POPULATION ESTIMATE OF CHINOOK SALMON ESCAPEMENT IN THE CHENA RIVER IN 1987 BASED UPON MARK AND RECAPTURE TECHNIQUES

By

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ABSTRACT

Gill nets of two different mesh sizes were used to capture adult chinook salmon (Oncorhynchus tshawytscha Walbaum) to estimate total escapement using mark and recapture techniques. A total of 517 chinook salmon was tagged, fin-clipped and released. Ninety-five marked fish were subsequently recovered from a total of 1,186 carcasses examined on the spawning grounds.

Tag loss was estimated at 27% for jaw tags, 30% for spaghetti tags, and approximately 13% for fish which had lost both tag types. Approximately 81% and 78% of the fish which lost jaw tags and spaghetti tags, respectively, were males.

No significant difference in the rate of recovery among different length categories or between sexes was found, nor was a significant difference found in the recovery rate by recovery date or between areas examined. A significant difference was detected however, in recovery rate by date of release. Due to the low number of subsequent recoveries from these few early releases, a population estimate stratified by time was not attempted.

An adjusted Petersen estimate of 6,404 chinook salmon with an approximate 95% confidence interval of ± 1,103 fish was obtained. An aerial census flown under fair survey conditions during the period of peak spawning accounted for 20.5% of the population estimate.

Overall mean timing of the chinook salmon run in the Chena River was estimated to be 22 July with 50% run passage occurring on the same date. A slight difference in timing by sex was observed.

The chinook salmon spawning population was composed of 6 age groups from 4 brood years. Both males and females were dominated by age group 1.4 (75.3%) with females being the most predominant (49.6% versus 25.7%). Females also predominated age group 1.5 while males dominated age group 1.3. The chinook salmon escapement male-to-female ratio was estimated at 1.00:1.38.

KEY WORDS: chinook salmon, Oncorhynchus tshawytscha, population estimate, mark and recapture, escapement, aerial census, Yukon River, Tanana River, Chena River.

INTRODUCTION

The Yukon River drainage is too extensive in size for a practical, complete escapement enumeration program during any given year. Consequently, low-level aerial surveys have been the primary method used to obtain escapement information on salmon stocks throughout the drainage. It is known however, that aerial surveys underestimate total spawner abundance due to the die-off of early spawners and arrival of late spawners (Bevan 1961, Neilson and Geen 1981, Cousens et al. 1982, Barton 1986). As a consequence the existing data base on chinook salmon reflects trends in escapements based upon relative abundance of spawners but does not portray total escapement abundance. A need exists to develop expansion factor(s) which can be applied to aerial survey results in order to project total spawning abundance.

The Chena River, one of the most important chinook salmon producing streams in the Yukon River drainage, was selected for study in 1986 and 1987 (Figure 1). Results from the 1986 investigations can be found in Barton (1987a). The river is located in the Yukon Plains section of the Central Alaskan Upland and Plains Province. More specifically, it lies in the Tanana Basin, heading south and east of the White Mountains in the North Plateau Province, through which it flows in a westerly direction for approximately 150 miles draining an area of approximately 1,980 square miles (Frey et al. 1970, Anderson 1970).

The Chena River typifies many of the larger chinook salmon producing streams in the Alaskan portion of the drainage in terms of the relative magnitude of observed spawners (e.g., Andreafsky, Anvik, Nulato and Salcha rivers). Since 1977, peak aerial escapement estimates of Chena River chinook salmon have ranged from 563 to 2,553 fish with a 10-year average of 1,630 fish (ADF&G 1986).

By obtaining a total estimate of chinook salmon escapement in the Chena River, the proportion represented by a peak aerial census can be estimated. This will in turn permit expansion of past aerial survey escapement records to total abundance estimates. Hopefully, results will also be useful in expanding historic aerial escapement records for other important chinook salmon producing streams throughout the drainage which are similar in physical and hydrological nature.

Funding for the Chena River study was provided in part by a federal grant in support of U.S./Canadian Yukon River negotiations as they pertain to the Pacific Salmon Treaty of 1985 and in part by the State of Alaska.

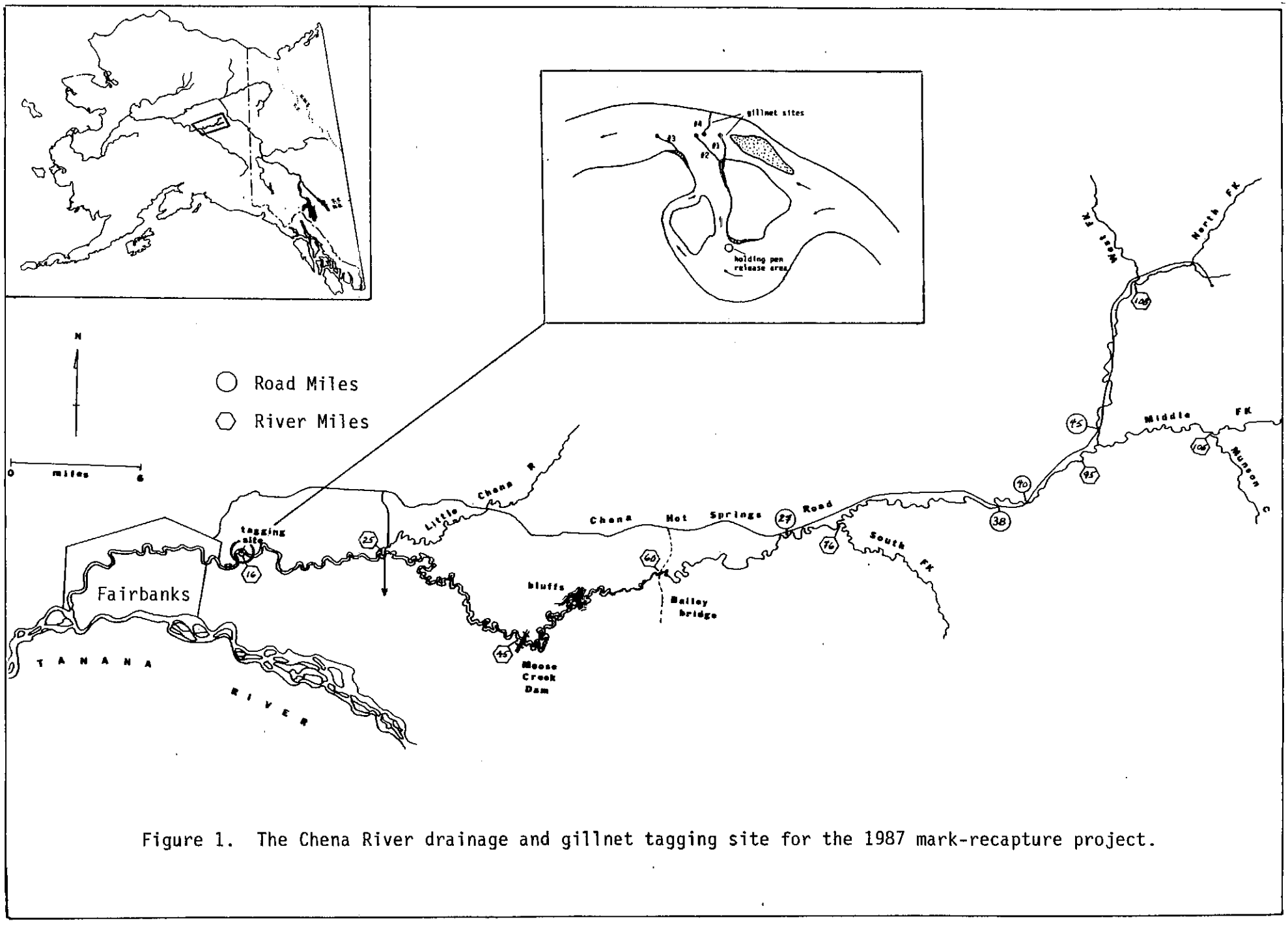


Figure 1. The Chena River drainage and gillnet tagging site for the 1987 mark-recapture project.

OBJECTIVES

Overall objectives of the 1987 Chena River chinook salmon study were to determine timing and magnitude of chinook salmon escapement and to estimate the proportion of the spawning population observed by a peak aerial census. The following specific objectives were identified:

1. Estimate the size of the Chena River chinook salmon spawning population using mark and recapture methods.

2. Estimate the proportion of the total Chena River chinook salmon escapement represented by an aerial survey point estimate during peak spawning.

3. Determine escapement timing of chinook salmon spawners in the Chena River.

4. Estimate the age, sex, and size composition of chinook salmon escapement in the Chena River.

5. Support ongoing chinook salmon stock separation studies based upon scale pattern analysis (SPA) and protein-gel electrophoretic analysis by collecting scales and tissue/organ samples.

MATERIALS AND METHODS

Test Fishing and Tagging

Two mesh size set gill nets (5-3/4 and 8-1/8 inch stretch measure) were fished daily at rivermile 16 of the Chena River to collect chinook salmon for tagging (see Figure 1). Three gill nets were fished: two 60-foot long by 15-foot deep chum salmon nets (5-3/4 inch mesh) and one 90-foot long by 20-foot deep chinook salmon net (8-1/8 inch mesh). Each net was constructed of multifilament nylon with half-inch braided filament core floatlines and oval grommeted floats. Leadlines were approximately 110 pounds per 100 fathoms.

The three nets were consistently fished during the same approximate 8-hour period (0615-1415 hours) each day to examine run timing using catch per unit effort (CPUE) data. Catch per unit effort was defined as the number of salmon captured per gill net hour per net. Additional fishing time was periodically allocated throughout the tagging period, particularly during the peak of the run, to insure sufficient numbers of chinook salmon

were tagged. Daily records were maintained documenting the duration of each gill net set by mesh size and resulting catch by species.

A two-person crew monitored gill nets continually by riverboat. When a fish was captured in a net, as evidenced by bobbing cork(s) in the floatline, the crew pulled alongside the net, removed the fish and placed it into a 50 gallon holding tank in the riverboat.

All chinook and chum salmon (O. keta Walbaum) captured were sexed by external examination and measured to the nearest 5 millimeters from mid-eye to fork of tail. A numbered metal locking jaw tag was secured to the left jaw of each chinook salmon. In addition, each chinook salmon was marked with a combination of adipose and pelvic fin clips which would identify its capture and release date to within 5 days. Orange spaghetti tags, placed immediately anterior to the dorsal fin, were also applied to a portion of the chinook salmon released. No chum salmon were tagged but the adipose fin was removed to identify recaptures. The marking schedule for chinook salmon was as follows:

1 - 5 July	Adipose plus right and left pelvic fin clip
6 - 10 July	Adipose plus right pelvic fin clip
11 - 15 July	Adipose plus left pelvic fin clip
16 - 20 July	Adipose fin clip only
21 - 31 July	Adipose plus right and left pelvic fin clip; in addition, application of a spaghetti tag

Upon completion of sampling (and tagging in the case of chinook salmon), salmon were released approximately 100 yards upstream of the test fishing site. A four foot square holding pen was constructed and utilized when necessary to ensure fish were released in a vigorous state.

Tag Recovery

Spawning ground surveys were conducted daily by riverboat to examine chinook salmon carcasses for tags subsequent to the test fishing portion of the study. The spawning area examined was from Moose Creek Dam (MCD) to approximately three miles up the Middle Fork river. All chinook salmon carcasses were collected using long handled spears, examined for tags and fin clips, sexed by external examination, and measured from mid-eye to fork of tail to the nearest 5 millimeters. All tags were removed and the date, recovery location, tag number, and fin clip combination carefully recorded for each fish.

Additional biological sampling associated with spawning ground surveys included collecting scales (3 per fish) from a subsample of 650 chinook salmon to estimate age composition of the

escapement and to provide samples for use in subsequent stock separation studies based upon SPA (Merritt et al. In press). From the subsample of 650 chinook salmon, tissue/organ samples (eye, heart, liver, and muscle) were collected on 150 fish with assistance of the U.S. Fish and Wildlife Service (USFWS) for subsequent use in genetic stock identification studies (GSI). The dorsal fin and a small section of spine was also collected from 50 of the electrophoretic samples for subsequent aging. Results associated with SPA and GSI sampling as well as fin and vertebrae collection will be reported at a later date.

Population Estimate

A population estimate of chinook salmon was made using an adjusted Petersen estimator which gives an unbiased estimate in most situations (Chapman 1951, cited in Ricker 1975). Its variance was calculated as per Seber (1982):

Population was estimated as:

$$N = ((M + 1)(C + 1)/(R + 1)) - 1$$

Its variance was estimated as:

$$V(N) = (M + 1)(C + 1)(C - R)(M - R)/((R + 1)^2 (R + 2))$$

Where: N = Size of population at time of tagging
M = Number of fish marked
C = Number examined for marks
R = Number of recaptured marks

Approximate 95% confidence limits for the population estimate were determined as follows:

$$N \quad (\pm) \quad 1.96 \quad (V(N))^{1/2}$$

Although gill nets are known to be very size selective (Ricker 1975), carcass surveys conducted through time are thought not to be selective, albeit availability of carcasses could differ between sexes due to different spawning behavior and redd defense resulting in different carcass wash-out patterns.

To evaluate the effect of marking and recapturing with selective gear, goodness-of-fit tests (Chi-square) were conducted to detect significant differences in the recovery rate among different length categories or between sexes. Further, to investigate if fish passed the tagging site outside the tagging period, a goodness-of-fit test was conducted to detect differences in the recovery rate among recovery strata. All Chi-square tests were conducted at the $\alpha = 0.05$ level of significance.

Aerial Surveys

Attempts were made to survey the Chena River spawning areas by single engine, fixed-wing aircraft throughout the chinook salmon spawning season. The number of live and dead salmon by species was recorded as well as survey conditions and overall survey effectiveness (i.e., a subjective rating of overall survey quality as good, fair, or poor) (Barton 1987b). Counts were recorded by river index area for each survey flown:

- Downstream of MCD
- MCD to confluence of South Fork
- Confluence of South Fork to confluence of Middle Fork
- Confluence of Middle Fork to confluence of West Fork
- Middle Fork from mouth upstream to confluence of Munson Cr

The primary index area for assessing whether or not the chinook salmon escapement objective (1,000 - 1,700) is met in the Chena River is that portion of the mainstem river between MCD and confluence of the Middle Fork. The escapement objective is based upon aerial survey index estimates which do not represent total escapement, but do reflect annual spawner abundance trends when using standard survey methods under acceptable survey conditions.

RESULTS

Test Fishing and Tagging

The first report of chinook salmon present in the Chena River was on 29 June by Sport Fish Division personnel when one was observed near rivermile 15 (R.A. Clark, ADF&G, Fairbanks, personal communication). Test fishing with gill nets was initiated at rivermile 16 on 1 July and terminated on 31 July. Apart from 3 and 5 July when no fishing was conducted, gill nets were consistently fished each day during the "standard" 8-hour period to examine run timing. As catches started to build in late July, fishing time was increased to 12 to 20 hours per day. A total of 524 chinook and 104 chum salmon were captured (Table 1 and Appendix A). Other species captured during the tagging portion of the studies included 2 sheefish (*Stenodus leucichthys* Pallas).

The small mesh or chum gear was effective in capturing both chum and chinook salmon. This gear accounted for 25% of the chinook salmon captured and 92% of the chum salmon captured. However, of the chinook salmon captured, 75% were males while 62% of the chum salmon captured in small mesh gear were males. The larger,

Table 1. Daily catches of chinook and chum salmon in test gill nets in the Chena River, July 1987. a

Date	Net Sites Fished	Approx. Hours Fished	Chinook Salmon Catch				Remarks	Chum Salmon Catches				Remarks
			Male	Female	Total	Cum.		Male	Female	Total	Cum.	
01-Jul	1,2,3	2	0	0	0	0		0	0	0	0	
02-Jul	1,2,3	8	2	0	2	2		0	0	0	0	
03-Jul	1,2,3	0				2				0	0	
04-Jul	1,2,3	8	0	0	0	2		0	0	0	0	
05-Jul	1,2,3	0				2				0	0	
06-Jul	1,2,3	8	5	0	5	7		0	0	0	0	
07-Jul	1,2,3	14	7	5	12 (8)	19	1 mort	0	0	0	0	
08-Jul	1,2,3	8	8	8	16	35		0	0	0	0	
09-Jul	1,2,3	8	6	5	11	46	1 mort	0	0	0	0	
10-Jul	1,2,3	8	5	2	7	53		1	2	3	3	
11-Jul	1,2,3	8	5	5	10	63		1	1	2	5	
12-Jul	1,2,3	8	18	6	24	87		0	0	0	5	
13-Jul	1,2,3	8	7	7	14	101		0	0	0	5	
14-Jul	1,2,3	13	10	4	14 (12)	115		2	0	2	7	
15-Jul	1,2,3	8	4	2	6	121		1	0	1	8	
16-Jul b	2,3,4	8	3	1	4	125		0	0	0	8	
17-Jul b	2,3,4	8	4	1	5	130		1	1	2	10	
18-Jul b	2,3,4	8	4	3	7	137		3	0	3	13	
19-Jul	1,2,3	8	6	2	8	145	1 recap	1	0	1	14	
20-Jul	1,2,3	12	17	9	26 (20)	171	1 sheefish	5	2	7 (3)	21	1 mort
21-Jul	1,2,3	20	41	36	77 (31)	248	2 mort,1 recap	10	11	21 (6)	42	
22-Jul	1,2,3	16	31	23	54 (24)	302	1 sheefish	4	3	7 (3)	49	1 mort
23-Jul	1,2,3	12	18	17	35 (25)	337	1 mort	5	1	6 (3)	55	
24-Jul	1,2,3	8	10	7	17	354		4	4	8	63	1 mort
25-Jul b	1,2,3,4	12	30	20	50 (36)	404	1 mort	11	3	14 (8)	77	
26-Jul b	2	9	3	10	13 (13)	417		1	0	1	78	
27-Jul b	2	8	6	12	18	435		0	0	0	78	
28-Jul b	2,3,4	8	12	31	43	478		2	0	2	80	
29-Jul b	2,4	8	5	16	21	499		5	0	5	85	
30-Jul	2,3,4	8	4	12	16	515		9	4	13	98	
31-Jul	2,3,4	8	3	6	9	524		5	1	6	104	
Totals		270	274	250	524		6 mort,2 recap	71	33	104		3 mort

a Number of chinook salmon successfully tagged and released (517) equals cumulative catch minus 6 mortalities and 1 fish which escaped prior to tag application. Numbers in parentheses indicate chinook salmon captured during the 8-hour period of approx. 0615-1415 hrs.
b Days on which high water affected number, location and duration of nets fished.

chinook gear captured 75% of the chinook salmon, of which 45% were males. Only 8 chum salmon (7 males and 1 female) were captured with large mesh gear.

Test net recaptures amounted to only 2 chinook and no chum salmon during the tagging portion of the study. Documented mortalities were 6 chinook (1.1%) and 3 chum (2.9%) salmon. One chinook salmon escaped prior to tag application.

All chinook salmon captured were measured and sexed. The male to female ratio was 1.00:0.91 (52% males; 48% females). While there was some overlap in the length frequency distributions of chinook salmon catches from the two mesh-sized gill nets, the larger mesh size captured a greater proportion of larger fish (Figures 2 and 3). A total of 517 chinook salmon were successfully tagged, fin-clipped and released throughout the period 1-31 July with the first release made on 2 July. The number of chum salmon which were sexed, measured, fin-clipped and released totaled 101 (68% males; 32% females).

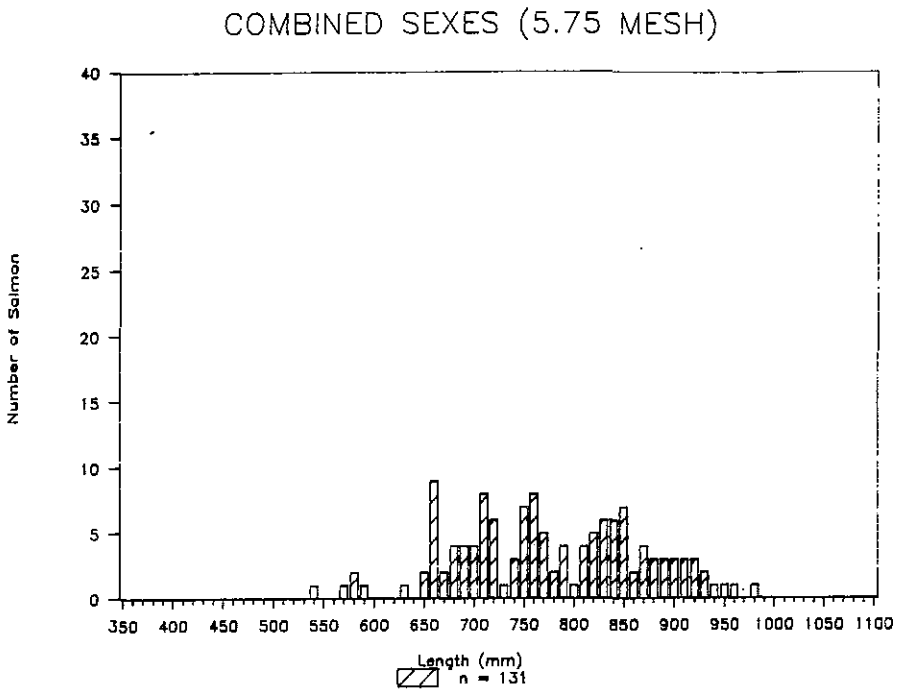
Two periods of high water affected test-netting (Figure 4 and Appendix B). The first period lasted 3 days (16-18 July) when increased river discharge temporarily destroyed the eddy at site 1, where a small mesh net was being fished. Consequently, that net was relocated to site 4 (see Figure 1). The second period of high water occurred from 25-29 July and was accompanied by excessive amounts of floating debris. The location and amount of small mesh gear which could be fished was again hampered on these days.

Tag Recovery

Portions of the Chena River salmon spawning grounds were examined daily from 4-19 August. Three complete surveys were conducted of the spawning grounds between MCD (rivermile 45) and approximately 3 rivermiles up the Middle Fork river (rivermile 100). A total of 1,186 chinook salmon carcasses was examined for tags and fin-clips. Lengths were measured on 1,029 of these fish and sex recorded for 1,030, while 156 were neither sexed nor measured due to their state of decomposition. A subsample of 651 fish were scale sampled for subsequent aging. The male to female ratio from all chinook salmon examined on carcass surveys (n = 1,030) was 1.00:1.35 (42.5% males; 57.5% females).

Scale age determination from 560 readable scales indicated that chinook salmon were represented by 6 age groups from 4 brood years (Table 2). The male to female ratio for the ageable samples (n = 560) was 1.00:1.38 (42% males; 58% females), basically the same as that for all carcasses examined.

Sexual dimorphism in size of Chena River chinook salmon is illustrated in Table 3 which shows females to be generally larger



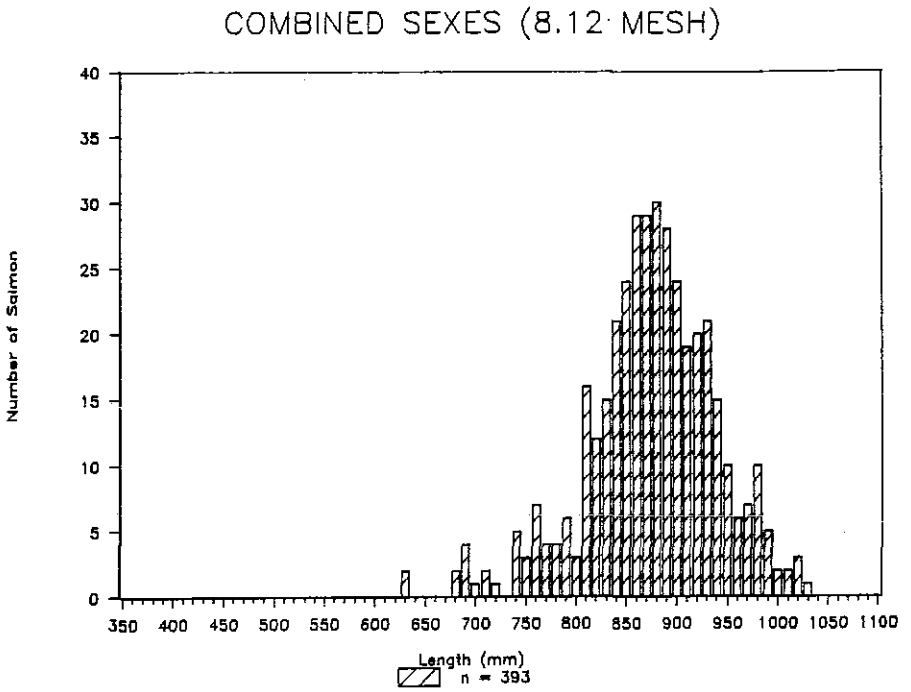


Figure 2. Length frequency distributions of chinook salmon captured in two mesh size gill nets at rivermile 16 of the Chena River, 1-31 July 1987.

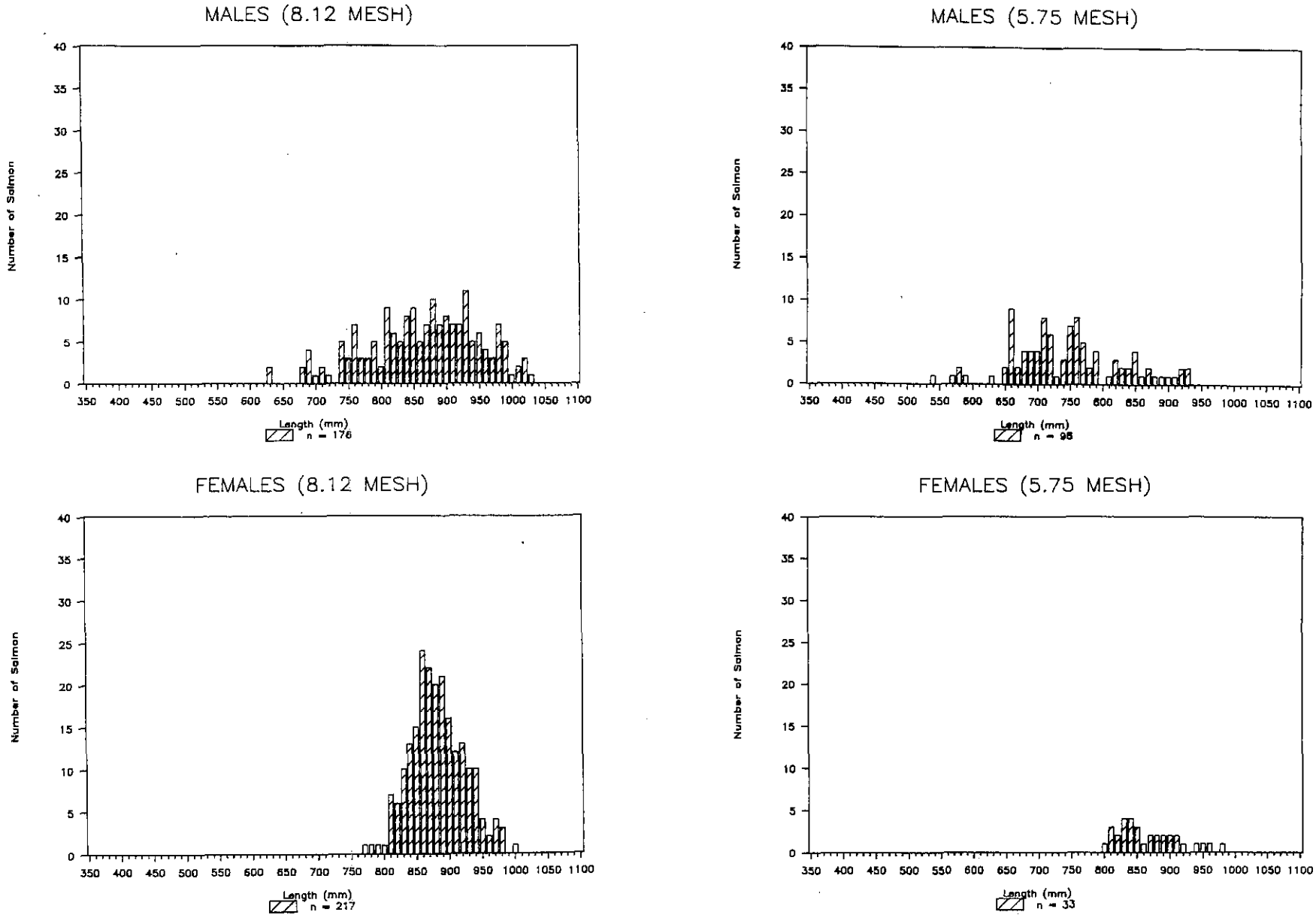


Figure 3. Length frequency distributions of chinook salmon (by sex and mesh size) captured in gill nets at rivermile 16 of the Chena River, 1-31 July 1987.

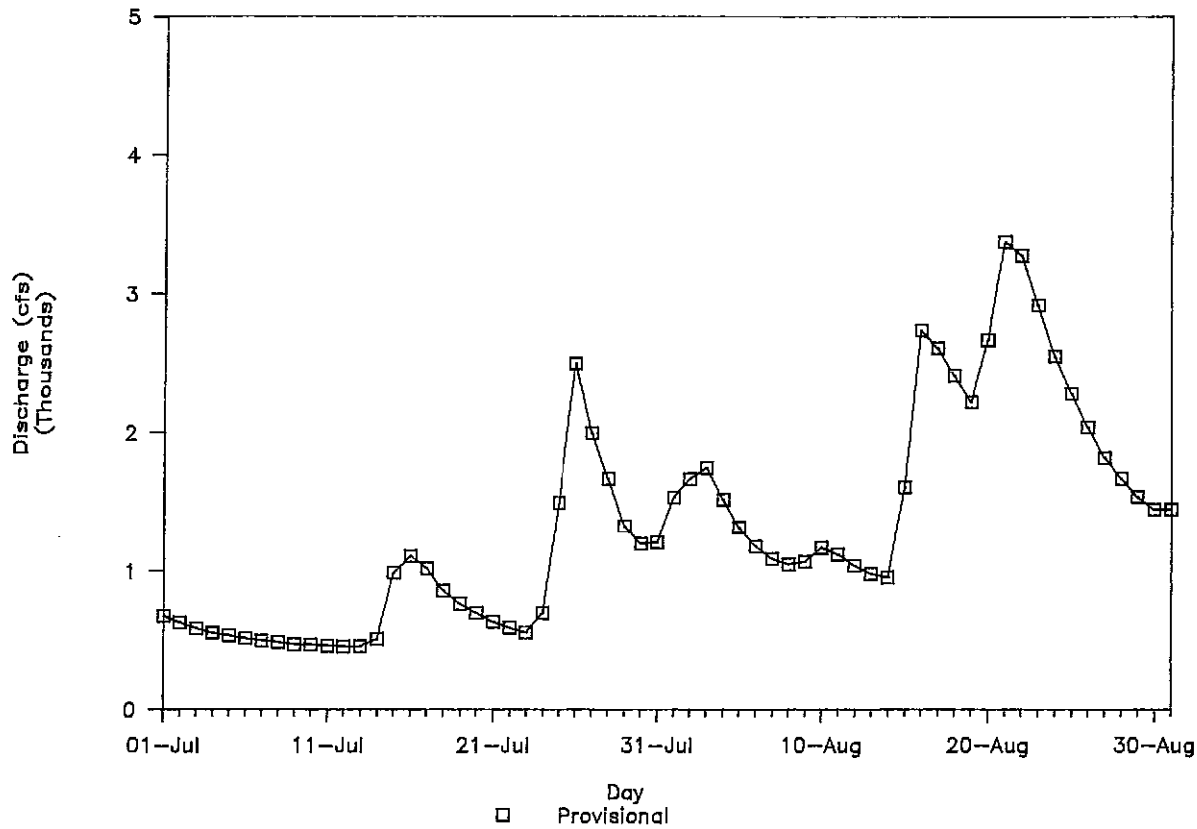


Figure 4. Mean daily discharge of the Chena River in July and August at the USGS gauging station below Moose Creek Dam, 1987.

Table 2. Age and sex composition of chinook salmon carcass samples in the Chena River, 1987.

Sample Size		Brood Year and Age Group a						
		1983	1982	1981		1980		
		1.2	1.3	1.4	2.3	1.5	2.4	Total
325	Females	0.2	1.2	49.6	0.0	6.6	0.4	58.0
235	Males	2.7	11.8	25.7	0.4	1.4	0.0	42.0
560	Combined	2.9	13.0	75.3	0.4	8.0	0.4	100.0
	SE	22.37	5.88	2.76	22.50	9.03	2.50	

a Age is designated as European: number of freshwater annuli followed by number of saltwater annuli.

Table 3. Mean length at age of chinook salmon carcass samples in the Chena River, 1987. a

	Brood Year and Age Group b						
	1983	1982	1981		1980		
	1.2	1.3	1.4	2.3	1.5	2.4	Total
FEMALE							
Length	870	732	868	0	909	863	
SE	0	23.68	2.61	-	8.63	2.50	
Sample Size	1	7	278	0	37	2	325 (58.0%)
MALE							
Length	542	701	853	693	938	0	
SE	9.62	5.94	6.26	22.50	31.92	-	
Sample Size	15	66	144	2	8	0	235 (42.0%)
							560 (100%)

a Mid-eye to fork of tail length in millimeters.

b Age is designated as European: number of freshwater annuli followed by number of saltwater annuli.

than males for a given age. Figure 5 presents length frequency distributions from carcass surveys.

A total of 95 marked chinook salmon (42 males and 53 females) was recovered; 75 with at least one tag in place and 20 which had lost tags but were identified by fin-clips. Tag loss was estimated at 27% for jaw tags, 30% for spaghetti tags, and approximately 13% for fish which had lost both tag types. Approximately 81% and 78% of the fish which lost jaw tags and spaghetti tags, respectively, were males. An additional 8 marked fish were reported by sport fishermen but these results were not included when generating the population estimate as creel census data were not collected from the Chena River sport fishery in 1987 from which to estimate total sport harvest.

Population Estimate

A total of 517 chinook salmon was marked and released over the period 2-31 July of which 95 were subsequently recovered from an examination of 1,186 carcasses on the spawning ground during the period 4-19 August. No significant difference (.05) was detected in the rate of recovery among length categories (Chi-square = 3.11, df = 1) or between sexes (Chi-square = 2.71, df = 1). Thus, there was no need to stratify by sex or size in deriving a population estimate. Length frequency distribution of chinook salmon captured in test gill nets was mirrored by length frequency distribution of chinook salmon carcasses (Figure 6).

Recovery effort must be of a duration to completely cover the spawning period. The recovery rate increased from 9% on 4 August to a high of 12% on 7 August; decreased to 6% on 10 August and remained near that level through 14 August; was 0 on 17 and 18 August; and reached 6% again on 19 August (Table 4). No significant difference (.05) was detected in recovery rates through time (Chi-square = 12.45, df = 9) (Table 5). Further, no significant difference (.05) was detected in the rate of recovery for males (Chi-square = 0.019, df = 1) or females (Chi-square = 0.028, df = 1) between the upper and lower halves of the spawning grounds examined, suggesting a thorough mixing of tagged fish.

A significant difference (.05) was detected, however, in the rate of recovery by release strata (Chi-square = 11.77, df = 3) with recovery rate for fish tagged during the early portion of the run being less than expected (Table 6). This suggests that tag application may have been disproportionate to run strength or the unlikely possibility that early arriving fish may have also spawned in other areas of the drainage which were not included in recovery surveys. Because of the relative low number of tags applied prior to 20 July together with the low number recovered from that period, a population estimate stratified by time was not attempted.

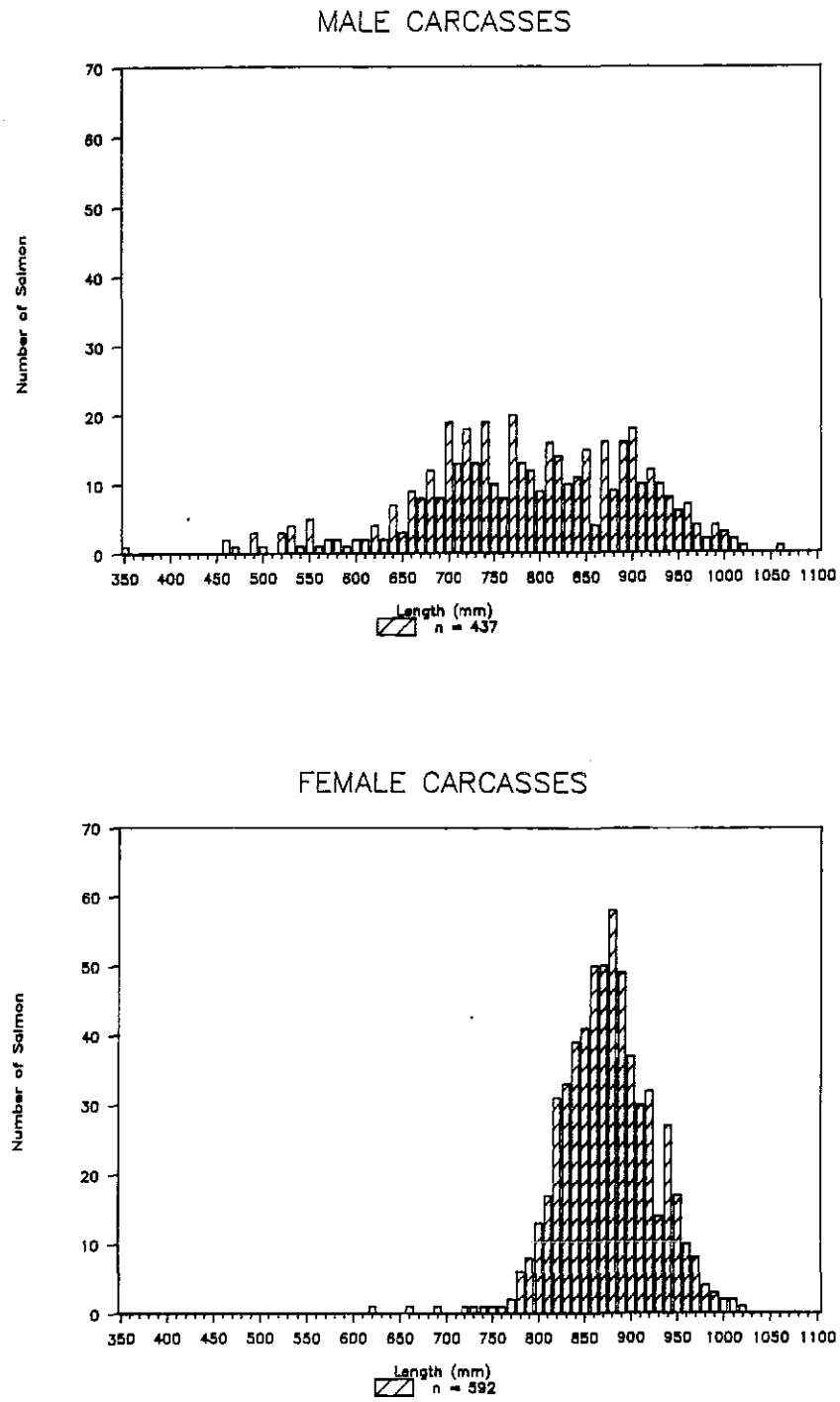
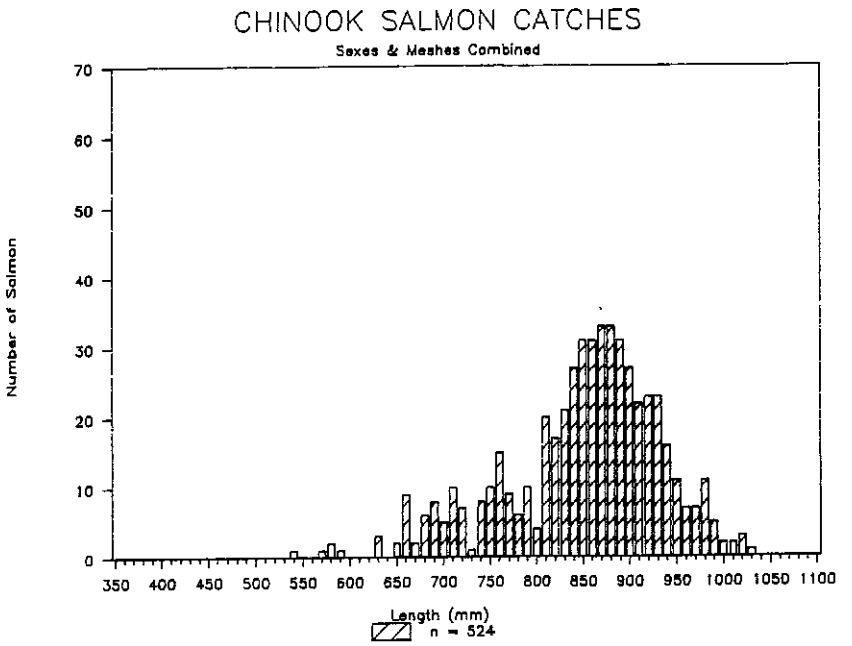


Figure 5. Length frequency distributions of male and female chinook salmon carcasses sampled in the Chena River, 4-19 August 1987.



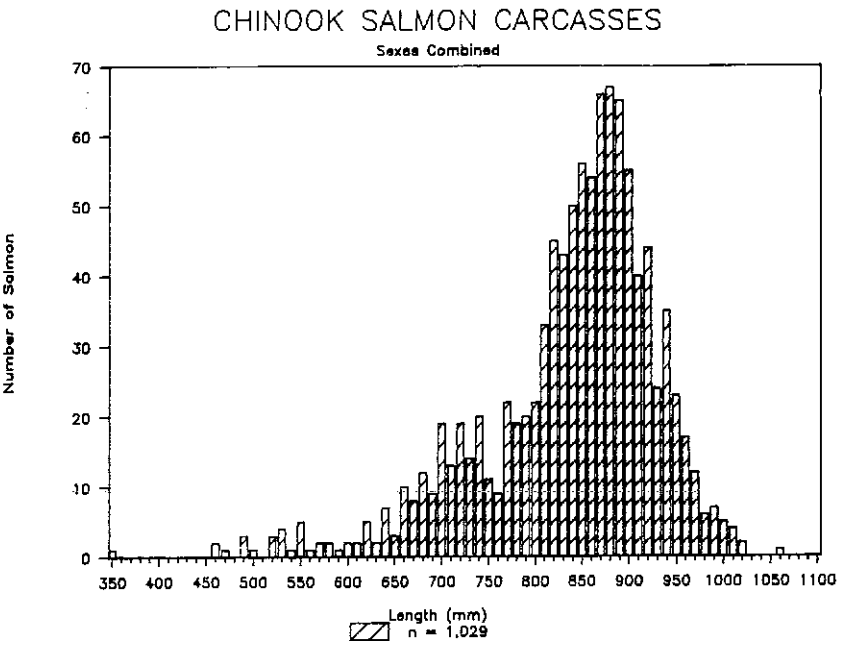


Figure 6. Comparison of length frequency distributions of chinook salmon captured at rivermile 16 (1-31 July) and chinook salmon carcasses recovered (4-19 August) in the Chena River, 1987.

Table 4. Number of chinook salmon tagged and sampled for tags in the Chena River by release and recovery date, 1987.

Release Strata (July)	Total Released	Marked Fish Recovered		Daily Recoveries of Tagged Chinook Salmon (4-19 August)																Total	Recovery Rate (RR)
		Clipped a	With Tags	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
2	2		0																	0	0.00
3		(0)	0																	0	--
4	0		0																	0	--
5		———	0																	0	--
6	5		1	1																1	0.20
7	11		1	1																1	0.09
8	16	(2)	0																	0	0.00
9	10		1											1						1	0.10
10	7	———	0																	0	0.00
11	10		0																	0	0.00
12	24		0																	0	0.00
13	14	(5)	0																	0	0.00
14	14		1	1																1	0.07
15	6	———	0																	0	0.00
16	4		0																	0	0.00
17	5		0																	0	0.00
18	7	(2)	0																	0	0.00
19	8		3	1			1				1									3	0.38
20	26	———	1							1										1	0.04
21	74		18	1	3	3	4	2		2	1			2						18	0.24
22	54		10	2	2	1	2	1			1			1						10	0.19
23	34		7	1	2		3	1												7	0.21
24	17		5			2	1			1	1									5	0.29
25	49		8			4	2							2						8	0.16
26	13	(11)	3		1		2													3	0.23
27	18		3			1					1		1							3	0.17
28	43		6				1				1		2	1					1	6	0.14
29	21		3			1													2	3	0.14
30	16		4											3					1	4	0.25
31	9		0																	0	0.00
Total Released	517																				0.15
Total Tags Recovered			75	8	8	12	16	4	-	4	6	-	3	10	-	-	0	0	4	75	(15% RR)
Total Clipped Recovered		20		2	3	0	8	4	-	0	0	-	0	3	-	-	0	0	0	20	
Total Marked Recovered				10	11	12	24	8	-	4	6	-	3	13	-	-	0	0	4	95	(18% RR)
Total Unmarked Recovered				101	131	116	169	67	-	59	101	-	79	162	-	-	11	37	58	1,091	
Total Sampled for Tags				111	142	128	193	75	-	63	107	-	82	175	-	-	11	37	62	1,186	
Recovery Rate (using tagged fish)				0.07	0.06	0.09	0.08	0.05	-	0.06	0.06	-	0.04	0.06	-	-	0.00	0.00	0.06	0.06	
Recovery Rate (using all marked fish)				0.09	0.08	0.09	0.12	0.11	-	0.06	0.06	-	0.04	0.07	-	-	0.00	0.00	0.06	0.08	

a Chinook salmon carcasses recovered which had lost tags but were identified as a marked fish by various fin clip combinations. Number in parentheses indicates marked fish recovered which were tagged by release strata, based upon fin clip combinations:

1-5 July	Adipose plus right and left pelvic fin clip
6-10 July	Adipose plus right pelvic fin clip
11-15 July	Adipose plus left pelvic fin clip
16-20 July	Adipose fin clip only
21-31 July	Adipose plus right and left pelvic fin clip and missing (ripped dorsal tissue) spaghetti tag

Table 5. Goodness-of-fit test for equal probability of capture among recovery strata (4-19 August) for the 1987 Chena River chinook salmon mark-recapture project.

	Date of Recovery Strata (4 - 19 August) a										
	4	5	6	7	8	10	11	13	14	17-19	Total
Total Marked Recovered	10	11	12	24	8	4	6	3	13	4	95
Total Unmarked Recovered	101	131	116	169	67	59	101	79	162	106	1,091
Total Examined for Marks	111	142	128	193	75	63	107	82	175	110	1,186
Recovery Rate	0.09	0.08	0.09	0.12	0.11	0.06	0.06	0.04	0.07	0.04	

Total Chi-square (b) =	0.14 +	0.01 +	0.30 +	4.72 +	0.66 +	0.22 +	0.77 +	1.94 +	0.07 +	2.63 +	
	0.01 +	0.00 +	0.03 +	0.41 +	0.06 +	0.02 +	0.07 +	0.17 +	0.01 +	0.23	= 12.45 c

a No carcass surveys were conducted on August 9, 12, 15, or 16.

b Arranged in order of correspondence to the above contingency table.

c Non-significant (a = 0.05, Chi-square = 12.45, df = 9).

Table 6. Goodness-of-fit test for equal probability of capture among release strata for the 1987 Chena River chinook salmon mark-recapture project.

	Dates of Release Strata (July)				
	1-10	11-15	16-20	21-31	Total
Total Marked Recovered	5	6	6	78	95
Total Marked Not Recovered	46	62	44	270	422
Total Released	51	68	50	348	517
Recovery Rate	0.10	0.09	0.12	0.22	

Total Chi-square (a) =	2.04	+	3.38	+	1.11	+	3.09	+		
	0.46	+	0.76	+	0.25	+	0.70	=	11.77	b

a Arranged in order of correspondence to the above contingency table.

b Significant (a = 0.05, Chi-sq = 11.77, df = 3)

Although the smallest chinook salmon captured in test nets in 1987 was only 540 mm, it is known from 1986 investigations that mesh sizes used could catch fish as small as 470 mm (Barton 1987a). Only one chinook salmon was observed on carcass surveys in 1987 smaller than 470 mm. Consequently, an adjusted Petersen population estimate for Chena River chinook salmon escapement in 1987 was made using all tagged fish and examined carcasses, regardless of size. Table 7 presents the chinook salmon population estimate of 6,404 with an approximate 95% confidence interval of ± 1,103 fish. Also shown for comparison are population estimates generated for each sex. The sum of these two estimates (6,319) differ by only 85 fish from the combined sex estimate.

Aerial Surveys

Four aerial surveys were flown of the Chena River in 1987 to enumerate salmon escapement. Surveys were flown on 20 July, 24 July, 28 July and 4 August. The first survey on 20 July was incomplete and rated "fair" for the areas which were surveyed. A total of 683 live chinook and 11 chum salmon were observed. The distribution of chinook salmon was as follows:

- MCD to South Fork - 398
- Confluence South Fork to confluence Middle Fork - 285
- Upstream of Middle Fork - Not surveyed

The 24 July survey was incomplete as only the area between MCD and the South Fork was surveyed. Survey conditions were poor as a result of heavy cloud cover, rain squalls, and glare. Only 234 chinook salmon were counted.

The survey on 28 July was given an overall rating of "poor" due to turbid water conditions downstream of the confluence of Middle Fork river. Only 262 chinook salmon were enumerated, of which 39 live fish were observed under "good" survey conditions in a 4-5 mile stretch of the mainstem Chena River upstream of the confluence of Middle Fork river.

The best survey of the season was obtained on 4 August which was given an overall rating of "fair". This less than "good" survey rating resulted primarily because it was estimated that approximately 60% of the mid-river channel was obscured by dark stained water downstream of the confluence of the South Fork river, particularly between MCD and Grange Hall Road. A total of 1,312 chinook salmon (1,205 live and 107 dead) was observed:

- MCD to South Fork - 768 (58%)
- Confluence South Fork to confluence Middle Fork - 458 (35%)
  includes 17 in lower 1 mile of South Fork
- In Middle Fork upstream to Munson Creek - 51 (4%)
- Mainstem Chena River upstream confluence Middle Fk - 35 (3%)

Table 7. Population estimate for Chena River chinook salmon, 1987. a

Sex	Number Tagged	Number Sampled for Tags	Number Tags Recovered	Estimated Population Size	Estimated Population Variance	Lower Confidence Bound b	Upper Confidence Bound b
Male	268	504	42	3,158	174,343	2,340	3,976
Females	249	682	53	3,161	131,255	2,451	3,871
Total		1,186	95	6,319	305,598	4,222	8,416
Combined	517	1,186	95	6,404	316,667	5,301	7,507

a Population was estimated as: $N = ((M + 1)(C + 1)/(R + 1)) - 1$

and its variance as: $V(N) = (M + 1)(C + 1)(C - R)(M - R)/((R + 1)^2(R + 2))$

where: N = Population Size
M = Number Tagged
C = Number Sampled for Tags
R = Number Tags Recovered

b A 95% confidence bound with a = 0.05

Weather and water conditions were not conducive for conducting more aerial surveys in 1987 during the chinook salmon spawning season.

DISCUSSION

It is important to note that whereas a larger, combined sex population estimate was obtained for the Chena River chinook salmon spawning escapement in 1986 (9,065 fish) than in 1987 (6,404 fish), more females were estimated to have spawned in 1987; on the order of magnitude of 600 - 1,400 fish.

The female population estimate in 1986 was 2,543 (± 990) versus 3,161 (± 710) in 1987; a difference of 618 females. When multiplying the combined sex population estimate in each year by the respective sex ratio observed during carcass surveys, resulting female numbers differ from the independent female estimates but still fall within respective 95% confidence bounds. For example 9,065 * 25% equals 2,266 females for 1986 and lies within the 95% confidence bounds of the independent female estimate for that year. Likewise, 6,404 * 58% equals 3,714 females for 1987 and lies within the 95% confidence bounds of the independent female estimate for that year. Estimating the number of female spawners present using the latter method, indicates 1,448 more females present in 1987 than in 1986.

In terms of assessing production potential from year to year in a given chinook salmon stream, this illustrates the importance of knowing or obtaining a good estimate of the number of females which reach the spawning grounds versus knowing the total number of spawners.

Annual fluctuations in chinook salmon escapement sex ratios are considered to be primarily a function of differences of age-at-maturity between sexes and variable year class strength. Yukon River chinook salmon return primarily as 5- and 6-year-olds and males usually dominate age 1.3 while females usually dominate 1.4. The higher percentage of females observed in the Chena River in 1987 as opposed to 1986 also reflects good brood year production from 1981, compounded possibly by a poor brood year return of males from 1982.

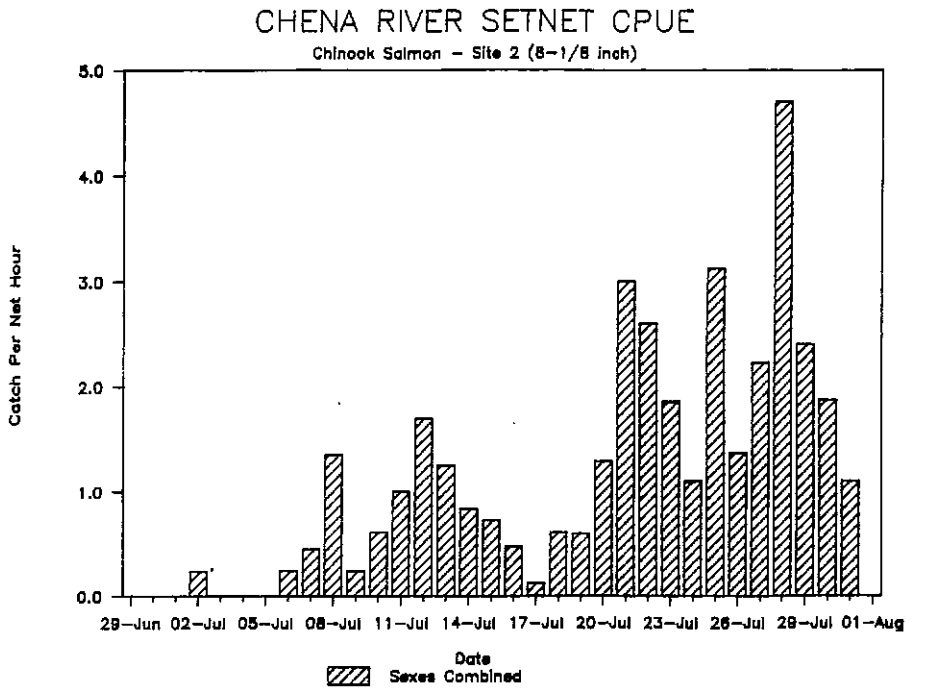
Timing of the Chena River chinook salmon migration was examined using an approach by Mundy (1982, 1984). He developed a time density model to describe salmon migration run timing. The pattern of the migration is described by the mean date of passage (a measure of the central tendency) and the standard deviation (a measure of dispersion). These statistics are calculated from the proportion of the total escapement occurring each day. Further, the median date is the day on which 50% run-passage occurs.

Only CPUE data from large mesh gear fished during the standard 8-hour daily period was used to estimate run timing. That gear was the most consistently fished, even during periods of high water. As a result the mean day of run passage for chinook salmon (sexes combined) in the Chena River in 1987 was estimated to be 22 July with a standard deviation of 6.9 days (Figure 7). It is interesting to note that identical timing results were observed when using total soaktime CPUE data of the large mesh nets. This may indicate little difference in timing by time of day. The median date of run passage also fell on 22 July. A slight difference in timing by sex was observed using daily 8-hour CPUE data from large mesh nets. The mean day for males was 20 July (SD = 7.0), 3 days earlier than for females (23 July; SD = 6.5).

Results from the peak aerial census flown on 4 August revealed the Chena River chinook salmon escapement objective was met in 1987 by the occurrence of 1,226 fish between MCD and the Middle Fork river. The total survey estimate of 1,312 chinook salmon represents 20.5% of the population estimate of 6,404 fish. By comparison, an estimated 22.4% of the population estimate was observed in the Chena River in 1986. The peak aerial surveys in both 1987 and 1986 were rated only "fair" and for similar reasons (i.e., 40-60% of the mainriver channel downstream of the South Fork river was obscured to the observer by dark stained water).

It is likely that a higher proportion of the actual population would be observed on peak surveys given "good" survey conditions (Table 8). Skaugstad (In press) reported that a peak aerial census represented approximately 40% of the mark and recapture population estimate made in the Salcha River in 1987. That survey was also flown under "fair" survey conditions. Similarly, 38.6% of the total season escapement passing through a DFO weir on the Big Salmon River in 1986 was estimated from a peak aerial survey flown under "fair" conditions (ADF&G 1986). In 1987, approximately 80% of the Big Salmon River chinook salmon weir count (through the date of the survey) was observed on a peak survey flown under "good" conditions. This survey later proved to represent 74.8% of the total weir count for the season (US/Canada JTC 1987). Similarly, 80% of the chinook salmon counting tower-estimated escapement in the East Fork Andreafsky River in 1987 was observed during a peak aerial census (US/Canada JTC 1987).

In a 1979 study of the Morice River in British Columbia, Neilson and Geen (1981) reported that the peak aerial chinook salmon count represented 52% of the total estimated spawning population for the season.



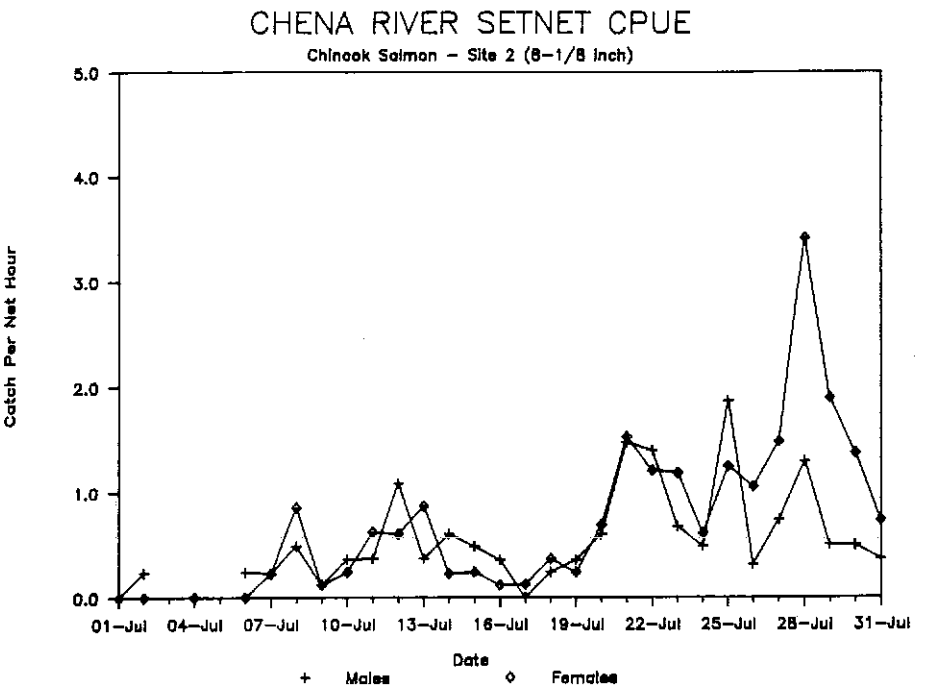


Figure 7. Chinook salmon run timing in the Chena River based upon CPUE of large mesh gill nets at rivermile 16, 1-31 July 1987.

Table 8. Comparsion of chinook salmon total estimated spawning populations and the proportion represented by an aerial census flown during peak of spawning.

Year	Location	Total Abundance Estimate and Method a	Aerial Census: Peak Count	Aerial Census: Rating (if known)	Percent of Total Estimate by Aerial Census	Source
1987	Chena River (AK)	6,404 (m/r)	1,312	fair	20.5%	
1987	Salcha River (AK)	4,771 (m/r)	1,898	fair	39.8%	Skaugstad In press
1987	East Fork Andreafsky River (AK)	2,011 (twr)	1,608	good	80.0%	US/Canada JTC 1987
1987	Big Salmon River (Y.T. CAN)	998 (weir)	747	good	74.8%	Barton 1987a
1986	Chena River (AK)	9,065 (m/r)	2,031	fair	22.4%	Barton 1987b
1986	Big Salmon River (Y.T. CAN)	1,816 (weir)	701	fair	38.6%	Barton 1987b
1986	Clear Creek (AK)	108 (weir)	47	poor	43.5%	Barton 1987c
1985	Clear Creek (AK)	444 (weir)	77	fair b	17.3%	Barton 1987c
1979	Morice River (B.C. CAN)	2,826 (g/s)	1,470		52.0%	Neilson and Geen 1981

a Methods are mark and recapture (m/r); tower counts (twr); weir counts (weir); and, population estimated from replicate ground surveys and stream life (g/s).

b Survey conditions were rated "fair" but timing of survey was late with regards to peak of spawning.

SUMMARY

1. A total of 524 chinook and 104 chum salmon and 2 sheefish were captured with two gill net mesh sizes at rivermile 16 of the Chena River from 1-31 July. Mortalities were 6 and 3 for chinook and chum salmon respectively, while 2 chinook and no chum salmon were recaptured in test nets.

2. All chinook salmon captured in test nets were measured and sexed. The male to female ratio was 1.00:0.91. A total of 517 chinook salmon was successfully tagged, fin-clipped and released. The number of chum salmon measured, sexed, fin-clipped and released totaled 101. Chum salmon were not tagged.

3. Chinook salmon carcass surveys were conducted by riverboat from MCD to approximately 3 rivermiles up the Middle Fork river during the period 4-19 August. A season total of 1,186 chinook salmon carcasses was examined for tags. Lengths were measured on 1,029 of these fish and sex recorded for 1,030.

4. A total of 95 marked chinook salmon was recovered; 75 with tags and 20 identified by fin-clips. Tag loss was estimated at 27% for jaw tags, 30% for spaghetti tags and approximately 13% for fish which had lost both tag types. Approximately 81% and 78% of the fish which lost jaw tags and spaghetti tags, respectively, were males.

5. The most abundant age groups of chinook salmon as determined from scales were age 1.4 (75%), age 1.3 (13%), and age 1.5 (8%). Both males and females were dominated by 6-year-olds (age 1.4) from the 1981 brood year, however females dominated that age group (49.6% versus 25.7%) as well as the 1.5 age group. Males on the other hand, dominated the 1.3 age group (12% versus 1%). The male to female ratio was 1.00:1.38 (42% males; 58% females).

6. No significant difference (.05) in probability of chinook salmon recapture was detected by sex or size category nor by time or location of recovery.

7. An adjusted Petersen population estimate for the 1987 Chena River chinook salmon escapement was 6,404 with an approximate 95% confidence interval of ± 1,103 fish.

8. The mean and median date of timing for the 1987 chinook salmon run in the Chena was estimated to be on 22 July.

A slight difference in timing by sex was observed with mean dates of 20 and 23 July for males and females, respectively.

9. The peak aerial census was made under "fair" survey conditions on 4 August. A total of 1,312 chinook salmon were enumerated which represents 20.5% of the population estimate. Based upon the 4 August survey, the Chena River chinook salmon escapement objective was achieved in 1987.

CONCLUSIONS AND RECOMMENDATIONS

The population estimate of 6,404 fish is considered to reflect the general order of magnitude of the 1987 Chena River chinook salmon spawning escapement. Whereas, the peak aerial census represented only 20.5% of the population estimate, it was conducted under "fair" survey conditions. More studies are needed to define the actual percentage accounted for under "good" survey conditions since a large proportion of the historical data base consists of aerial estimates made under such conditions. It is recommended that studies be continued in 1988.

Findings in 1987 revealed little difference between tag loss of either jaw or spaghetti tags. Thus, it is recommended that spaghetti tags (in combination with fin clips) be used in the future since less time is required for tag application and less fish handling stress is incurred.

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Appendix A. Test gillnet daily catch records by mesh size in the Chena River, July 1987.

Date	Site Number	Mesh Size	Fishing Time: Time Set	Time Pulled	Duration Minutes	Duration Hours	Chinook Salmon: Male	Female	Total	Chum Salmon: Male	Female	Total	Remarks
01-Jul	1	5.75	1445	1610	85	1.4	0	0	0	0	0	0	
02-Jul	1	5.75	0640	1450	490	8.2	0	0	0	0	0	0	
03-Jul	1		—	—	0	0.0							
04-Jul	1	5.75	0615	1415	480	8.0	0	0	0	0	0	0	
05-Jul	1		—	—	0	0.0							
06-Jul	1	5.75	0615	1425	490	8.2	2	0	2	0	0	0	
07-Jul	1	5.75	0610	1935	805	13.4	2	1	3	0	0	0	1 chinook mort
08-Jul	1	5.75	0615	1420	485	8.1	1	0	1	0	0	0	
09-Jul	1	5.75	0615	1430	495	8.3	1	1	2	0	0	0	
10-Jul	1	5.75	0610	1420	490	8.2	0	0	0	1	1	2	1 chum mort
11-Jul	1	5.75	0655	1500	485	8.1	2	0	2	0	0	0	
12-Jul	1	5.75	0605	1415	490	8.2	3	0	3	0	0	0	
13-Jul	1	5.75	0615	1415	480	8.0	3	0	3	0	0	0	
14-Jul	1	5.75	0610	1905	775	12.9	2	1	3	2	0	2	
15-Jul	1	5.75	0620	1440	500	8.3	0	0	0	0	0	0	
16-Jul	1		—	—	0	0.0							
17-Jul	1		—	—	0	0.0							
18-Jul	1		—	—	0	0.0							
19-Jul	1	5.75	0630	1445	495	8.3	1	0	1	0	0	0	net fished poorly - high water
20-Jul	1	5.75	0610	2400	685 a	11.4	4	0	4	2	0	2	1 sheefish
21-Jul	1	5.75	0001	2205	1260 b	21.0	6	4	10	4	5	9	1 chinook mort: 1 chinook recap
22-Jul	1	5.75	0625	2210	945	15.8	4	2	6	0	1	1	1 sheefish
23-Jul	1	5.75	0615	1805	710	11.8	4	0	4	2	1	3	
24-Jul	1	5.75	0620	1430	490	8.2	3	1	4	3	2	5	1 chum mort
25-Jul	1	5.75	0620	1430	490	8.2	2	1	3	3	0	3	
							40	11	51	17	10	27	
01-Jul	2	8.13	1420	1612	112	1.9	0	0	0	0	0	0	
02-Jul	2	8.13	0620	1445	505	8.4	2	0	2	0	0	0	
03-Jul	2		—	—	0	0.0							
04-Jul	2	8.13	0620	1425	485	8.1	0	0	0	0	0	0	
05-Jul	2		—	—	0	0.0							
06-Jul	2	8.13	0610	1420	490	8.2	2	0	2	0	0	0	
07-Jul	2	8.13	0615	1930	795	13.3	3	3	6	0	0	0	
08-Jul	2	8.13	0620	1428	488	8.1	4	7	11	0	0	0	
09-Jul	2	8.13	0610	1425	495	8.3	1	1	2	0	0	0	
10-Jul	2	8.13	0615	1425	490	8.2	3	2	5	0	0	0	
11-Jul	2	8.13	0650	1450	480	8.0	3	5	8	0	0	0	
12-Jul	2	8.13	0610	1425	495	8.3	9	5	14	0	0	0	
13-Jul	2	8.13	0620	1420	480	8.0	3	7	10	0	0	0	
14-Jul	2	8.13	0615	1925	790	13.2	8	3	11	0	0	0	
15-Jul	2	8.13	0615	1430	495	8.3	4	2	6	0	0	0	
16-Jul	2	8.13	0620	1435	505	8.4	3	1	4	0	0	0	high water
17-Jul	2	8.13	0640	1450	490	8.2	0	1	1	0	0	0	
18-Jul	2	8.13	0610	1420	490	8.2	2	3	5	2	0	2	
19-Jul	2	8.13	0620	1440	500	8.3	3	2	5	0	0	0	1 chinook recap
20-Jul	2	8.13	0615	2400	695 c	11.6	7	8	15	1	0	1	
21-Jul	2	8.13	0001	2215	1180 d	19.7	29	30	59	0	1	1	1 chinook escaped untagged
22-Jul	2	8.13	0620	2205	945	15.8	22	19	41	0	0	0	
23-Jul	2	8.13	0620	1810	710	11.8	8	14	22	1	0	1	
24-Jul	2	8.13	0615	1425	490	8.2	4	5	9	1	0	1	
25-Jul	2	8.13	0625	2400	770 e	12.8	24	16	40	0	0	0	1 chinook mort
26-Jul	2	8.13	0001	1445	570 f	9.5	3	10	13	1	0	1	high water
27-Jul	2	8.13	0830	1635	485	8.1	6	12	18	0	0	0	high water
28-Jul	2	8.13	0615	1445	510	8.5	11	29	40	0	0	0	
29-Jul	2	8.13	0620	1415	475	7.9	4	15	19	0	0	0	
30-Jul	2	8.13	0625	1425	480	8.0	4	11	15	0	0	0	
31-Jul	2	8.13	0620	1430	490	8.2	3	6	9	1	0	1	
							175	217	392	7	1	8	

-Continued-

Date	Fishing Time: Site Number	Mesh Size	Time Set	Time Pulled	Duration Minutes	Duration Hours	Chinook Salmon: Male	Female	Total	Chum Salmon: Male	Female	Total	Remarks
01-Jul	3	5.75	1500	1615	75	1.3	0	0	0	0	0	0	
02-Jul	3	5.75	0645	1440	475	7.9	0	0	0	0	0	0	
03-Jul	3		--	--	0	0.0							
04-Jul	3	5.75	0625	1430	485	8.1	0	0	0	0	0	0	
05-Jul	3		--	--	0	0.0							
06-Jul	3	5.75	0605	1415	490	8.2	1	0	1	0	0	0	
07-Jul	3	5.75	0620	1925	785	13.1	2	1	3	0	0	0	
08-Jul	3	5.75	0625	1432	487	8.1	3	1	4	0	0	0	
09-Jul	3	5.75	0605	1420	495	8.3	4	3	7	0	0	0	1 chinook mort
10-Jul	3	5.75	0620	1430	490	8.2	1	0	1	0	1	1	
11-Jul	3	5.75	0645	1445	480	8.0	0	0	0	1	1	2	
12-Jul	3	5.75	0615	1430	495	8.3	6	1	7	0	0	0	
13-Jul	3	5.75	0625	1425	480	8.0	1	0	1	0	0	0	
14-Jul	3	5.75	0620	1935	795	13.3	0	0	0	0	0	0	
15-Jul	3	5.75	0610	1415	485	8.1	0	0	0	1	0	1	
16-Jul	3	5.75	0630	1440	490	8.2	0	0	0	0	0	0	high water
17-Jul	3	5.75	0630	1440	490	8.2	2	0	2	0	0	0	
18-Jul	3	5.75	0615	1425	490	8.2	0	0	0	1	0	1	
19-Jul	3	5.75	0615	1430	495	8.3	1	0	1	1	0	1	
20-Jul	3	5.75	0620	2400	710 g	11.8	6	1	7	2	2	4	1 chum mort
21-Jul	3	5.75	0001	2220	1320 h	22.0	6	2	8	6	5	11	1 chinook mort
22-Jul	3	5.75	0615	2155	940	15.7	5	2	7	4	2	6	1 chum mort
23-Jul	3	5.75	0625	1815	710	11.8	6	3	9	2	0	2	1 chinook mort
24-Jul	3	5.75	0610	1420	490	8.2	3	1	4	0	2	2	
25-Jul	3	5.75	0630	2400	780 i	13.0	4	3	7	6	3	9	
26-Jul	3	5.75	0001	0120	120	2.0	0	0	0	0	0	0	
27-Jul	3		--	--	0	0.0							
28-Jul	3		--	--	0	0.0							
29-Jul	3		--	--	0	0.0							
30-Jul	3	5.75	0630	1430	480	8.0	0	0	0	3	2	5	
31-Jul	3	5.75	0615	1420	485	8.1	0	0	0	0	0	0	
							51	18	69	27	18	45	
10-Jul	4	8.13	0710	1140	270	4.5	1	0	1	0	0	0	net fished poorly
11-Jul			--	--	0	0.0							
12-Jul			--	--	0	0.0							
13-Jul			--	--	0	0.0							
14-Jul			--	--	0	0.0							
15-Jul			--	--	0	0.0							
16-Jul	4	5.75	1010	1430	260	4.3	0	0	0	0	0	0	
17-Jul	4	5.75	0650	1500	490	8.2	2	0	2	1	1	2	
18-Jul	4	5.75	0605	1410	485	8.1	2	0	2	0	0	0	
19-Jul	4	5.75	0610	1420	490	8.2	1	0	1	0	0	0	
20-Jul	4		--	--	0	0.0							
21-Jul	4		--	--	0	0.0							
22-Jul	4		--	--	0	0.0							
23-Jul	4		--	--	0	0.0							
24-Jul	4		--	--	0	0.0							
25-Jul	4	5.75	1440	1730	170	2.8	0	0	0	2	0	2	
26-Jul	4		--	--	0	0.0							
27-Jul	4		--	--	0	0.0							
28-Jul	4	5.75	0625	1430	485	8.1	1	2	3	2	0	2	lots of debris
29-Jul	4	5.75	0625	1420	475	7.9	1	1	2	5	0	5	
30-Jul	4	5.75	0620	1420	480	8.0	0	1	1	6	2	8	
31-Jul	4	5.75	0625	1435	490	8.2	0	0	0	4	1	5	
							8	4	12	20	4	24	
					Grand Total		274	250	524	71	33	104	

a Actual fishing time was 0610-1415 and 2040-2400 hrs.
b Actual fishing time was 0001-0325 and 0630-2205 hrs.
c Actual fishing time was 0615-1425 and 2035-2400 hrs.
d Actual fishing time was 0001-0345 and 0620-2215 hrs.
e Actual fishing time was 0625-1745 and 2230-2400 hrs.
f Actual fishing time was 0001-0110 and 0625-1445 hrs.
g Actual fishing time was 0620-1435 and 2025-2400 hrs.
h Actual fishing time was 0001-0335 and 0615-2220 hrs.
i Actual fishing time was 0630-1750 and 2220-2400 hrs.

Appendix B. Mean daily water discharge in the Chena River as measured at the USGS guaging station below Moose Creek Dam, July - August 1987. a

July	Discharge (cfs)	August	Discharge (cfs)
1	676	1	1,540
2	628	2	1,670
3	588	3	1,750
4	556	4	1,520
5	537	5	1,320
6	516	6	1,180
7	501	7	1,090
8	486	8	1,050
9	471	9	1,070
10	468	10	1,170
11	462	11	1,120
12	456	12	1,040
13	459	13	980
14	510	14	955
15	990	15	1,610
16	1,110	16	2,740
17	1,020	17	2,610
18	860	18	2,410
19	764	19	2,220
20	700	20	2,670
21	636	21	3,380
22	592	22	3,280
23	560	23	2,920
24	700	24	2,550
25	1,500	25	2,280
26	2,500	26	2,040
27	2,000	27	1,820
28	1,670	28	1,670
29	1,330	29	1,540
30	1,200	30	1,450
31	1,210	31	1,450

a Provisional data provided by USGS.