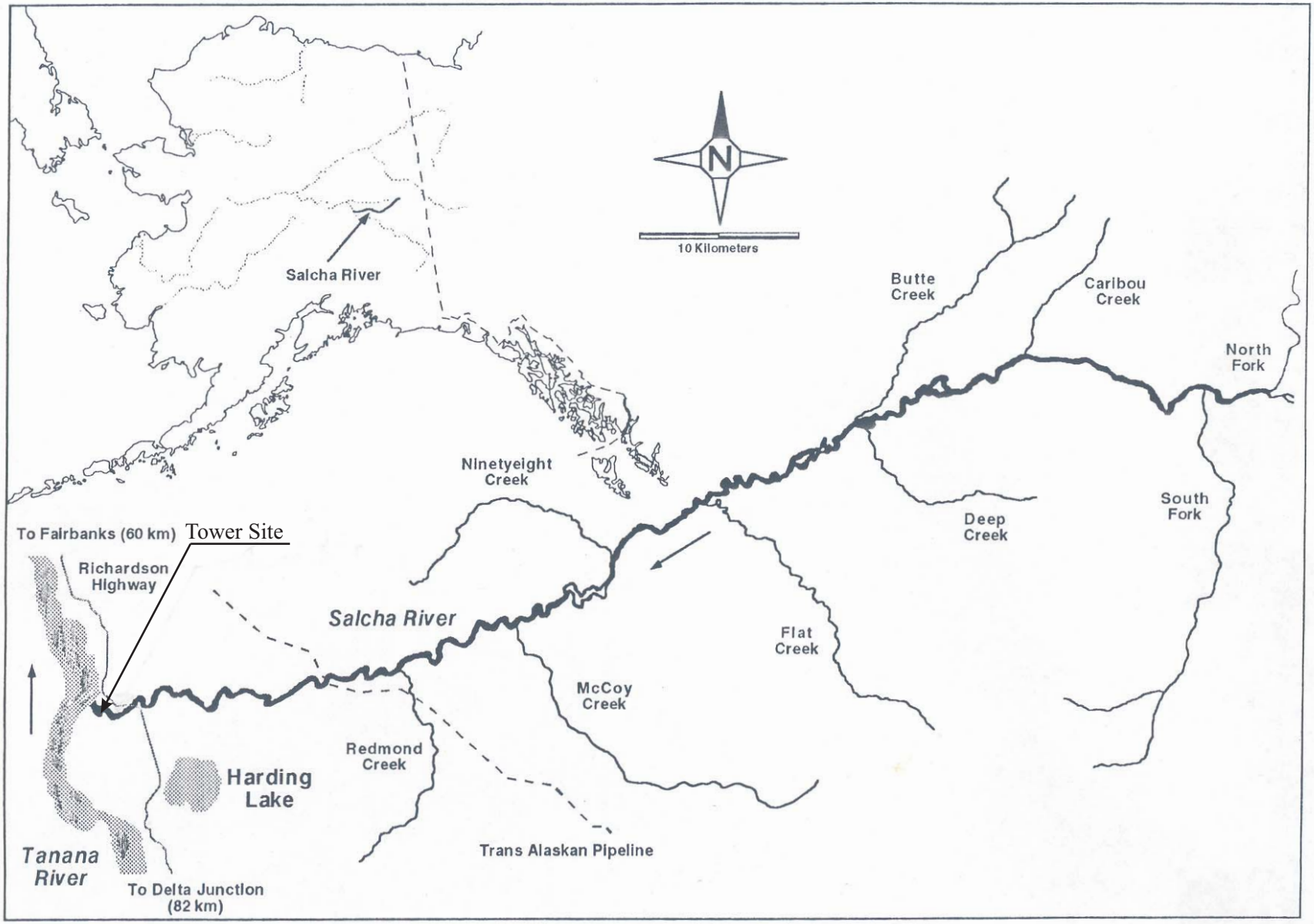

Figure 6.-Salcha River study area.

Table 11.-Daily chinook and chum salmon[a] passage at the counting site on the Salcha River, 2001. Shaded cells indicate days with missing counts due to high water.

Date	Day of Run	Count Periods	Chinook			Chum		
			Count	Estimated Passage	SE[a]	Count	Estimated Passage[a]	SE
1-Jul-01		8	0	0	-	0	0	
2-Jul-01		16	0	0	0	0	0	
3-Jul-01		16	0	0	0	0	0	
4-Jul-01		16	0	0	0	0	0	
5-Jul-01	1	23	2	6	3	0	0	
6-Jul-01	2	24	7	21	7	0	0	
7-Jul-01	3	0		35	49			
8-Jul-01	4	0		83	49			
9-Jul-01	5	0		201	49			
10-Jul-01	6	16	25	113	49	0	0	
11-Jul-01	7	24	64	192	25	0	0	
12-Jul-01	8	24	159	477	44	0	0	
13-Jul-01	9	24	219	657	79	0	0	
14-Jul-01	10	24	173	519	63	0	0	
15-Jul-01	11	24	60	180	38	5	15	13
16-Jul-01	12	24	159	477	71	27	81	22
17-Jul-01	13	24	179	537	93	27	81	20
18-Jul-01	14	24	275	825	86	63	189	26
19-Jul-01	15	24	267	801	55	101	303	37
20-Jul-01	16	24	244	732	62	137	411	42
21-Jul-01	17	24	276	828	75	108	324	45
22-Jul-01	18	24	475	1,425	211	49	147	31
23-Jul-01	19	20	348	1,191	95	71	252	25
24-Jul-01	20	0						
Total		427	2,923	9,300	322	588	1,803	92

[a] Chum salmon passage during the chinook salmon run only. Counts were suspended during high water beginning on July 24, when counts resumed the chinook and chum salmon runs were essentially over.

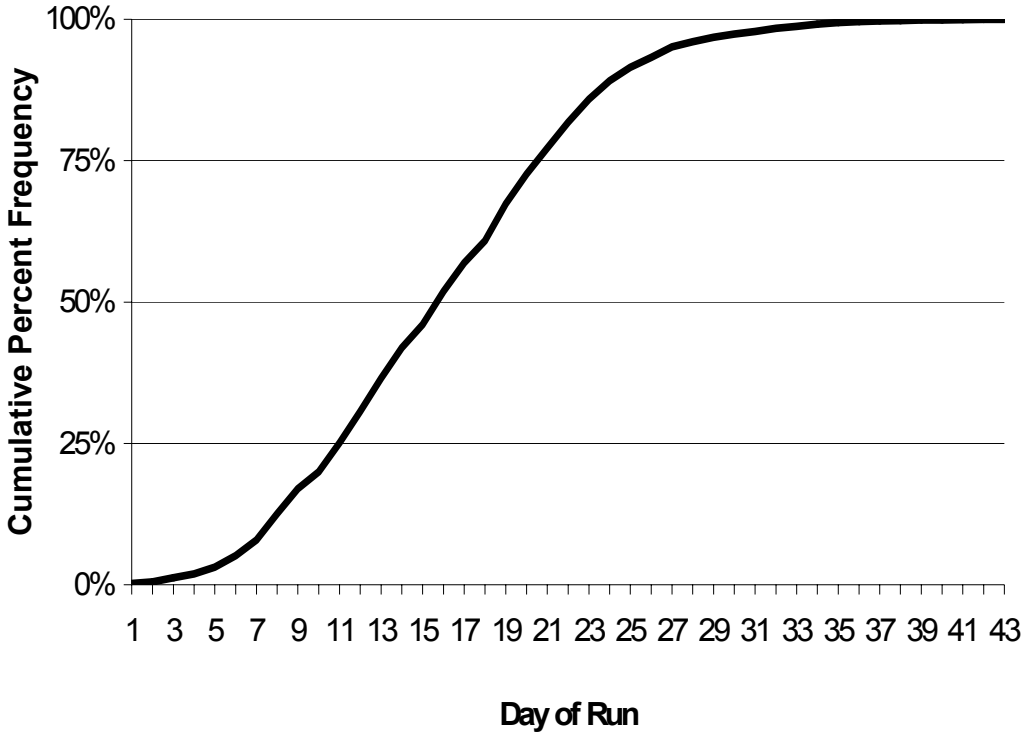

Figure 7.-Average proportional cumulative passage by day of run of Salcha River chinook salmon, 1993-95, 1997-99. Comparative data for 2001 is not included because counts terminated on day 19, as the run was peaking. Day 1 of the 2001 run was 5 July.

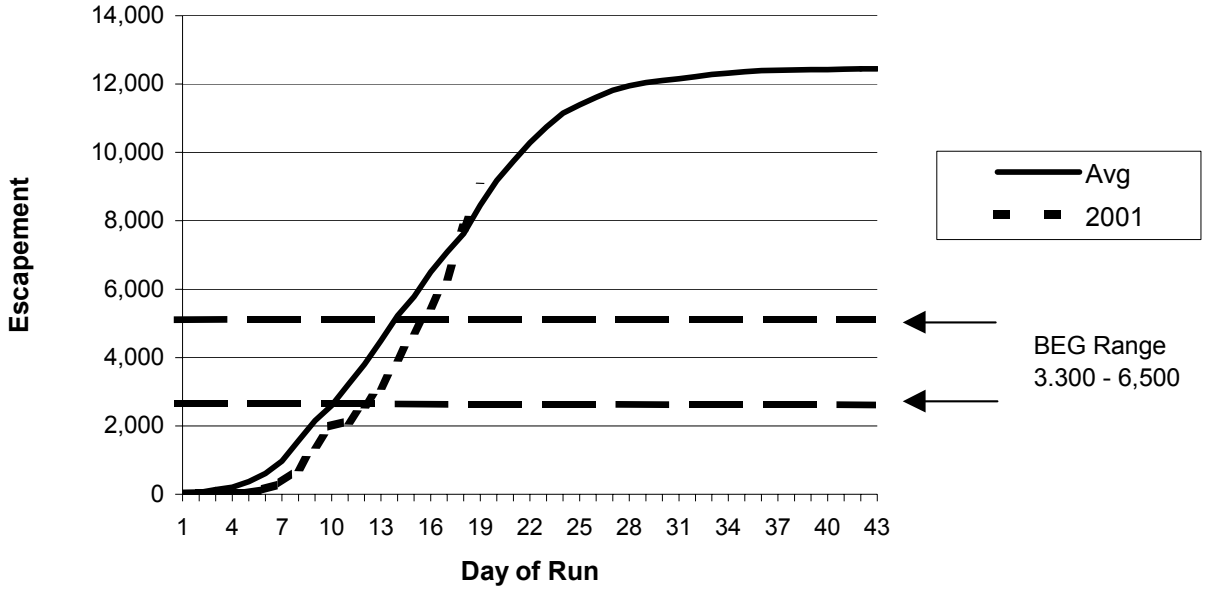

Figure 8.-Expanded cumulative passage by day of run of Salcha River chinook salmon comparing average of 1993-95, 1997-99 with 2001. Day 1 of the 2001 run was 5 July.

The BSFA enumerated chum salmon during and after the chinook salmon run. The first chum salmon were counted on 15 July, and very small numbers were still passing when counts ended on 19 September (Table 11). Efforts to obtain a complete escapement estimate were hampered by the same surge of high water that impacted the chinook escapement estimate. Large numbers of chum salmon likely passed during the forced hiatus between 23 July and 7 August. Counts were also interrupted during 17-18 August and 16-17 September. Documented escapement was 14,900 chum salmon. Raw count data is available as electronic files described in Appendix A.

Age-Sex-Length Compositions

A total of 308 chinook salmon carcasses were collected from the Salcha River during 12-14 and 26 August. The sex composition for this sample, including those fish not aged, was 0.63 males and 0.37 females. The gender bias correction factor, R_p, for the Salcha River was estimated to be 0.75 (SE = 0.19). The estimated proportion of females in the 2001 escapement, based on carcass survey data corrected to the electrofishing standard, was 0.28 (SE = 0.19). The correction factor for the Salcha River is very imprecise due to large annual variation between years.

Ages were determined for 0.63 of the sample collected in 2001. The largest age classes for males sampled and aged in 2001 were ages 1.3 (0.43), and 1.4 (0.40; Table 11). However, 52% of the males over 800 mm MEF in length (as opposed to 28% of those less than 800 mm in length) could not be aged due to errors in scale collection. One can surmise that if more of the larger males could have been successfully aged, age 1.4 might be the dominant age class. Males were also represented by ages 1.1 (0.01) and 1.2 (0.17). Age 1.4 dominated among aged females (0.72; Table 12). Females were also represented by ages 1.3 (0.19) and 1.5 (0.08). Lengths of males ranged from 330 to 1,020 mm MEF. Lengths of females ranged from 620 to 990 mm MEF. Corrected abundance estimates of age classes within sex strata were not calculated due to the small sample size (120 males and 72 females aged) and the disproportionate distribution among the age classes of scales that were aged.

Carcass sampling of chinook salmon on the Salcha River was undertaken by Sport Fish Division personnel from 1987-1998, but has since been taken over by the BSFA. The mean length at age for chinook salmon has varied between years for a given age and sex, but no consistent trends that might indicate a long term change in age composition or length at age have been apparent.

COHO SALMON COUNT IN THE DELTA CLEARWATER RIVER

INTRODUCTION

The Delta Clearwater River, a spring-fed tributary to the Tanana River, is located near Delta Junction about 160 km southeast of Fairbanks (Figure 9). Length of the mainstem is about 32 km, and the river's north fork is approximately 10 km in length. There are a number of shallow spring areas adjacent to the main channel.

The Delta Clearwater River has the largest known coho salmon escapements in the Yukon River drainage (Parker 1991). Spawning occurs throughout the main channel and in the spring areas. Before reaching the spawning grounds of the Delta Clearwater River, 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 3). Subsistence or personal use fishing also occurs in each district.

Coho salmon in the Delta Clearwater River support a popular fall sport fishery. Annual harvest's exceeded 1,000 coho salmon from 1986-1991. In recent years, catch has been high but harvest

Table 12.-Number sampled, estimated proportions, abundance[a] and mean length by sex and age class of chinook salmon in the Salcha River, 2001.

Age[b]	Sample Size	Sample Proportion	Corrected Abundance	SE	Length Mean	SE	Min	Max
			Male					
1.1	1	0.01	N/A [e]	N/A [e]	330	-	-	-
1.2	20	0.17	N/A [e]	N/A [e]	536	10	470	660
1.3	51	0.43	N/A [e]	N/A [e]	716	12	520	930
1.4	48	0.40	N/A [e]	N/A [e]	844	11	660	1,000
Total Aged	120	1.00						
Total Males[c]	194	0.63			754	10	330	1,020
Corrected Total[d]		0.72	9,608	993				
			Female					
1.2	0	0.00	N/A [e]	N/A [e]	-	-	-	-
1.3	14	0.19	N/A [e]	N/A [e]	724	15	640	820
1.4	52	0.72	N/A [e]	N/A [e]	840	7	770	990
1.5	6	0.08	N/A [e]	N/A [e]	867	19	780	910
Total Aged	72	1.00						
Total Females	114	0.37			826	7	620	990
Corrected Total[d]		0.28	3,720	993				

[a] Projected abundance based on passage pattern at on 23 July, when counts were terminated due to high water.

[b] Age is represented by 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).

[c] Totals include those chinook salmon which could not be aged. In these samples 52% of the 83 males with lengths in excess of 800 mm could not be aged.

[d] Corrected by a factor of 0.7541 (for females, with correction factor for males following suit) to reduce carcass survey gender bias identified by comparing data collected during carcass surveys and electrofishing.

[e] Insufficient numbers of aged fish and skewed proportions of aged fish within sample of males preclude apportionment of estimated numbers of males and females into age classes.

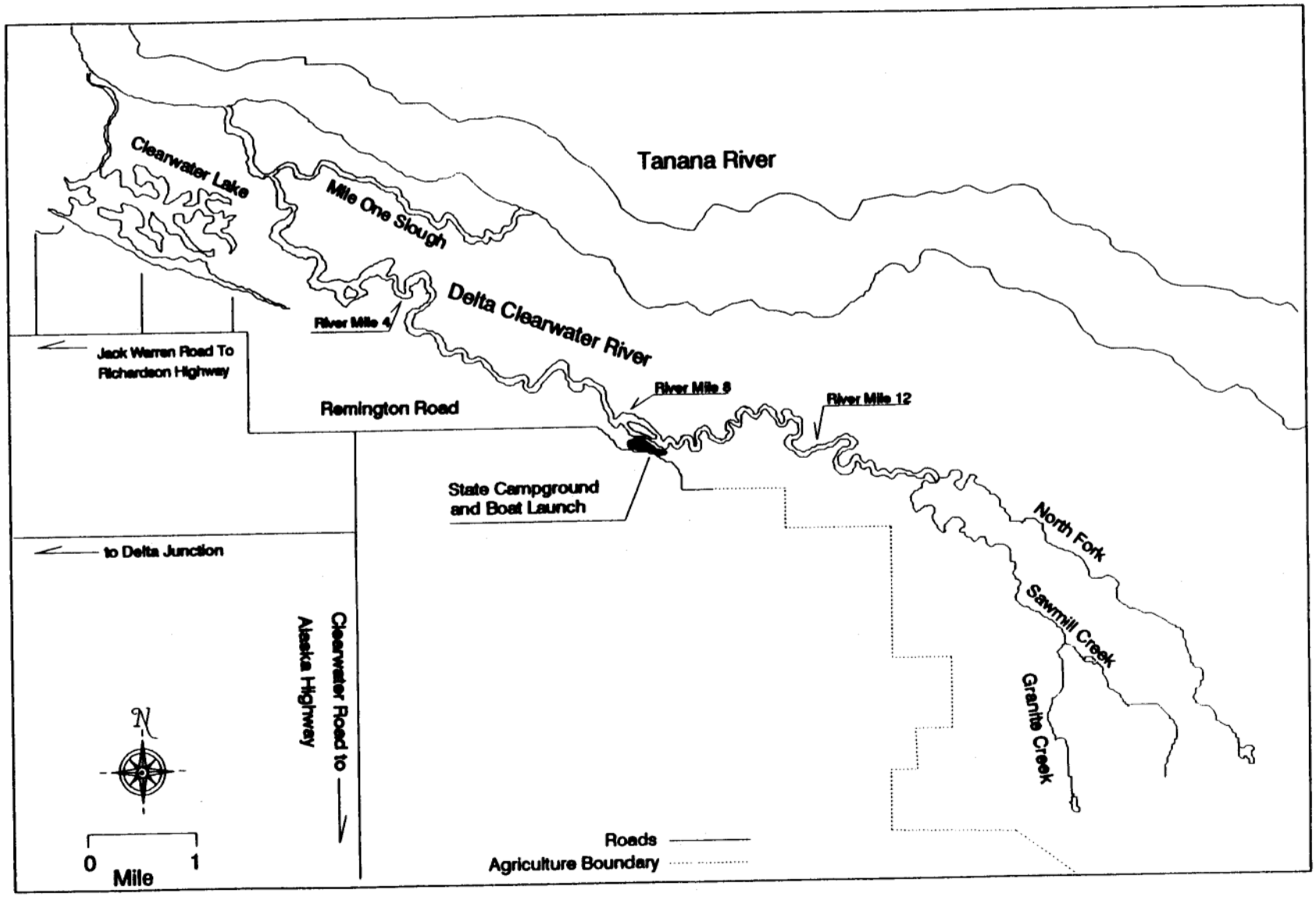

Figure 9.-Delta Clearwater River study area.

relatively low (Mills 1979-1994; Howe et al. 1995, 1996, 2001a-d; Walker et al 2003; Jennings et al. *In prep*; Table 13). The daily bag and possession limit is three coho salmon.

Historically, escapements of coho salmon into the Delta Clearwater River have been monitored by counting fish from a drifting riverboat (Parker 1991). In recent years, aerial surveys have been conducted to estimate escapement in non-boatable portions of the river (Evenson 1995, 1996; Evenson and Stuby 1997; Stuby and Evenson 1998, and Stuby 1999-2001). Escapement information has been used to evaluate management of the commercial, subsistence, and personal use fisheries, in addition to regulating the sport harvest of coho salmon by opening and closing the season and changing the bag limit. The Alaska Department of Fish and Game has established an escapement goal of 9,000 coho salmon for the Delta Clearwater River (measured with boat counts). When counts indicate that the goal may not be achieved, the bag limit may be reduced or the fishery closed. If the count exceeds the escapement goal, the bag limit may be increased. However, given the observed low harvest rates, such an increase would result in little additional harvest. The objective of the coho salmon escapement project for the Delta Clearwater River in 2001 was to count coho salmon at approximately weekly intervals throughout the run from a drifting riverboat.

METHODS

Adult coho salmon in the mainstem of the Delta Clearwater River were counted from a drifting riverboat equipped with an observation platform elevated 2 m above the water. The river was divided into 1.6-km (1-mi.) sections and counts were summarized (Figure 9). The sections were sequentially numbered beginning at the mouth. Counts were made at approximately weekly intervals until the run was judged to have peaked on 19 October, at which time the counting ceased.

Prior to 1994, the shallow spring areas adjacent to the mainstem river were not included in the surveys. Between 1994 and 1998, aerial (helicopter) surveys of the areas inaccessible by boat were conducted in order to determine the proportion of fish that spawn in these areas relative to the main river. Aerial surveys were discontinued after 1998. Instead, an expansion factor was used to approximate abundance of spawning coho salmon in the spring areas. Expansion for the tributaries/spring areas is based on the average proportion of total escapement (0.213) observed in these areas during five annual aerial surveys. The calculated abundance of coho salmon in the spring areas was added to the number of coho salmon counted during the boat survey to calculate escapement for the entire system.

RESULTS

The peak boat survey of the mainstem river was conducted on 19 October. Coho salmon were distributed throughout the entire mainstem in densities varying from 75 to 1,125 fish per mile (Table 14). A total of 46,875 fish were counted. This count was expanded by 0.213 (12,672) to account for fish spawning in adjacent spring areas. Total calculated escapement was 59,547 coho salmon.

DISCUSSION

Escapement for 2001 in the Delta Clearwater River was the second largest since combined mainstem and spring area counts began in 1994. The 2001 escapement exceeded the previous five-year average by 43,444 and exceeded the escapement goal by about 38,000 salmon. The

Table 13.-Peak escapements, harvests, and catch of coho salmon in the Delta Clearwater River, 1972-2001.

Year	Peak Escapement Counts: 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[r]	7,991	722	NA
1986	21 Oct	5,490	5,367	NA	10,857	9,002	1,005	NA
1987	27 Oct	11,700	10,600	NA	22,300	9,576	1,068	NA
1988	28 Oct	5,300	16,300	NA	21,600	13,059	1,291	NA
1989	25 Oct	5,400	7,200	NA	12,600	16,455	1,049	NA
1990	26 Oct	4,525	3,800	NA	8,325	13,471	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	937	2,435
1997	24 Oct	4,975	6,550	2,375[h]	13,900[i]	27,767	794	3,776
1998	20 Oct	7,700	3,400	2,775[h]	13,875[i]	29,755	479	1,932
1999	28 Oct	4,250	6,725	2,799[j]	13,774[k]	30,355	76	1,634
2000	24 Oct	4,025	5,200	12,364[j]	11,589[k]	17,061	252	1,890
2001	19 Oct	27,500	19,375	12,672[j]	59,547[k]	16,103	816	5,392

[a] Mile 0 to Mile 8.

[b] Mile 8 to Mile 17.5.

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

[d] Data were obtained from Mills (1979-1994) Howe et al. (1995-2001a-d), Walker et al. 2003, and Jennings et al. *In prep*.

[e] Data are not available.

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

[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.

[j] Expansion for the non-navigable portion is based on the average proportion observed in these areas from 5-years of aerial survey data.

[k] Total includes expansion for non-navigable portions of the river.

Table 14.-Counts of adult coho salmon in the Delta Clearwater River, 2001.

River Mile	Mainstem River (Boat Survey) Count (19 Oct)
17.5-16	950
16-15	2,825
15-14	2,325
14-13	2,475
13-12	2,500
12-11	1,750
11-10	2,300
10-9	2,225
9-8	2,025
8-7	1,875
7-6	1,175
6-5	4,100
5-4	2,725
4-3	7,150
3-2	3,200
2-1	6,250
1-0	1,025
Summary	
17.5-0 (Mainstem)	**46,875**
Tributaries[a]	12,672
Total Count (boat-count of mainstream plus tributary expansion)	**59,547**

[a] Expansion for the tributaries/spring areas (mainstem count x 1.27) is based on the average proportion of total escapement (0.2128) observed in these areas during 5 annual aerial surveys.

1997 parent year, from which most of this escapement originated, was within the lower half of the range of escapements since 1994 (Table 12).

There were restrictions and closures on commercial, subsistence, and personal use fishing for fall-run chum salmon during the time when coho salmon were moving up the Yukon River. Since both species are harvested during chum salmon fisheries, restrictions likely contributed to the large escapement.

ACKNOWLEDGMENTS

Doug Edwards, Samantha Strom, Tim Stadtmiller, Elwin Lawler, Valerie Baxter, and Justin Crawford were the front-line crew on the counting towers and carcass surveys. Fronty Parker and Lisa Stuby conducted the Delta Clearwater River coho count. Richard Price aged all the scale samples. Mike Wallendorf and Dan Reed assisted with data analysis and project design. Matt Evenson edited the report, and Matt Evenson and Lisa Stuby provided background and support as the author took over project responsibilities. Sara Case prepared the final report. The U.S. Army Corps of Engineers provided access to the Moose Creek Dam and assistance with installing equipment. Alyeska Pipeline Service Co. provided access to the pipeline work pad at pipeline milepost 438.2 for the Chatanika River tower. The U.S. Fish and Wildlife Service provided partial funding for this work. Bering Sea Fishermen's Association readily shared Salcha River tower count and age, sex and length composition data on chinook salmon with Sport Fish Division.

LITERATURE CITED

Baker, T. T. 1988. Creel censuses in interior Alaska in 1987. Alaska Department of Fish and Game, Fishery Data Series No. 64, Juneau.

Baker, T. T. 1989. Creel censuses in interior Alaska in 1988. Alaska Department of Fish and Game, Fishery Data Series No 95, Juneau.

Barton, L. H. 1987a. Population estimate of chinook salmon escapement in the Chena River in 1986 based upon mark and recapture techniques. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks. Arctic, Yukon, and Kuskokwim Region, Yukon River Salmon Escapement Report No. 31.

Barton, L. H. 1987b. Yukon area salmon escapement aerial survey manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks. Arctic, Yukon, and Kuskokwim Region, Yukon River Salmon Escapement Report No. 33.

Barton, L. H. 1988. Population estimate of chinook salmon escapement in the Chena River in 1987 based upon mark and recapture techniques. Alaska Department of Fish and Game, Regional Informational Report No. 3F88-05, Fairbanks.

Barton, L. H. and R. Conrad. 1989. Population estimate of chinook salmon escapement in the Chena River in 1988 based upon mark and recapture techniques. Alaska Department of Fish and Game, Regional Informational Report No. 3F89-13, Fairbanks.

Borba, B. M. and H. H. Hamner. 1998. Subsistence and Personal Use Salmon Harvest Estimates Yukon Area, 1997. Regional Information Report 3A98-23.

Borba, B. M. and H. H. Hamner. 1999. Subsistence and Personal Use Salmon Harvest Estimates Yukon Area, 1998. Regional Information Report 3A99-23.

Burkholder, A. 1991. Abundance, egg production, and age-sex-size composition of the chinook salmon escapement in the Salcha River, 1990. Alaska Department of Fish and Game, Fishery Data No. 91-5, Anchorage.

LITERATURE CITED (Continued)

Clark, R. A., and W. P. Ridder. 1987. Tanana Drainage creel census and harvest surveys, 1986. Alaska Department of Fish and Game, Fishery Data Series No. 12, Juneau.

Cochran, W.G. 1977. Sampling Techniques. 3rd Edition. John Wiley. New York. 428 pp.

Doxey, M. *In prep*. Fisheries Management Report for Sport Fisheries in the Lower Tanana River Management Area for 2000-2002. Alaska Department of Fish and Game, Fishery Management Report, Anchorage.

Evenson, M. J. 1991. Abundance, egg production, and age-sex-size composition of the chinook salmon escapement in the Chena River, 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-6, Anchorage.

Evenson, M. J. 1992. Abundance, egg production, and age-sex-size composition of the chinook salmon escapement in the Chena River, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-4, Anchorage.

Evenson, M. J. 1993. Abundance, egg production, and age-sex-length composition of the chinook salmon escapement in the Chena River, 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-6, Anchorage.

Evenson, M. J. 1995. Salmon studies in Interior Alaska, 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-5, Anchorage.

Evenson, M. J. 1996. Salmon studies in Interior Alaska, 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-17, Anchorage.

Evenson, M. J. 2002. Optimal production of chinook salmon from the Chena and Salcha rivers. Alaska Department of Fish and Game, Fishery Manuscript Series No. 02-01, Anchorage.

Evenson, M. J. and L. Stuby. 1997. Salmon studies in Interior Alaska, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-31, Anchorage.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association. 55:708-713.

Hallberg, J. E. and A. E. Bingham. 1991. Creel surveys conducted in interior Alaska during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-56, Anchorage.

Hallberg, J. E. and A. E. Bingham. 1992. Creel surveys conducted in interior Alaska during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-7, Anchorage.

Hallberg, J. E. and A. E. Bingham. 1993. Creel surveys conducted in interior Alaska during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-7, Anchorage.

Hallberg, J. E. and A. E. Bingham. 1994. Creel surveys conducted in interior Alaska during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-27, Anchorage.

Hallberg, J. E. and A. E. Bingham. 1995. Creel surveys conducted in interior Alaska during 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-21, Anchorage.

Hallberg, J. E. and A. E. Bingham. 1996. The Delta Clearwater and Salcha River creel surveys conducted in 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-20, Anchorage.

Howe A. H., G. Fidler and M. Mils 1995. Harvest, catch and participation in Alaska sport fisheries during 1994. Alaska Department of Fish and Game. Fishery Data Series No. 95-24. 212 pp.

Howe, A. L., G. Fidler, A. E. Bingham, and M. J. Mills. 1996. Harvest, catch, and participation in Alaska sport fisheries during 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-32, Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001a. Revised Edition: Harvest, catch, and participation in Alaska sport fisheries during 1996. Alaska Department of Fish and Game, Fishery Data Series 97-29 (Revised), Anchorage.

LITERATURE CITED (Continued)

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001b. Revised Edition: Harvest, catch, and participation in Alaska sport fisheries during 1997. Alaska Department of Fish and Game, Fishery Data Series 98-25 (Revised), Anchorage.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001c. Revised Edition: Participation, catch, and harvest in Alaska sport fisheries during 1998. Alaska Department of Fish and Game, Fishery Data Series 99-41 (Revised), Anchorage.

Howe, A. L., G. Fidler, C. Olnes, A. E. Bingham, and M. J. Mills. 2001d. Participation, catch, and harvest in Alaska sport fisheries during 1999. Alaska Department of Fish and Game, Fishery Data Series 01-8, Anchorage.

Jennings, G. B., K. Sundet, A. E. Bingham, and H.K. Sigurdsson. *In prep*. Participation, catch, and harvest in Alaska sport fisheries during 2001. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Merritt, M. F., A. Bingham, and N. Morton. 1990. Creel surveys conducted in Interior Alaska during 1989. Alaska Department of Fish and Game. Fishery Data Series No. 90-54, Anchorage.

Mills, M. J. 1979. Alaska statewide sport fish harvest studies (1977). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1978-1979 Project F-9-11, 20 (SW-I-A).

Mills, M. J. 1980. Alaska statewide sport fish harvest studies (1978). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1979-1980, Project F-9-12, 21 (SW-I-A).

Mills, M. J. 1981a. Alaska statewide sport fish harvest studies (1979). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22 (SW-I-A).

Mills, M. J. 1981b. Alaska statewide sport fish harvest studies (1980). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22 (SW-I-A).

Mills, M. J. 1982. Alaska statewide sport fish harvest studies (1981). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1981-1982, Project F-9-14, 23 (SW-I-A).

Mills, M. J. 1983. Alaska statewide sport fish harvest studies (1982). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project F-9-15, 24 (SW-I-A).

Mills, M. J. 1984. Alaska statewide sport fish harvest studies (1983). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1983-1984, Project F-9-16, 25 (SW-I-A).

Mills, M. J. 1985. Alaska statewide sport fish harvest studies (1984). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1984-1985, Project F-9-17, 26 (SW-I-A).

Mills, M. J. 1986. Alaska statewide sport fish harvest studies (1985). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1985-86, Project F-10-1, 27(RT).

Mills, M. J. 1987. Alaska statewide sport fisheries harvest report (1986). Alaska Department of Fish and Game. Fishery Data Series No. 2, Juneau.

Mills, M. J. 1988. Alaska statewide sport fisheries harvest report (1987). Alaska Department of Fish and Game. Fishery Data Series No. 52, Juneau.

Mills, M. J. 1989. Alaska statewide sport fisheries harvest report (1988). Alaska Department of Fish and Game. Fisheries Data Series No. 122, Juneau.

Mills, M. J. 1990. Harvest and participation in Alaska Sport Fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage.

Mills, M. J. 1991. Harvest, catch, and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage.

Mills, M. J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage.

LITERATURE CITED (Continued)

Mills, M. J. 1993. Harvest, Catch, and Participation in Alaska Sport Fisheries During 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage.

Mills, M. J. 1994. Harvest, Catch, and Participation in Alaska Sport Fisheries During 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage.

Mosher, K. H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. United States Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Washington, D.C., Circular 317.

Parker, J. F. 1991. Status of coho salmon in the Delta Clearwater River of interior Alaska. Alaska Department of Fish and Game, Fishery Manuscript No. 91-4, Anchorage.

Ryan, P, and M. Christie. 1976. Scale reading equipment. Fisheries and Marine Service, Canada, Technical Report PAC/T-75-8, Vancouver.

Schultz, K., D. Bergstrom, R. Holder, and B. Borba. 1994. Salmon fisheries in the Yukon area, Alaska, 1994. A report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Regional Information Report No. 3A94-31, Anchorage.

Skaugstad, C. L. 1988. Abundance and age-sex-size composition of the 1987 Salcha River chinook salmon escapement. Alaska Department of Fish and Game, Fishery Data Series No. 37, Juneau.

Skaugstad, C. L. 1989. Abundance and age-sex-size composition of the 1988 Salcha River chinook salmon escapement. Alaska Department of Fish and Game, Fishery Data Series No. 75, Juneau.

Skaugstad, C. L. 1990a. Abundance, egg production, and age-sex-size composition of the chinook salmon escapement in the Salcha River, 1989. Alaska Department of Fish and Game, Fishery Data No. 90-23, Anchorage.

Skaugstad, C. L. 1990b. Abundance, egg production, and age-sex-size composition of the 1989 Chena River chinook salmon escapement. Alaska Department of Fish and Game, Fishery Data No. 90-13, Anchorage.

Skaugstad, C. L. 1992. Abundance, egg production, and age-sex-length composition of the chinook salmon escapement in the Salcha River, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-2, Anchorage.

Skaugstad, C. L. 1993. Abundance, egg production, and age-sex-length composition of the chinook salmon escapement in the Salcha River, 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-23, Anchorage.

Skaugstad, C. L. 1994. Salmon Studies in Interior Alaska, 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-14, Anchorage.

Stuby, L., and M. J. Evenson. 1998. Salmon studies in Interior Alaska, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 97-11, Anchorage.

Stuby, L. 1999. Salmon studies in Interior Alaska, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-31, Anchorage.

Stuby, L. 2000. Salmon studies in Interior Alaska, 1999. Alaska Department of Fish and Game, Fishery Data Series No. 00-4, Anchorage.

Stuby, L. 2001. Salmon studies in Interior Alaska, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 01-24, Anchorage.

Walker, R. J., C. Olnes, K. Sundet, A. L. Howe, and A. E. Bingham. 2003. Participation, catch, and harvest in Alaska sport fisheries during 2000. Alaska Department of Fish and Game, Fishery Data Series 03-05, Anchorage

Welander, A. D. 1940. A study of the development of the scale of the chinook salmon (*Oncorhynchus tshawytscha*). Master's thesis, University of Washington, Seattle.

APPENDIX A

Appendix A.-Archived[a] project data and operational files germane to this 2001 report.

Data File	Description
CHENATOW01. zip	Excel spreadsheet of hourly counts of chinook and chum salmon, daily expansions of escapement, and variance estimates for the Chena River, 2001.
BSSALTOW01. xls	Excel spreadsheet of hourly counts of chinook and chum salmon, daily expansions of escapement, and variance estimates for the Salcha River, 2001.
Fbks KS Update "01-05" 2001.doc	Five in-season run status updates describing the 2001 Tanana KS run and fisheries.
CHATTOW01. zip	Excel spreadsheet of hourly counts of chinook and chum salmon, daily expansions of escapement, and variance estimates for the Chatanika River, 2001.
Chena-Chat KS 2001 Sched & Assignments EOS Summary.doc	Counting Schedule and crew assignments for 2001 Chena -Chatanika salmon counts, carcass surveys, and project tasks.
Salcha and Chena KS run timing 01.xls	Excel spreadsheets with graphs. Historic run timing is compared with 2001 run timing in terms of cumulative escapement abundance and cumulative % of escapement by day of run.
Chena-Salcha 2001 AS analysis.xls	Excel spreadsheet with formulas correcting chinook sex ratios from carcass surveys to electrofishing standard, estimating age-class abundance, and calculating standard errors
CorrSexRat-ElecCarc.xls	Excel spreadsheet (Dan Reed) with historic data analysis and derived tables for input of carcass survey sample sizes of female KS in Chena and Salcha Rivers. Produces gender bias electrofishing correction. Foundation for formulas in "Chena-Salcha 2001 AS analysis.xls"
Chena-Chatanika 2001 Age-Sex Summary.xls	Data file of sex, and age data for chinook salmon carcasses collected from the Chena and Chatanika River, 2001. Raw Data and summaries prepared by Commercial Fish Division
Salcha 2001 KS ASL.xls	Data file of length sex and age data for chinook salmon carcasses collected from the Salcha River, 2001, with spreadsheet summarizing age class length data and calculating standard errors.
DCR Expansion.xls	Worksheet for expansion of DCR coho counts by proportion in spring areas
DCR-coho counts2001.xls	Excel spreadsheet with counts and expansion formulas for the Delta Clearwater River coho abundance estimate in 2001

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